# FEEDING ANIMALS:

## A PRACTICAL WORK

UPON

## THE LAWS OF ANIMAL GROWTH

SPECIALLY APPLIED TO

*THE REARING AND FEEDING OF HORSES, CATTLE, DAIRY COWS, SHEEP AND SWINE.*

BY

ELLIOTT W. STEWART,

ONE OF THE EDITORS OF THE NATIONAL LIVE STOCK JOURNAL; LATE NON-RESIDENT PROFESSOR OF THE PRINCIPLES OF AGRICULTURE IN CORNELL UNIVERSITY.

**WITH ILLUSTRATIONS.**

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FOURTH EDITION.

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# PREFACE TO FOURTH EDITION.

The patronage of the most advanced farmers extended to the previous editions of FEEDING ANIMALS has been a very agreeable surprise to the author, and made him feel desirous of rewriting some of the most important chapters of the book, but impaired health has quite prevented this. Yet the typographical errors and errors in analysis have been corrected as far as discovered; and an important addition of four pages has been made to the tables of food analyses, made by American chemists, which is likely to be a nearer approximation to American food values than analyses of the same foods made in Europe. Certain combinations of foods are so often made in rations that a short table of such combinations is given, in the hope that it may be found useful.

The author believes that this book now contains more precise information upon all topics relating to feeding stock than can be found in any other single publication, and he hopes the same generous appreciation and patronage will be extended to this as to the previous editions.

# PREFACE TO FIRST EDITION.

THIRTY years ago, to recruit his health, the author removed from professional labor in the city to a farm in the country. Having a liking for stock, he naturally turned his attention early to this branch of farming. And not being able to find much printed instruction upon the subject of feeding any class of stock, he began early to experiment for himself and to keep a record of his experiments.

And as these materials grew upon his hands, the author conceived the idea of writing and publishing a book upon subjects discussed in this, unless some one should anticipate him in this needed service to the great live stock interest. It will thus be seen that the author has taken leisurely to his work; and it would give him great pleasure if he could believe that his work is as ripe and complete as the years it has been growing upon his hands.

The first methodical preparation of this work began in January, 1877, in a series of articles published in the *National Live Stock Journal* under the general title to this book—FEEDING ANIMALS,—signed, *Alimentation.*

These extended to 41 articles, and mapped out the frame-work of the book. But the author drew also, to some extent, upon articles which he had written for the *Country Gentleman*, and *Rural New Yorker*, and perhaps other papers, using these in the details of the book.

The first three chapters were written last, as necessary preliminary knowledge to the full understanding of the discussions of the work.

Chemical research has thrown much light upon the feeder's art, and the author has endeavored to give the latest and fullest analyses of grasses, forage plants, grains, and by-products of grains, used as stock foods, to be found in any one book extant.

Stock barns have become so important an element in successful stock-feeding, that the author has given a pretty thorough discussion of this topic, with full illustrations of the octagonal form of barn. The principles of feeding are discussed in a separate chapter; then each class of stock is taken up separately, and the method of feeding and management from birth to commercial age fully explained. A chapter on Dairy Cattle goes into the selection and management of this very important class of farm stock.

The author has not ventured into the discussion of veterinary remedies, contenting himself with the description of a few simple water remedies, endeavoring to impress the reader with the necessity of preventing diseases rather than of curing them.

The aim of the author throughout has been to discuss all matters from the practical rather than the theoretical stand-point; and his work, such as it is, is herewith presented to the public, hoping that its suggestions may lighten the labor and increase the profits of, at least, some who intelligently cultivate the great live stock specialty.

The author takes pleasure in acknowledging his obligations to many writers upon the topics here discussed, but he has endeavored to give due credit to each for the matter thus used.

Ease of reference being a matter of great importance in a book of varied contents, the author has endeavored to make a very full analytical index, which will enable the reader easily to find any matter discussed in the book.

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# INTRODUCTION.

The live stock interest of the United States has expanded so rapidly during the last two decades and has now reached such proportions as to lead every other agricultural industry. In fact, it may be said that most other branches of farming are merely incidental to the great live stock industry—that is, all our cereal grains and grasses, except wheat and rice, are raised with a special reference to their value as food for animals.

That the importance and value of this great interest in agriculture may be apparent, we will glance at the statistics of each of its specialties, giving only the numbers and value of each class of live stock, without considering their annual income:

HORSES AND MULES.

| | 1840. | 1850. | 1860. | 1870. | 1880. |
|---|---|---|---|---|---|
| Horses........ | 4,000,000 | 4,336,719 | 6,249,174 | 8,702,000 | 12,000,000 |
| Value in 1880. | ........ | ........ | ........ | ........ | $740,000,000 |
| Mules......... | 335,669 | 559,331 | 1,151,148 | 1,242,311 | 2,000,000 |
| Value in 1880. | ........ | ........ | ........ | ........ | $140,000,000 |
| Total value, horses and mules. | | | | | $880,000,000 |

These figures follow closely the census reports and those made by the Department of Agriculture for these periods.

CATTLE.

| | 1850. | 1860. | 1870. | 1880. |
|---|---|---|---|---|
| Milch Cows......... | 6,385,094 | 8,728,862 | 10,023,000 | 13,433,000 |
| In 1880 the number must reach 12,000,000, value | | | | $322,392,000 |
| Other cattle......... | 11,993,763 | 16,911,475 | 18,348,581 | 23,982,560 |
| And must now reach 25,000,000, value | | | | $481,686,080 |
| Total value of cattle | | | | $803,078,080 |

SHEEP.

| 1850. | 1860. | 1870. | 1880. |
|---|---|---|---|
| 21,732,220 | 22,471,275 | 28,477,951 | 40,000,000 |

Value of sheep.......................................... $95,600,000

SWINE.

| 1840. | 1850. | 1860. | 1870. | 1880. |
|---|---|---|---|---|
| 26,301,293 | 30,354,213 | 33,512,867 | 29,457,500 | 47,683,951 |

Value of swine.......................................... $224,114,500

Total value of these four classes of live stock ......$2,002,792,580

This, over two thousand millions, is the invested capital, and the yearly production is more than one thousand millions of dollars. We have from two to three times the number of cattle, in proportion to population, as compared with the principal countries of Europe, and from three to six times as many swine in proportion to population; nearly three times the proportional number of horses of France, the German states or England. Russia is the only country approximating the United States in the proportion of horses. England, France and Germany equal the United States in the proportional number of sheep.

It will thus be seen that the live stock industry of this country is already very great, but the small proportion of our land yet improved shows that live stock production is capable of almost indefinite extension; and that this extension must depend largely upon the intelligence and practical knowledge with which the business is pursued. It is evident that a small saving in the cost of production will amount to very great figures when applied to such enormous aggregates. And when we consider the complicated nature of the animal system, and that the growth of the animal depends upon the supply of appropriate food, it becomes apparent that the successful prosecution of this business depends upon a sound theoretical and practical knowledge of the relation of food to animal growth. And yet when a novice, desirous of acquiring this knowledge, seeks aid from books which treat systematically and practically upon this most important subject, he finds only fragmentary hints here and there in books and agricultural journals. He will find books upon breeds of cattle, horses, sheep and swine—books upon the philosophy of breeding—but upon the philosophy and practice of feeding animals he will find nothing complete, even for a single class of animals. It is true we may find a very good exposition of the German experiments in Dr. Armsby's Manual of Cattle Feeding, but these experiments are not sufficiently broad to cover the whole field, and have not yet been practically adapted to our needs. They are well worthy of our careful study, and we shall endeavor to show the extent of their application to American cattle feeding.

As all farmers, from time immemorial, have been in the habit of feeding more or less animals, it has been taken for granted that this knowledge came by instinct, and required no study to obtain. When a superior animal was produced, an explanation was always sought in the breed—it was always charged to the blood. When anything is now said concerning the management of those famous breeders who developed the Long-horns and the Short-horns from the inferior animals they began with, their skill and genius in selecting the points to be improved and the animals to be coupled, representing these in greatest perfection, are always dwelt upon with the highest admiration. Little else is mentioned. They forget the grand requisite of success, without which these celebrated breeders would have been little distinguished above their neighboring farmers, and that is—feeding. It may be laid down as an axiom, that breeding alone can produce nothing beyond what is inherent in the animals coupled and their ancestors. Something never comes from nothing. It is food and management that makes a beautiful specimen of any strain of blood. A skillful feeder may often grow a more perfect individual animal out of a three-quarter blood

Short-horn than an indifferent feeder will out of the longest and most fashionably pedigreed Short-horn.

Darwin expresses the opinion that food is one of the most powerful causes of variation in animals,* and when an improvement is thus begun by judicious feeding it may be perpetuated by breeding; but feeding leads the improvement. This position does not undervalue pedigree, for it takes a long effort of both breeding and feeding to establish the fixed characteristics of the Short-horns, or other pure breeds; but it is folly to magnify the pedigree extravagantly, and forget the essential agency that established the improvement and made the pedigree valuable. But all this is gradually changing, and farmers are beginning to see the importance of closely studying the effect of food upon the animals they rear and feed.

The Germans have felt the want of knowledge upon this subject, and have been diligently experimenting upon it, especially for the last fifteen years. They are assisting in laying a foundation for the science of feeding, and the experiment stations of this country, we trust, will soon be working in the same direction.

The author, from extensive observation among stock raisers and feeders, believes that a practical work upon feeding animals, which shall use only so much of scientific formula as is necessary to a proper understanding of the subject, is now more needed than upon any other branch of agriculture. And it has been his primary object, in the preparation of this book, to discuss every topic from a practical standpoint, adding to the personal experience of the author all well-established data and experiments of the most intelligent investigators. Science and practice must go hand-in-hand. Happily, the prejudice of the farmer against science in his calling is fast dying out; and the scientific investigator cordially welcomes the practical

*Animals and Plants, vol. 2, p. 309.

information of the most accurate farmers, and bases his deductions largely upon the facts which they have established.

Our farm animals are kept with a view to use or profit. It is, therefore, of the highest importance that the food consumed should produce the best result in growth or product.

To aid the reader in understanding the value of the different foods, the chemical constituents of each is given from analyses by the best chemists of this country and Europe; and added to this, all the most reliable experiments in feeding, both in this country and England, together with the German experiments to determine the digestibility and nutritive value of the ingredients in each food commonly employed in growing and fattening animals, are given and explained. These German experiments are the most important contribution to the science of feeding during the last quarter of a century. And these German tables, in connection with the numerous feeding trials given for each class of stock, it is hoped will enable the practical feeder to fully comprehend the comparative and economical value of each class of foods he desires to employ.

Animal physiology is so far treated and illustrated as to give a general insight into the process of digestion in the different classes of farm stock; and the principles of animal hygiene so far considered as to suggest the general mode of preventive treatment to maintain the health of animals.

As shelter is an important item in the economical management of stock in many of our states, the subject of the construction of barns and basement stables, for all purposes of stock-keeping, is discussed and illustrated.

The new system of ensilage appears to have so many important advantages in preserving all the succulent qualities and digestibility of the grasses and leguminous plants, and to render practical the application of the soiling system to all parts of the country—placing the cold and the mild climates upon nearly equal advantage—that it is thought worthy of a full statement of all its good points, illustrated with plans of silos, and with practical directions for building the same in the most economical manner, from the various materials found in different localities.

# FEEDING ANIMALS.

## CHAPTER I.

### COMPOSITION OF ANIMAL BODIES.

THAT the reader may have a clear understanding of the philosophy of growing animals, and of the office to be performed by the food, we deem it necessary to give a short preliminary explanation of vegetable and animal bodies.

The true relation of animal to vegetable life is not so well comprehended by the mass of farmers as it should be, and a concise statement of these principles will assist them in understanding their application to the various subjects discussed in this book.

The natural function of plants or vegetables is to absorb the inorganic matter of soil and air, and convert it into organized structures of a complex character. Plants use only mineral food, and advance this by organizing it into a higher form. Their food consists mostly of water, carbonic acid and ammonia. Water is composed of oxygen and hydrogen; carbonic acid is made up of carbon and oxygen; and ammonia of hydrogen and nitrogen. These four elements are called the *organic elements,* because they compose the bulk of all plants. The combustible portion of all plants and animals is made up of these organic elements; the incombustible part is formed of sulphur, phosphorus, chlorine, potassium, sodium, calcium, magnesium, silicon, and iron. These are the principal elements. Sometimes iodine, bromine, and a few other simple elementary bodies are found in plants and animals. Vegetable and animal substances are often looked upon as very different in their composition, but the most important of these elements are quite identical in vegetables and animals. Vegetable albumen, which is often found coagulated in boiling vegetable juices, is identical with the albumen of the white of eggs. The fibrin of blood is in no wise different from the fibrin of wheat and many other cereal grains; and the curd or casein of milk is the same as the legumen of peas and beans. And these substances are all convertible into each other within the animal organism. We shall consider the separate elements of vegetable foods in the next chapter.

It was formerly supposed that animals had the power of changing and combining the elements of their food into such form as their necessities required; but it is now believed that they do not possess the power of even compounding the substance of the muscles from its elements, and can only appropriate from vegetables what they find ready formed for their use—that the vegetable must elaborate, and the animal can merely appropriate. Food, then, must contain all the elements of animal bodies. It will therefore be profitable to consider the composition of animal bodies—the blood, the flesh, or muscles, the fat, the bones, the skin, hair or wool, horn, etc.

1st. The blood, on an average, contains water, 79 per cent., and 20 per cent. of organic matters, consisting principally of a nitrogenous substance analagous to fibrin, which separates in long strings when blood is beaten with a stick immediately after being drawn, and some albumen, which remains dissolved in the liquid part of the blood or serum. On heating, the albumen coagulates and separates into whitish flakes, like the white of eggs, with which it is identical in composition, also some fatty matter and a trace of sugar. The ash of blood is almost one per cent., and is rich in chloride of sodium, or common salt, and contains a large proportion of the phosphates of soda, lime and magnesia.

To the eye the blood appears to be a homogeneous red liquid, but on microscopic examination is found to consist of a colorless fluid—called *liquor sanguinis*, or plasma of the blood—holding in suspension very great numbers of globular bodies—the colored and colorless corpuscles of the blood. The colored greatly outnumber the colorless corpuscles; and the former consist largely of coloring matter—hæmoglobin—which gives blood its red color. The shade of color depends upon the amount of oxygen. Arterial blood contains oxyhæmoglobin, which is a bright red, crystaline body, having a similar composition to albuminoids, but with the addition of about 0.45 per cent. of iron, from which the color is supposed to be derived. We here give a tabular view, exhibiting the relative composition of the blood corpuscles and the liquor sanguinis, as determined by Schmidt and Lehman:

| 1,000 Parts of Blood Corpuscles Contain: | | 1,000 Parts of Liquor Sanguinis Contain: | |
|---|---|---|---|
| Water | 688.00 | Water | 902.90 |
| Solid constituents | 312.00 | Solid constituents | 97.10 |
| Specific gravity | 1088.5 | Specific gravity | 1028 |
| | | Fibrin | 4.05 |
| Hæmoglobin and proteids of the stroma | 298.97 | Proteids, chiefly serum-albumin | 78.84 |
| Fat | 2.31 | Fat | 1.72 |
| Extractive matters | 2.60 | Extractive matters | 3.94 |
| Mineral substances | 8.12 | Mineral substances | 8.55 |
| Chlorine | 1.686 | Chlorine | 3.644 |
| Sulphur trioxide | 0.066 | Sulphur trioxide | 0.155 |
| Phosphorus pentoxide | 1.134 | Phosphorus pentoxide | 0.191 |
| Potassium | 3.328 | Potassium | 0.323 |
| Sodium | 1.052 | Sodium | 3.341 |
| Oxygen | 0.667 | Oxygen | 0.403 |
| Calcium phosphate | 0.114 | Calcium phosphate | 0 311 |
| Magnesium phosphate | 0.073 | Magnesium phosphate | 0.222 |

The blood contains all the elements of every part of the body. Yet it bears but a small proportion to the whole body, averaging only from 6 to 8 per cent. Although the blood is constantly furnishing material to build up the tissues of the body in every part, yet its quantity remains practically the same, and its chemical constituents may be considered unvarying—the blood is constantly forming from the food and as constantly being absorbed by the secretory vessels.

2d. The fleshy parts, or muscles, of animals consist, principally, of muscular fibre, or fibrin; and contain, besides cellular tissue, nervous substance, blood, and lymphatic vessels and an acid juice. This juice contains lactic acid, a little albumen, some salts of potash, phosphate of lime, and magnesia, and gives the taste to flesh. This muscular fibre has a close analogy to the fibrin of blood, to albumen, white of eggs, casein, gluten, legumen, and albumen of vegetables. All these substances contain about 16 per cent. of nitrogen, and a small quantity of phosphorus and sulphur.

These albuminoids contained in the muscles, cellular tissue, blood and lymphatic vessels have a general composition, according to J. F. W. Johnston, of:

| | |
|---|---|
| Water | 77.00 |
| Albuminoids, with a little fat | 22.00 |
| Phosphate of lime | .66 |
| Other saline matter (sulphur, etc.) | .34 |
| | 100.00 |

The ultimate composition of albuminoids has about the following average:

| | |
|---|---|
| Carbon | 53.00 |
| Hydrogen | 7.00 |
| Nitrogen | 16.00 |
| Oxygen | 22.50 |
| Sulphur | 1 50 |
| | 100.00 |

It will be important when considering the effect of albuminoids in the fattening ration of animals to refer to this analysis.

3d. The skin, hair, horn, hoof and wool possess a similar composition to the muscular parts of the animal body, the principal difference consisting in a larger proportion of sulphur (three to five per cent.) which they contain, and varying proportions of nitrogen. They consist of a substance resembling gluten and gelatine in composition, and, containing less water than muscular fibre, they leave from one to two per cent. of ash. According to Johnston they contain of organic matter:

| | *Horse's Hoof.* (Mulder.) | *Skin.* | *Wool.* | *Hair.* | *Horn.* |
|---|---|---|---|---|---|
| Carbon | 51.41 | 50.99 | 50.65 | 51.53 | 51.99 |
| Hydrogen | 6.96 | 7.07 | 7.03 | 6.69 | 6.72 |
| Nitrogen | 17.46 | 18.72 | 17.71 | 17.94 | 17.28 |
| Oxygen and Sulphur | 24.72 | 23.22 | 24.61 | 23.84 | 24.01 |
| | | 100.00 | 100.00 | 100.00 | 100.00 |

4th. The fat of animals is a mixture of several organic compounds, which are all distinguished by containing a large proportion of carbon, united with oxygen and hydrogen, but has no nitrogen, or inorganic matter. The same constituents which are found in animal exist in the vegetable oils and fatty matters of vegetables.

In order that the reader may have a mode of comparison of the relative value of fat and starch in foods, we give the following average analyses of fats:

| | *Carbon.* | *Hydrogen.* | *Oxygen.* |
|---|---|---|---|
| Beef fat | 76.50 | 11.91 | 11.59 |
| Mutton fat | 76.61 | 12.03 | 11.36 |
| Pork fat | 76.54 | 11.94 | 11.52 |

5th. The bones consist of about one-third organic matter, made up mostly of gelatine, containing about 18 per cent. of nitrogen; and the other two-thirds, or 66 per cent., of phosphate of lime, carbonate of lime, phosphate of magnesia, potash and common salt.

The formula given by Johnston is as follows:

COMPOSITION OF BONES.

| | |
|---|---|
| Gelatine | 35 |
| Phosphate of lime | 55 |
| (Containing phosphoric acid, 23.38) | |
| Carbonate of lime | 4 |
| Phosphate of magnesia | 3 |
| Soda, potash and common salt | 3 |
| | 100 |

This is from the mature animal. The bones of an animal at birth do not contain more than 50 per cent. of ash.

Chemically considered, then, animal bodies consist of: 1st. Organic matters free from nitrogen. 2d. Organic matters rich in nitrogen—fibrin and albumin. 3d. Inorganic salts—chloride of sodium, phosphate of lime, potash, etc. 4th. Water. These constituents of the animal body must all be derived from the food.

That most painstaking and accurate experimenter, to whom all agriculturists are deeply indebted, Sir J. B. Lawes, of Rothamsted, England, with his assistant, Dr. Gilbert, undertook an experiment, a few years ago, to determine the proportion of the different parts of the animal, and the composition of each part. The fat and the nitrogenous or lean was carefully determined by analysis in the dressed carcass, in the offal, and in the entire animal. There were a large number of oxen, sheep and pigs in these feeding experiments, and from these ten were selected. These consisted of a fat calf, a half-fat ox, a fat ox, a fat lamb, a store sheep, a half-fat old sheep, a fat sheep, a very fat sheep, a store pig and a fat pig.

The pòpular idea had been that all animals, except the fattest, contained more lean flesh than fat. But this table refutes this idea most conclusively. The fat ox and fat lamb contained about three times as much fat as lean flesh. This table, which we give, contains very precise evidence of the useful and the waste parts of the animal, and can be studied with profit, as showing how the parts of the animal change as the process of fattening goes on.*

In explanation of this table: The *carcass* is that part of the animal consumed as food. The *offal* is made up of those parts not consumed as human food, and embraces skin, feet, head and all the internal organs, except the kidney and kidney fat. The relative proportion of fat in the carcasses analyzed is given; but the nitrogenous matters are found in large proportion in the offal, so that the relative proportions of the constituents of the whole body are considered. In a fat and fully-grown animal, there is 49 per cent. of water, 33 per cent. of dry fat, 13 per cent. of dry nitrogenous matter—muscles separated from fat, hide, etc., and 3 per cent. of mineral matter. In the lean animal the average proportion is 54 per cent. of water, 25½ per cent. of dry fat, 17 per cent. of dry nitrogenous matter, and 3½ per cent. of mineral substances.

This table contains a summary of the most important experiments ever carried out to ascertain the facts here stated. This clearly shows how a lean animal exchanges water for fat, and how the animal may be improving most profitably without gaining much in weight by a substitution of fat for water. He shows that during the last stages of fattening the gain may consist of 75 or more per cent. of dry substance.

We place this table in the first chapter that it may be easy of reference in illustration of the feeding experiments given in the progress of the work.

We also print here an extensive table of proportions of the various parts of cattle, sheep, and swine, from the German of Wolff, for a translation of which we are indebted

* "Experimental Inquiry into the Composition of some of the Animals Slaughtered as Human Food." By John Bennet Lawes, F. R. S., F. C. S., and Joseph Henry Gilbert, Ph. D., F. C. S. Philosophical Transactions of the Royal Society, Part II., 1860.

SUMMARY OF THE COMPOSITION OF THE TEN ANIMALS—SHOWING THE PERCENTAGE OF MINERAL MATTER, DRY NITROGENEOUS COMPOUNDS, FAT, TOTAL DRY SUBSTANCE AND WATER.

1st. In fresh carcass. 2d. In fresh offal (equal sum of parts, excluding contents of stomach and intestines). 3d. In entire animal (fasted live weight, including therefore the weight of contents of stomach and intestines).

| DESCRIPTION OF ANIMALS. | PER CENT. IN CARCASS. | | | | | PER CENT. IN OFFAL. | | | | | PER CENT. IN ENTIRE ANIMAL. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mineral Matter. | Dry Nitrogeneous Compounds. | Fat. | Dry Substance. | Water. | Mineral Matter. | Dry Nitrogeneous Compounds. | Fat. | Dry Substance. | Water. | Mineral Matter. | Dry Nitrogeneous Compounds. | Fat. | Dry Substance. | Contents of Viscera. | Water. |
| Fat calf | 4.48 | 16.6 | 16.6 | 37.7 | 62.3 | 3.41 | 17.1 | 14.6 | 35.1 | 64.9 | 3.80 | 15.2 | 14.8 | 33.8 | 3.17 | 63.8 |
| Half fat ox | 5.56 | 17.8 | 22.6 | 46.0 | 54.0 | 4.05 | 20.6 | 15.7 | 40.4 | 59.6 | 4.66 | 16.6 | 19.1 | 40.3 | 8.19 | 51.5 |
| Fat ox | 4.56 | 15.0 | 34.8 | 54.4 | 45.6 | 3.40 | 17.5 | 26.3 | 47.2 | 52.8 | 3.92 | 14.5 | 30.1 | 48.5 | 5.98 | 45.5 |
| Fat lamb | 3.63 | 10.9 | 36.9 | 51.4 | 48.6 | 2.45 | 18.9 | 20.1 | 41.5 | 58.5 | 2.94 | 12.3 | 28.5 | 43.7 | 8.54 | 47.8 |
| Store sheep | 4.36 | 14.5 | 23.8 | 42.7 | 57.3 | 2.19 | 18.0 | 16.1 | 36.3 | 63.7 | 3.16 | 14.8 | 18.7 | 36.7 | 6.00 | 57.3 |
| Half fat old sheep | 4.13 | 14.9 | 31.3 | 50.3 | 49.7 | 2.72 | 17.7 | 18.5 | 38.9 | 61.1 | 3.17 | 14.0 | 23.5 | 40.7 | 9.05 | 50.2 |
| Fat sheep | 3.45 | 11.5 | 45.4 | 60.3 | 39.7 | 2.32 | 16.1 | 26.4 | 44.8 | 55.2 | 2.81 | 12.2 | 35.6 | 50.6 | 6.02 | 43.4 |
| Extra fat sheep | 2.77 | 9.1 | 55.1 | 67.0 | 33.0 | 3.64 | 16.8 | 34.5 | 54.9 | 45.1 | 2.90 | 10.9 | 45.8 | 59.6 | 5.18 | 35.2 |
| Store pig | 2.57 | 14.0 | 28.1 | 44.7 | 55.3 | 3.07 | 14.0 | 15.0 | 32.1 | 67.9 | 2.67 | 13.7 | 23.3 | 39.7 | 5.22 | 55.1 |
| Fat pig | 1.40 | 10.5 | 49.5 | 61.4 | 38.6 | 2.97 | 14.8 | 22.8 | 40.6 | 59.4 | 1.65 | 10.9 | 42.2 | 54.7 | 3.97 | 41.3 |
| Means of all | 3.69 | 13.5 | 34.4 | 51.6 | 48.4 | 3.02 | 17.2 | 21.0 | 41.2 | 58.8 | 3.17 | 13.5 | 28.2 | 44.9 | 6.13 | 49.0 |
| Means of eight of the half fat, fat, and very fat animals | 3.75 | 13.3 | 36.5 | 53.6 | 46.4 | 3.12 | 17.4 | 22.4 | 42.9 | 57.1 | 3.23 | 13.3 | 29.9 | 46.4 | 6.26 | 47.3 |
| Means of six of the fat and very fat animals | 3.38 | 12.3 | 39.7 | 55.4 | 44.6 | 3.03 | 16.9 | 24.1 | 44.0 | 56.0 | 3.00 | 12.7 | 32.8 | 48.5 | 5.48 | 46.0 |

to Dr. Armsby's Manual of Cattle Feeding. A study of this table will give the reader accurate information of the percentage proportion of all the various parts of the animal, and he will see the proportion of valuable parts, and the true basis of judging of the value of an animal to the butcher, etc. This table will be needed for frequent reference. It shows in an admirable way the changes from the lean to the fat animal, from the young to the mature.

We trust that in this chapter the reader will find a full explanation of all questions that may arise in relation to the composition of animal bodies.

## Proportions of the Various Parts of Cattle, Sheep and Swine.

| | Ox. | | | | Sheep. | | | | | Swine. | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Well fed. | Half fat. | Fat. | Fat calf. | Lean. | Well fed. | Half fat. | Fat. | Very fat. | Well fed. | Fat. |
| | per ct. | per ct. | per ct. | per ct. | per ct. | per ct. | per ct. | per ct. | per ct. | per ct. | per ct. |
| Contents of stomach and intestines | 18.0 | 15.0 | 12.0 | 7.0 | 16.0 | 15.0 | 14.0 | 12.0 | 10.0 | 7.0 | 5.0 |
| Blood | 4.7 | 4.2 | 3.9 | 4.8 | 3.9 | 3.9 | 3.6 | 3.2 | 3.2 | 7.3 | 3.6 |
| Skin and horns | 8.4 | 7.4 | 6.0 | 6.8 | | | | | | | |
| Legs to gambrel joints | 1.9 | 1.7 | 1.6 | 1.9 | 9.6 | 9.3 | 8.0 | 7.2 | 6.5 | .... | ... |
| Washed wool | .... | .... | .... | ... | 5.0 | 4.7 | 4.3 | 4.0 | 3.6 | .... | ... |
| Wool-dirt | .... | .... | .... | .... | 4.8 | 4.5 | 4.0 | 3.6 | 3.2 | .... | ... |
| Head | 2.8 | 2.7 | 2.6 | | | | | | | .... | .... |
| Tongue and gullet | 0.6 | 0 6 | 0.5 | 4.8 | 4.6 | 4.3 | 3.7 | 3.2 | 2.8 | 0.5 | 0.4 |
| Heart | 0.4 | 0 5 | 0.5 | 0.6 | 0.4 | 0.3 | 0.4 | 0.3 | 0.2 | 0.5 | 0.3 |
| Lungs and windpipe | 0.7 | 0.7 | 0.6 | 1.2 | 1.5 | 1.5 | 1.2 | 1.0 | 1.0 | 1.4 | 0.9 |
| Liver and gall bladder, | 1.5 | 1.3 | 1.3 | 1.6 | 1.4 | 1.3 | 1.3 | 1.3 | 1.0 | 2.6 | 1.7 |
| Diaphragm | 0.5 | 0.5 | 0.5 | 0.4 | 0.3 | 0.3 | 0.3 | 0.2 | 0.2 | .... | .... |
| Spleen | 0.2 | 0.2 | 0.2 | 0.3 | 0.2 | 0.2 | 0.2 | 0.1 | 0.1 | 0.2 | 0.2 |
| Stomach, without contents | 4.5 | 3.0 | 2.7 | 1.2 | 2.4 | 2.3 | 2.3 | 2.0 | 1.5 | 1.2 | 0.7 |
| Intestines, without contents | 2.0 | 1.5 | 1.4 | 2.4 | 2.3 | 2.2 | 1.9 | 1.7 | 1.3 | 3.9 | 2.2 |
| Fat of omentum and intestines | 2.3 | 2.9 | 4.5 | 2.4 | 3.0 | 4.1 | 4.9 | 6.8 | 8.0 | 1.7 | 2.5 |
| Four quarters, including kidneys and kidney fat, | 47.4 | 55.7 | 60.3 | 60.0 | 43.3 | 45.3 | 49.4 | 52.8 | 57.1 | 72.8 | 82.1 |
| Loss | 4.1 | 2.1 | 1.4 | 4.6 | 1.3 | 0.8 | 0.5 | 0.6 | 0.3 | 0.9 | 0.4 |
| Total | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

SUMMARY.

| | Ox. | | | | Sheep. | | | | | Swine. | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Well fed. | Half fat. | Fat. | Fat calf. | Lean. | Well fed. | Half fat. | Fat. | Very fat. | Well fed. | Fat. |
| | per ct. | per ct. | per ct. | per ct. | per ct. | per ct. | per ct. | per ct. | per ct. | per ct. | per ct. |
| Blood | 4.7 | 4.2 | 3.9 | 4.8 | 3.9 | 3.9 | 3.6 | 3.2 | 3.2 | 7.3 | 3.0 |
| Skin, head, legs and tongue | 13.7 | 12.4 | 10.9 | 13.5 | 24.0 | 22.8 | 20.0 | 18.0 | 16.1 | .... | .... |
| Entrails | 9.8 | 7.7 | 7.2 | 7.7 | 8.5 | 8.1 | 7.7 | 6.6 | 5.3 | 9.8 | 6.0 |
| Flesh and fat | 49.7 | 58.6 | 64.8 | 62.4 | 46.3 | 49.4 | 54.3 | 59.6 | 65.1 | 74.5 | 84.6 |
| Contents of stomach and intestines | 18.0 | 15.0 | 12.0 | 7.0 | 16.0 | 15.0 | 14.0 | 12.0 | 10.0 | 7.0 | 5.0 |

CONSTITUENTS OF CARCASS (DRESSED WEIGHT, INCLUDING FAT OF OMENTUM, ETC.).

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Flesh, without fat and bones | 36.0 | 38.0 | 35.0 | 43.0 | 33.2 | 33.5 | 33.1 | 29.0 | 27.0 | 46.4 | 40.0 |
| Bones | 7.4 | 7.3 | 7.1 | 9.3 | 7.1 | 6.6 | 5.9 | 5.5 | 5.2 | 8.0 | 5.8 |
| Fat in flesh | 2.0 | 7.9 | 14.7 | 5.5 | 2.0 | 3.3 | 8.0 | 14.7 | 20.5 | 16.5 | 32.4 |
| Fat on kidneys | 2.0 | 2.5 | 3.5 | 2.2 | 1.0 | 1.9 | 2.4 | 3.6 | 4.4 | 1.9 | 3.9 |
| Fat on omentum and intestines | 2.3 | 2.9 | 4.5 | 2 4 | 3.0 | 4.1 | 4.9 | 6.8 | 8.0 | 1.7 | 2.5 |
| Total | 49.7 | 58.6 | 64.8 | 62.4 | 46.3 | 49.4 | 54.3 | 59.6 | 65.1 | 74.5 | 84.6 |

FLESH OF CARCASS, WITHOUT FAT OR BONES.

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Dry matter | 8.0 | 8.4 | 7.5 | 8.8 | 6.8 | 6.7 | 6.3 | 5.4 | 5.1 | 8.1 | 7.3 |
| Water | 28 0 | 29.6 | 27.5 | 34.2 | 26.4 | 26.8 | 26.8 | 23.6 | 21.9 | 38.3 | 32.7 |
| Total | 36.0 | 38.0 | 35.0 | 43.0 | 33.2 | 33.5 | 33.1 | 29.0 | 27.0 | 46.4 | 40.0 |

IN 100 PARTS OF FLESH, WITHOUT BONES (BUTCHERS' MEAT).

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Fat | 5.3 | 17.2 | 29.4 | 11.3 | 5.7 | 9.0 | 19.5 | 33.6 | 43.2 | 26.2 | 45.5 |
| Muscle substance | 19.8 | 17.5 | 14.5 | 17.0 | 18.0 | 17.1 | 14.5 | 11.7 | 10.2 | 12.3 | 9.7 |
| Ash | 1.2 | 0.9 | 0.8 | 1.1 | 1.3 | 1.1 | 0.8 | 0.7 | 0.6 | 0.6 | 0.4 |
| Water | 73.7 | 64.4 | 55.3 | 70.6 | 75.0 | 72.8 | 65.2 | 54.0 | 46.0 | 60.9 | 44.4 |
| Total | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

PERCENTAGE COMPOSITION OF LIVE ANIMALS.

| | Ox. | | | | Sheep. | | | | | Swine. | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Well fed. | Half fat. | Fat. | Fat calf. | Lean. | Well fed. | Half fat. | Fat. | Very fat. | Well fed. | Fat. |
| | per ct. | per ct. | per ct. | per ct. | per ct. | per ct. | per ct | per ct. | per ct. | per ct. | per ct. |
| Fat | 7.1 | 14.9 | 26.8 | 13.1 | 8.6 | 13.2 | 18.3 | 28.1 | 37.2 | 22.5 | 40.2 |
| Protein | 15.8 | 15.5 | 13.7 | 15.3 | 15.4 | 14.8 | 13.8 | 12.2 | 11.0 | 13.9 | 11.0 |
| Ash | 4.8 | 4.4 | 3.9 | 4.5 | 3.4 | 3.3 | 3.2 | 2.9 | 2.8 | 2.7 | 1.8 |
| Water | 54.3 | 50.2 | 43.6 | 60.1 | 56.6 | 53.7 | 50.7 | 44.8 | 39.0 | 53.9 | 42.0 |
| Contents of stomach and intestines | 18.0 | 15.0 | 12.0 | 7.0 | 16.0 | 15.0 | 14.0 | 12.0 | 10.0 | 7.0 | 5.0 |
| Total | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

THE SAME, LESS CONTENTS OF STOMACH AND INTESTINES.

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Fat | 8.7 | 17.5 | 30.5 | 14.1 | 10.2 | 15.5 | 21.3 | 31.9 | 41.4 | 24.2 | 42.3 |
| Protein | 19 2 | 18.3 | 15.6 | 16.5 | 18.3 | 17.4 | 16.0 | 13.9 | 12.2 | 15.0 | 11.9 |
| Ash | 5.9 | 5.2 | 4.4 | 4.8 | 4.0 | 3.9 | 3.8 | 3.3 | 3.1 | 2.9 | 1.9 |
| Water | 66.2 | 59.0 | 49.5 | 64.6 | 67.5 | 63.2 | 58.9 | 50.9 | 43.3 | 57.9 | 43.9 |
| Total | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

MINERAL MATTER IN 100 PARTS OF LIVE ANIMALS.

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Phosphoric acid | 1.92 | 1.76 | 1.56 | 1.64 | 1.33 | 1.29 | 1.25 | 1.13 | 1.09 | 1.10 | 0.73 |
| Lime | 2.14 | 1 96 | 1.74 | 1.93 | 1.40 | 1.35 | 1.31 | 1.19 | 1.15 | 1.15 | 0.77 |
| Magnesia | 0.06 | 0.06 | 0.05 | 0.06 | 0.05 | 0.04 | 0.04 | 0.04 | 0.04 | 0.05 | 0.03 |
| Potash | 0.18 | 0.16 | 0.14 | 0.29 | 0.16 | 0.16 | 0.15 | 0.14 | 0.13 | 0.15 | 0.10 |
| Soda | 0.14 | 0.13 | 0.12 | 0.07 | 0.15 | 0.15 | 0.14 | 0.13 | 0.12 | 0.19 | 0.07 |
| Silica | 0.02 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | .... | .... |
| Sulphuric acid, chlorine and carbonic acid | 0.34 | 0.32 | 0.28 | 0.50 | 0.29 | 0.29 | 0.29 | 0.25 | 0.25 | 0.15 | 0.10 |
| Total | 4.80 | 4.40 | 3.90 | 4.50 | 3.40 | 3.30 | 3.20 | 2.90 | 2.80 | 2.70 | 1.80 |

# CHAPTER II.

## ELEMENTS OF FODDER VEGETABLES.

Having considered in the last chapter the complicated structure of the animal body, we now proceed to show the feeder how these complex bodies of animals are nourished and renewed by the assimilation and substitution of the same elements contained in vegetables. These animal bodies are constantly undergoing changes, the substances of which they are composed are broken down or destroyed, and substances identical in composition in vegetable foods are replacing them in the animal economy.

A Nutrient.—The term nutrient, which will frequently be used, means any single chemical compound, such as starch, sugar, fat, gluten, casein, albumen, etc., which is capable of nourishing the body or repairing its waste.

Every fodder used in feeding animals is composed of more than one nutrient; and these nutrients are contained in very unlike proportions in different feeding stuffs.

Ration.—The animal body is made up of these various compounds, but the proportions of the various constituents are nearly the same at all times, so that the food on which it is sustained should have about the same proportion of these different nutrients as are the proportions of these elements in the animal body. The skill of the feeder is shown in combining these different foods so as to make up a mixture meeting all the wants of the animal. This combination is properly called *a ration*.

To explain: The animal body is made up of nitrogenous, and non-nitrogenous elements, with some mineral substances. Some fodders possess all these elements in proper combination, such as a mixture of grasses or meadow hay. Some have one and some the other group of nutrients in excess; such as straw, turnips and Indian corn, have the carbonacious elements in excess, whilst oil-cake, malt-sprouts, etc., contain an excess of the nitrogenous or albuminoid nutrients—but when properly mixed these will constitute a complete food or ration.

Let us now explain the three groups of nutrients contained in vegetables.

## Nitrogenous Nutrients.

We shall not attempt to go into a detailed explanation of all the names of nitrogenous substances which modern chemists have found to exist in vegetables used as food for animals. So far as any practical advantage to the feeder, these nitrogenous substances may all be considered to have the same general composition as the albuminoids of the animal body, and are generally called albuminoids. Three of these vegetable albuminoids, best understood, albumen, casein, and fibrin, we shall proceed to explain and compare them with animal albuminoids—giving a table containing these with several other subdivisions recently made by chemists.

If we examine wheat flour, making it into a dough, then washing it several times on a piece of muslin, tied over the mouth of a tumbler, until the water passes through clear, the flour is separated into its two chief constituent parts—the starch, which forms the chief portion of the wheat, is washed through the muslin ; the gluten, mixed with the bran of the grain, remains on the muslin, in the form of a whitish-gray, sticky substance. The gluten thus obtained is not simple, but a mixture of several similar substances and some fatty matters. If the milky liquid which passes through the muslin is allowed to stand undisturbed for a little time, all the starch will settle to the bottom of the tumbler, and the liquid above will be quite clear, and may be drawn off. On boiling this clear liquid, white, voluminous flakes of vegetable albumen (a substance similar to the white of eggs) will separate. After removing the albumen and evaporating the liquid, a little sugar and gum will be found. Thus starch, sugar, gum, fat, gluten, albumen, and salts are found in wheat. In Indian corn, rye, and barley these constituents will be found nearly the same; but in oats, peas, beans, etc., instead of gluten and albumen, will be found a substance which resembles, in nearly all chemical characteristics, casein of the curd of milk. This substance, having first been found in leguminous plants, is called legumen, and is so near like casein as to be called vegetable casein.

The most of the table on opposite page is taken from analyses by Ritthausen.

Chemists have also found certain nitrogenous organic substances in the grasses and other vegetables, having some chemical resemblance to ammonia—called *amides*. But a separate discussion of these is not important, since in analyses these are included in the total amount of nitrogen in the plant.

The term *protein* is now largely used by chemists to mean all the albuminoids collectively. As will be seen by the above table, all these substances contain about 16 per cent. of nitrogen, and small quantities of sulphur or phosphorus, or both. It will be noted that the percentage of nitrogen is substantially the same in these vegetable substances as in animal albumen, casein, and fibrin, and they can hardly be distinguished from each other. Therefore we see that the material of which the flesh and blood of animals principally consist, exist ready-formed in the

ANIMAL AND VEGETABLE ALBUMINOIDS.

| | Animal Albumen. | Vegetable Albumen. | Gluten of Wheat. | Casein of Milk. | Legumen from Oats. | Legumen from Peas. | Legumen from Beans. | Fibrin from Wheat. | Fibrin from Barley. | Fibrin from Maize. | Mucedin from Wheat. | Gliadin from Wheat. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Carbon | 53.5 | 53.5 | 52.90 | 53.0 | 51.63 | 51.48 | 51.48 | 54.31 | 54.55 | 54.69 | 54.11 | 52.67 |
| Hydrogen | 7.0 | 7.2 | 7.00 | 7.0 | 7.49 | 7.02 | 6.96 | 7.18 | 7.27 | 7.51 | 6.90 | 7.10 |
| Nitrogen | 15.5 | 16.5 | 16.95 | 16.0 | 17.45 | 17.13 | 14.76 | 16.89 | 15.70 | 16.33 | 16.63 | 18.01 |
| Oxygen | 22.4 | 21.6 | 22.05 | 22.5 | 22.64 | 23.97 | 26.35 | 20.61 | 22.48 | 20.78 | 21.48 | 21.37 |
| Sulphur | 1.6 | 1.2 | 1.10 | 1.5 | 0.79 | 0.40 | 0.45 | 1.01 | ...... | 0.69 | 0.88 | 0.85 |
| | 100. | 100. | 100. | 100. | 100. | 100. | 100. | 100. | 100. | 100. | 100. | 100. |

cereals and leguminous seeds which animals eat. They are also found in smaller quantities in grass, clover, hay, and other foods. Without undergoing much change in the animal stomach, they are assimilated and readily converted into blood and thence into muscular fibre. But all these plants which serve as food for animals, contain only a small proportion of albumen, casein, and gluten, and other albuminoids; their great bulk is made up of starch, gum, sugar, cellular fibre, and some other carbo-hydrates. They present the animal with a mixture in which the substance of the muscles exists ready-formed; and for this reason the albumen, casein, legumen, gluten, and other nitrogenous compounds of vegetables were first called *flesh-forming principles*, or flesh formers. They are now more commonly called albuminoids, or proteids. Careful experiments have shown that no foods which do not contain albuminous compounds can sustain animal life for more than a few days. A sheep, weighing 52 lbs., being fed on sugar dissolved in water, died in 20 days, and lost 21 lbs. A goose, weighing 6 lbs. 1 oz., fed on sugar, died in 22 days; another, fed on starch, lived 27 days. Dogs fed on starch, sugar, gum, butter, and other food perfectly free from albuminoids, apparently keep their condition the first week, then rapidly become emaciated, and die at about the end of the fifth week, only a little later than if no food had been given them. It has also been found that animals cannot live upon albuminoids alone. But foods rich in albuminoids have a great superiority in feeding value.

## Non-nitrogenous Nutrients.

Carbo-hydrates.—As we have seen, the great bulk of vegetables is made up of non-nitrogenous compounds—called carbo-hydrates. The principal of these are *cellulose, a woody fibre, starch, dextrine, cane, grape and fruit sugar*, and the *gums*. They are called carbo-hydrates because they are composed simply of carbon, and the elements of water—hydrogen and oxygen.

*Cellulose.*—The cellular structure of all plants, and of the trunks of trees, consist of this substance. It constitutes the frame-work of plants; and the cells of this frame-work are internally coated, or incrusted with a harder and tougher substance, called *lignin*. These two substances are so much found together, and their chemical composition is so nearly alike, that they may properly be considered together.

Pure cellulose has the same chemical composition as starch, and all woody fibres can be changed into starch by heat and by acids.

The dried stalks of all grass and fodder plants are composed largely of cellulose.

EFFECT OF HEAT UPON WOODY FIBRE.—J. F. W. Johnston quotes from Schübler the following: "If wood be reduced to the state of fine sawdust, and be then boiled in water to separate everything soluble, afterwards dried by a gentle heat, then heated several times in a baker's oven, it will become hard and crisp, and may be ground in the mill into fine meal. The powder thus obtained is slightly yellow in color, but has a taste and smell similar to the flour of wheat; it ferments when made into paste with yeast or leaven, and when baked gives a light, homogeneous bread. Boiled with water, it yields a stiff, tremulous jelly like that from starch."

It thus appears, that by the agency of heat, woody fibre may be changed into starch.

EFFECT OF ACID UPON IT.—If these parts of fine sawdust, or fragments of old linen be rubbed in a mortar with four parts of sulphuric acid, added by degrees, it will, in 15 minutes, be rendered completely soluble in water. If the solution in water be freed from acid with chalk, and then evaporated, a substance resembling gum arabic is obtained. And, according to Schleiden, the fibre may be seen, under the microscope, gradually to change from without inwards, first into starch, then into gum. The fibre of wood or linen may be changed directly into sugar by the prolonged action of dilute sulphuric acid.

Digestibility of Cellulose.—Woody fibre was formerly thought to be quite indigestible. Haubner, about 1850, showed that ruminants digested a large proportion of cellulose. And hundreds of digestion experiments have shown that this substance is an important part of fodder for herbivorous domestic animals. The German experiments have undertaken to fix the percentage of cellulose digested in a large number of our coarse fodders, and also of cereal grains. Of the former, ruminants were found to digest from 30 to 70 per cent., whilst the cellulose of grains was found less digestible. The woody fibre of young and tender plants was found much more digestible than when nearer maturity, and more lignin had formed. It is doubted even now if lignin is digestible, especially in its crude state.

*Starch.*—This is one of the most abundant substances in the vegetable kingdom, being found in all plants. It is exceeded in quantity only by cellulose. It is supposed to be formed in the green leaves of plants and trees from the carbonic acid of the air, aided by sunlight. It seems to be deposited most rapidly in plants near the time of ripening. It is found largely in the cereal grains. Indian corn contains 60 to 68 per cent., and wheat from 62 to 72 per cent.

Starch appears to the eye like particles of meal, yet under a strong microscope it is found to consist of small and regular grains or globules.

We have seen how starch may be separated from wheat or other grain. If fresh plants, such as grass before blossom, are bruised and mascerated, and the liquid then pressed out, a large portion of the starch will pass with the juice from the vegetable tissue, and after standing for a short time, will settle as a mealy mass. Almost every housewife knows how to separate starch from potatoes.

It cannot be dissolved in cold water without the grains are mashed very fine, and then only a small proportion is dissolved. But when mixed with water at the boiling point, the grains absorb water and burst. It is from this fact that cooking starchy food is supposed to render it much more digestible. When boiled with weak acids or alkalies it is converted into grape sugar, even the action of saliva is supposed to change starch into sugar. Liebig supposed it turned into sugar in the process of digestion. We shall give its composition with other carbo-hydrates.

*Dextrine.*—This may be considered as an artificial product of starch, produced by dry heat upon it. It is a commercial article under the name of British gum.

*Sugars.*—There are cane, grape and fruit sugars. The first is produced from the juice of the sugar cane plant, from beet root, sugar-maple and other plants—this is the principal sugar of commerce. Grape sugar and fruit sugar occur in the juices of many plants, and are often found together and in the fruits and honey. They are all soluble in water, and easily digested. In the process of digestion, cellulose and starch are supposed to be turned into sugar.

THE PECTIN SUBSTANCES.—These are found in fruits and roots. In fruits these substances form jellies, but their exact chemical composition has not been much investigated. It has been supposed by some careful observers that the pectin of fruits and of turnips, beets, carrots and other roots, has an important effect in assisting in the digestion of other food, that this substance assists in rendering other carbo-hydrates soluble, or by gelatinizing the contents of the stomach. But these points have not been very much investigated.

It is found that pectin is increased in roots and fruits by cooking. The process of digestion may perhaps have the same effect.

FATS.—All our fodders and roots contain a small proportion of fat, and this is one of the most important of the carbo-hydrates. The fats in plants have, substantially, the same composition as the fats of the animal body. In the analyses which will be given of all these bodies, it will be seen that the fats contain a much larger proportion of carbon and correspondingly less oxygen; and in burning gives out about 2½ times as much heat as starch, sugar, etc., and are estimated to have 2½ times the nutritive value of such carbohydrates.

Fat is found in different fodders about in the following proportions: Average meadow hay 2.5 per cent., best 3; clover, very good, 3.2; timothy 3 per cent.; turnips and other roots 0.1 to 0.2; Indian corn 4 to 7 per cent.; oats 6.0; rye 2.0; barley 2.5, etc.; straw from 1 to 2 per cent. But the seeds, of cotton, flax, hemp, and some other plants, contain from 10 to 38 per cent. of oil. These oil-bearing seeds are put under pressure to extract the oil as an article of commerce, but the residue (oil cake) retains a considerable proportion of oil.

Oil has a great effect in rapid fattening of animals, but they are also able to store up fat from the carbo-hydrates.

The following table of the analysis of the carbo-hydrates above described will give the reader a correct idea of their composition, and how nearly they approximate to each other:

| | *Carbon.* Per cent. | *Hydrogen.* Per cent. | *Oxygen.* Per cent. |
|---|---|---|---|
| Pure cellulose........... | 44.44 | 6.17 | 49.39 |
| Cellulose, mixed with lignin.................... | 55.30 | 5.80 | 38.90 |
| Starch ................... | 44.44 | 6.17 | 49.39 |
| Cane sugar.............. | 42.11 | 6.43 | 51.46 |
| Milk sugar ............... | 42.11 | 6.43 | 51.46 |
| Grape sugar............. | 40.00 | 6.67 | 53.33 |
| Fruit sugar............... | 40.00 | 6.67 | 53.33 |
| Gum ..................... | 45.10 | 6.10 | 48.80 |
| Fats.................. ... | 76.50 | 12.00 | 11.50 |

The pectine substances have a composition probably very similar to gum. The above table will show, at once, how close a relation there is between all the members of this group of substances. The fats are not usually classed with the carbo-hydrates, because the oxygen and hydrogen are not in the proportion to form water, but being composed of the same elements, and answering the same purpose in the animal economy, they may all be classed together. Even when fat is used to supply animal heat it has two and one-half times the heating power of starch.

In all plants cultivated for food, there is a greater or less amount of fatty matter, identical in composition with the several kinds of fat in animal bodies. The fatty matters of the food are extracted by the stomach of the animal, and easily assimilated. Plants prepare fatty matters from their elements—carbon, oxygen and hydrogen—and present them ready-formed to the animal. But the animal possesses the power of preparing fat from starchy food when there is not fat enough ready-formed for its wants, and may accumulate fat from starchy food, when given in abundance.

## Inorganic Nutrients.

Our food plants also receive from the soil phosphates of lime, magnesia, and soda, chlorides of sodium and potassium, oxide of iron, sulphate of iron, and potash; and these same compounds exist in the bodies of animals in the same combination as found in plants. The plant is therefore dependent upon the soil and the animal upon the plant.

That the reader may get a definite idea of the proportion of the mineral constituents of some of our forage plants and grains, together with some of the by-fodders, we give the following table, which will be found convenient for reference. We give the number of pounds, and fractions of a pound, of ash, and of the separate elements of that ash, in 100 pounds of the dry substance of hay, straw, grain, roots, etc. This will enable the reader more easily to figure the exact proportion of any mineral constituent in any ration fed:

HAY.

| 100 Pounds of Substance. | Ash. | Potash. | Soda. | Magnesia. | Lime. | Phosphoric acid. | Sulphuric acid. | Silica. | Chlorine. | Sulphur. |
|---|---|---|---|---|---|---|---|---|---|---|
| | lbs. | lbs. | lbs. | lbs. | lbs. | lbs. | lbs. | lbs. | lbs. | lbs. |
| Meadow hay.... | 6.66 | 1.71 | 0.47 | 0.33 | 0.77 | 0.41 | 0.34 | 1.97 | 0.53 | 0.17 |
| Dead ripe hay.. | 6.62 | 0.50 | 0.19 | 0.23 | 0.85 | 0.29 | 0.05 | 4.18 | 0.38 | 0.27 |
| Red clover ..... | 5.65 | 1.95 | 0.09 | 0.69 | 1.92 | 0.56 | 0.17 | 0.15 | 0.21 | 0.21 |
| Swedish clover. | 4.65 | 1.57 | 0.07 | 0.71 | 1.48 | 0.47 | 0.19 | 0.06 | 0.13 | .... |
| Green vetches.. | 7.34 | 3.09 | 0.21 | 0.50 | 1.93 | 0.94 | 0.27 | 0.13 | 0.23 | 0.15 |
| Green oats ..... | 6.18 | 2.41 | 0.20 | 0.20 | 0.41 | 0.51 | 0.17 | 2.05 | 0.25 | 0.15 |

GREEN FODDER.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Meadow grass in blossom.. | 2.33 | 0.60 | 0.16 | 0.11 | 0.27 | 0.15 | 0.12 | 0.69 | 0.19 | 0.06 |
| Young grass.... | 2.07 | 1.16 | 0.04 | 0.06 | 0.22 | 0.22 | 0.08 | 0.21 | 0.04 | 0.04 |
| Timothy........ | 2.10 | 0.61 | 0.06 | 0.08 | 0.20 | 0.23 | 0.08 | 0.75 | 0.11 | 0.08 |
| Oats beginning to head..... | 1.70 | 0.71 | 0.08 | 0.06 | 0.12 | 0.14 | 0.06 | 0.47 | 0.08 | 0 03 |
| Barley beginning to head | 2.23 | 0.86 | 0.04 | 0.07 | 0.16 | 0.23 | 0.07 | 0.70 | 0.12 | 0.05 |
| Rye fodder ..... | 1.63 | 0.63 | 0.01 | 0.05 | 0.12 | 0.24 | 0.02 | 0.52 | .... | .... |
| Hungarian millet .. .... | 2.31 | 0.86 | .... | 0.19 | 0.25 | 0.13 | 0.08 | 0.67 | 0.15 | .... |
| Red clover ..... | 1.34 | 0.46 | 0.02 | 0.16 | 0.46 | 0.13 | 0.04 | 0.04 | 0.05 | 0.05 |
| White clover ... | 1.36 | 0.24 | 0.11 | 0.14 | 0.44 | 0.20 | 0.12 | 0.06 | 0.04 | 0.06 |
| Swedish clover. | 1.02 | 0.35 | 0.02 | 0.16 | 0.32 | 0.10 | 0.04 | 0.01 | 0.03 | .... |
| Lucern ......... | 1.76 | 0.45 | 0.02 | 0.10 | 0.85 | 0.15 | 0.11 | 0.04 | 0.03 | 0.08 |
| Green peas . ... | 1.37 | 0.56 | .... | 0.11 | 0.39 | 0.18 | 0.05 | 0.04 | 0.02 | .... |

ROOT CROP.

| 100 Pounds of Substance. | Ash. | Potash. | Soda. | Magnesia. | Lime. | Phosphoric acid. | Sulphuric acid. | Silica. | Chlorine. | Sulphur. |
|---|---|---|---|---|---|---|---|---|---|---|
| | lbs. | lbs. | lbs. | lbs. | lbs. | lbs. | lbs. | lbs. | lbs. | lbs. |
| Potato | 0.94 | 0.56 | 0.01 | 0.04 | 0.02 | 0.18 | 0.06 | 0.02 | 0.03 | 0.02 |
| Artichoke | 1.03 | 0.67 | .... | 0.03 | 0.04 | 0.16 | 0.03 | .... | 0.02 | .... |
| Beet | 0.80 | 0.43 | 0.12 | 0.04 | 0.04 | 0.08 | 0.03 | 0.02 | 0.05 | 0.01 |
| Turnip | 0.75 | 0.30 | 0.08 | 0.03 | 0.08 | 0.10 | 0.11 | 0.02 | 0.03 | 0.04 |
| White turnip | 0.61 | 0.31 | 0.02 | 0.01 | 0.08 | 0.11 | 0.04 | 0.01 | 0.04 | .... |
| Carrot | 0.88 | 0.32 | 0.19 | 0.05 | 0.09 | 0.11 | 0.06 | 0.02 | 0.03 | 0.01 |
| Beet tops | 1.48 | 0.43 | 0.31 | 0.14 | 0.17 | 0.08 | 0.11 | 0.07 | 0.17 | 0.05 |
| Turnip tops | 1.40 | 0.32 | 0.11 | 0.06 | 0.45 | 0.13 | 0.14 | 0.05 | 0.12 | 0.05 |
| Carrot tops | 2.61 | 0.37 | 0.60 | 0.12 | 0.86 | 0.12 | 0.21 | 0.15 | 0.19 | 0.14 |
| Cabbage heads | 1.24 | 0.60 | 0.05 | 0.04 | 0.19 | 0.20 | 0.11 | 0.01 | 0.03 | 0.05 |

STRAW.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Winter wheat | 4.26 | 0.49 | 0.12 | 0.11 | 0.26 | 0.23 | 0.12 | 2.82 | .... | 0.16 |
| Winter rye | 4.07 | 0.76 | 0.13 | 0.13 | 0.31 | 0.19 | 0.08 | 2.37 | .... | 0.09 |
| Barley | 4.39 | 0.92 | 0.20 | 0.11 | 0.33 | 0.19 | 0.16 | 2.36 | .... | 0.13 |
| Oats | 4.40 | 0.97 | 0.23 | 0.18 | 0.36 | 0.18 | 0.15 | 2.12 | .... | 0.17 |
| Maize fodder | 4.72 | 1.66 | 0.05 | 0.26 | 0.50 | 0.38 | 0.25 | 1.79 | .... | 0.39 |
| Pea straw | 4.92 | 1.07 | 0.26 | 0.38 | 1.86 | 0.38 | 0.28 | 0 28 | 0.30 | 0.07 |
| Bean straw | 5.84 | 2.59 | 0.22 | 0.46 | 1.35 | 0.41 | 0.01 | 0.31 | 0.81 | 0.22 |

GRAIN AND SEEDS.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Wheat | 1.77 | 0.55 | 0.06 | 0.22 | 0.06 | 0.82 | 0.04 | 0.03 | .... | 0.15 |
| Rye | 1.73 | 0.54 | 0.03 | 0.19 | 0.05 | 0.82 | 0.04 | 0.03 | .... | 0.17 |
| Barley | 2.18 | 0.48 | 0.06 | 0.18 | 0 05 | 0.72 | 0.05 | 0.59 | ... | 0.14 |
| Oats | 2.64 | 0.42 | 0.10 | 0.18 | 0.10 | 0.55 | 0.04 | 1.23 | .... | 0.17 |
| Maize | 1.23 | 0.33 | 0.02 | 0.18 | 0.03 | 0.55 | 0.01 | 0.03 | ... | 0.12 |
| Millet | 1.23 | 0.23 | 0.07 | 0.23 | .... | 0 66 | 0.02 | .... | .... | .... |
| Sorghum | 1.60 | 0.42 | 0 05 | 0.24 | 0.02 | 0.81 | .... | 0.12 | .... | .... |
| Buckwheat | 0.92 | 0.21 | 0.06 | 0.12 | 0.03 | 0.44 | 0.02 | .... | 0.02 | .... |
| Flax-seed | 3.22 | 1.04 | 0.06 | 0.42 | 0.27 | 1.30 | 0.04 | 0.04 | .... | 0.17 |
| Hemp-seed | 4.81 | 0.97 | 0.04 | 0.27 | 1.13 | 1.75 | 0.01 | 0 57 | 0.01 | .... |
| Peas | 2 42 | 0.98 | 0.09 | 0.19 | 0.12 | 0.88 | 0.08 | 0.02 | 0.06 | 0.24 |
| Vetches | 2.07 | 0.63 | 0.22 | 0.18 | 0.06 | 0.79 | 0.09 | 0 04 | 0.02 | .... |
| Beans | 2.96 | 1.20 | 0.04 | 0.20 | 0.15 | 1.16 | 0.15 | 0.04 | 0.08 | 0.23 |

MANUFACTURED PRODUCTS.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Wheat bran | 5.56 | 1.33 | 0.03 | 0.94 | 0.26 | 2.88 | .... | 0.06 | .... | .... |
| Rye bran | 7.14 | 1.93 | 0.09 | 1.13 | 0.25 | 3.42 | ... | ... | .... | .... |
| Brewers' grain | 1.20 | 0.05 | 0.01 | 0.12 | 0.14 | 0.46 | 0.01 | 0.39 | .... | .... |
| Malt sprouts | 5.96 | 2.08 | .... | 0.08 | 0.09 | 1.25 | 0.38 | 1 77 | .... | .... |
| Rape cake | 5 60 | 1.36 | 0.01 | 0.64 | 0 61 | 2.07 | 0.19 | 0.49 | 0.01 | .... |
| Linseed cake | 5.52 | 1.29 | 0.08 | 0.88 | 0.47 | 1.94 | 0.19 | 0.36 | 0.03 | .... |
| Walnut cake | 4.64 | 1.54 | .... | 0.57 | 0.31 | 2 03 | 0.05 | 0.07 | 0.01 | .... |
| Cotton-seed cake | 6.15 | 2.18 | .... | 0.26 | 0.28 | 2.95 | 0.07 | 0.25 | .... | .... |

The above table is somewhat extended, but as the feeder often desires to know the mineral constituents of his fodder, he will find this in convenient form for ascertaining the precise character of the mineral substances, and the quantity he is furnishing daily to his stock.

Respiratory Food.—But as these preliminary chapters are given to show the parallel between the nitrogenous and mineral elements of plants and animals, we must also explain those non-nitrogenized substances, starch, gum, sugar, etc., which are not found in the animal body, although animals eat large quantities of starch, gum, sugar, and cellulose, and they are necessary for the life of the animal. What becomes of these substances? Science has proved that they are used to support respiration. Leibig has named starch, gum, sugar, cellulose, etc.,—composed of carbon and water only—*the principles of respiration.* Let us illustrate this. If we slake a little burnt lime with water and allow the undissolved lime to settle, then pour off the clear lime water; and if we then breathe through a glass tube into this clear lime water, the liquid soon becomes milky, and after a little a white powder may be seen falling to the bottom of the glass vessel. This proves that by breathing into lime water we add something to it. Chemists know that carbonic acid has a great affinity for lime, with which it forms a white, insoluble powder—carbonate of lime. Thus, while breathing, animals are constantly throwing off the carbon in the form of carbonic acid, and this carbon is derived from the starch, etc., of the food. Leibig has calculated that a horse, during twenty-four hours, throws off four to five pounds of carbon. Animals require food containing a large amount of starch to supply this element of respiration.

This was the accepted theory of scientists to a very recent period. Now, however, as we have explained elsewhere, it is believed that the oxidation of the carbon of the food takes place in the cells and the capillaries of the body instead of the lungs, and that animal heat is thus generated all over the body. This shows the same necessity for carbonaceous food as the first theory, and as this effete matter from the combustion of the carbon in the cells and capillaries is constantly thrown off at the lungs, it may, although not strictly correct, be called the food of respiration.

Here, then, we find one important use for starch, gum, and sugar in food; these being composed entirely of carbon and water, are so simple in combination that the carbon is easily separated, and therefore are admirably adapted to generate animal heat. If the food is deficient in starch, gum, or sugar, but contains fat, then fat is used to supply carbon. Albuminoids also contain carbon; and when there is no other resource for this element of combustion, albuminoids are decomposed to supply the carbon required; but herbivorous animals do not thrive when fed wholly upon nitrogenous food. For this reason, foods very rich in albuminoids should not be fed alone—that is peas, or oil-meal should always be mixed with hay, straw, turnips, or other roots rich in starch, sugar, etc. Fatty substances differ from starch, gum, and sugar, simply in containing more hydrogen than is necessary to form water with the oxygen present. Fatty matters are thus not so easily decomposed to furnish the necessary carbon as the starchy compounds.

It becomes evident from the points discussed, that the health of animals cannot be sustained without a mixed diet; that the food given in order to keep the animal in health must contain: 1. Starch, gum, sugar, or cellulose, to supply the carbon given off in respiration. 2. Fat, or fatty oil, to supply the fatty matter which exists in all animal bodies. 3. Gluten, albumen, legumen, or casein, to make up for the natural waste of the muscles and cartilages, and to grow this part of the system of the young animal. 4. Earthy phosphates, to supply the growth and waste of the bones; and 5. Saline substances—sulphates and chlorides—to replace what is daily excreted. It is therefore plain, that that food is best which has the greatest variety of constituents. The skillful feeder must have a practical knowledge of all these principles, and will not attempt to maintain his stock on one kind of food, or upon any ration that does not contain all these elements abundantly. He will make it a point to give as great a variety as his circumstances will permit, that he may fully supply his animal's wants and tastes.

This statement of the fundamental principles upon which cattle feeding is based, seemed necessary to a complete understanding of all the points that will arise in the treatment of the subjects proposed.

# CHAPTER III.

## DIGESTION.

In a work upon practical feeding, it may be thought unnecessary to go into the physiology of digestion, but every intelligent feeder should understand the general principles that underlie his business; and the process of digestion would seem to be the fundamental principle of animal production. We do not propose to go into any elaborate discussion of this subject, but merely to touch upon such general points as will give the reader some idea of the general process of digestion.

### Digestion Begins in the Mouth—Mastication, Salivary Glands, and the Saliva.

The mouth is the vestibule of the alimentary canal. Here are crushed all the alimentary substances, which are often very hard, resisting and rough, and nature has provided a very thick epidermis to cover the mucous membrane of the mouth, and protect it from injury in those parts that come in contact with these rough, hard substances, as on the upper surface of the tongue, palate, roof of the mouth, and the cheeks. And it is in this mucous membrane covering the tongue that are situated those small organs of taste, that give perception of flavors, thus exciting a desire for food. and no doubt informs the animal of the good or bad quality of the food.

The saliva is secreted by glands situated around the cavity of the cheeks, and this fluid softens the food, assists in its mastication and digestion, and must have some chemical action upon the food after it reaches the stomach.

A gland may be defined as an organ, the function of which is to separate from the blood some particular substance, and discharge it through an excretory duct, whose internal surface is continuous with the mucous membrane. A simple gland is merely a follicle of the mucous membrane, and a collection of these follicles is a compound gland, and if the groups of which it is composed are loosely bound together like clusters of grapes, it is called conglomerate, as in the salivary glands; but if united into a solid mass, such as the liver, it is called a conglobate gland. Inside of these follicles are cells, which are the active agents in the secreting process, whilst they are surrounded by a network of capillaries in which the blood circulates and furnishes the materials for these secretions. These cells are so minute as to require the aid of a microscope for their examination.

The salivary glands are five in number—four of them in pairs: 1. The parotid gland, which is much the largest, is situated at the posterior angle of the lower jaw, or near the ear. 2. The maxillary or sub-maxillary gland is on the interior central border under the lower jaw. 3. The sublingual gland is situated under the tongue. 4. The molar glands are situated parallel to the molar arches. 5. The labial (or lip glands) and the palatine glands (under mucous covering of the soft palate), these latter are mostly single follicles, and each has a separate excretory duct discharging its secretion into the mouth. The saliva is an extremely watery fluid, having only from 6 to 8 parts of solid matter in 1,000 parts, but this solid or saline matter plays an important part in digestion. There is an active ferment, called *ptyalin*, in saliva, which, although found in very small proportion, possesses the property of changing starch into sugar in the process of digestion, thus rendering it soluble. The constitution of the saliva is also slightly alkaline, and more so while the animal is masticating its food. A horse or an ox is supposed to discharge about two quarts of saliva in a half hour whilst masticating its food. This is sufficient to insalivate a small ration of hay, or what the animal could masticate in that time. The mere sight of food excites the flow of saliva, causing the mouth to "water," and the harder and drier the food the more the saliva will flow during mastication. It is also found that after swallowing even sloppy food saliva will continue to flow into the mouth. The saliva must be considered a most important factor in the process of digestion. And for this reason the food of ruminants is best given in such form as to insure its remastication. This is accomplished by mixing finely-ground food with fibrous fodder, causing both to be raised in the cud and remasticated. The proper preparation of dry fodder by chopping in a cutter, as an aid to mastication and digestion, will be considered in a future chapter.

## Stomach of Solipeds.

The stomach of the horse (fig. 1) is a membranous sac situated on the left side of the abdominal cavity, close behind the diaphragm; has the spleen attached to its left extremity, and its lower part covered with the caul. It has been compared in shape to the Scotch bag-pipes. It is so situated that every contraction of the diaphragm, or inspiration of air, displaces or drives it back, and the fuller the stomach, the greater the labor of the diaphragm under quick motion and frequent breathing, hence a full meal or large draft of water should never be given just before great exertion or rapid movement. The stomach of an average sized horse holds only about three gallons. It has four coats. The outside coat lines the cavity of the belly, and is the common covering of all the intestines, and this coat secretes a fluid which prevents all friction between it and the intestines. This is called the *peritoneum*, and stretches around the inside of the stomach.

The second is the muscular coat, composed of two layers of fibers, one running lengthways and the other circularly, and the contraction of these muscles give a gentle motion to the stomach, mingling the food more completely together, and facilitating the intermixture of the gastric juice; and these muscles also force the food, when properly prepared, into the intestine.

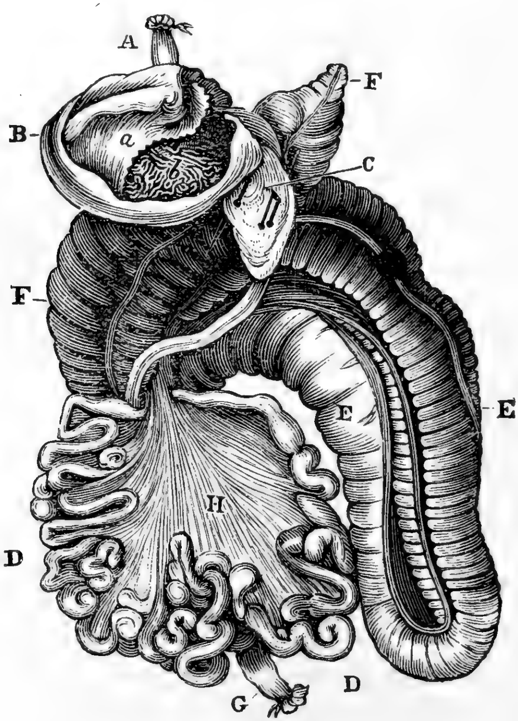



*Fig.* 1.—STOMACH AND INTESTINES OF THE HORSE.

*A*. The lower part of the œsophagus or gullet.
*B*. The stomach laid open to show *a*, the cuticular, and *b*, the villous coat.
*C*. The duodenum or first small intestine, laid open to show the mouths of ducts leading from the liver and pancreas.
*D*, *D*. The small intestines.
*E*, *E*. The colon, showing its convolutions, foldings and bands.
*F*. The cœcum, the principal receptacle for water.
*G*. The rectum.
*H*. The mesentery, the folds of the peritoneum inclosing the intestines and holding them in place.

The third, or cuticular coat (*B*, *a*, fig. 1), covers only a portion of the inside of the stomach, and is a continuation of the lining of the œsophagus or gullet. It contains numerous glands which secrete a mucus fluid. It covers about one-half of the inside of the stomach.

The fourth is the mucus or villous (velvet) coat (*B*, *b*), which secretes the *gastric juice*, and here true digestion commences. The mouths of the numerous little vessels, upon this coat, pour out this digesting fluid, which mixes with the food and converts it into *chyme*. After being converted into *chyme* it passes the orifice called *pylorus* (meaning doorkeeper) and enters the small intestines; the hard or undissolved part of the food being turned back to undergo further action.

## Stomachs of Ruminants and Their Functions.

The peculiarities in form of the digestive organs of the different classes of our domestic animals should be well understood. And, having explained and illustrated that of the horse, ass and mule, called solipeds, we now illustrate and explain the more complicated digestive organs of ruminants. The illustrations answer equally well for cattle and sheep. There are very slight differences in the position of the organs, but this is not material to an understanding of the process of digestion in both. Fig. 2 was drawn by Prof. James Law for the *Live Stock Journal*, and we also give his written description of the stomachs of ruminants. Fig. 3 is the external appearance of the stomach of a young sheep, taken from Dr. Randall's "Sheep Husbandry of the South." Fig. 4 is an illustration of the internal appearance of the stomachs given by the learned author, Youatt.

Professor Law, who stands in the front rank of comparative physiologists, after speaking of the great variety in the form and arrangement of the digestive organs of different classes of animals, and that these varied forms bear a strict relation to the habits of the animal and the condition in which it lives, says:

"The flesh feeders possess a very capacious stomach, in which the highly nitrogenous food is long retained and digested by the secretions of the gastric glands. The bowels are short and of small capacity, in accordance with the restricted amount of other ingredients in the food which are soluble in the intestinal liquids. In the herbivora, on the other hand, which subsist on food rich in carbo-hydrates and comparatively poor in albuminoids, the true digesting stomach is small and the intestines enormously long and capacious. The capacity of the stomach of the dog is three-fifths of that of the entire gastro-intestinal canal, whereas that of the horse is only about two-twenty-fifths of the abdominal part of the alimentary tube.

"At first sight the ruminant appears to be an exception to this rule, as the gastric cavities amount to no less than seven-tenths of the abdominal part of the digestive canal; but this idea is dispelled by the consideration that the fourth or true digestive stomach, which alone corresponds to that of the horse or dog, is relatively as small as in the solipede. The first three stomachs are mainly macerating and triturating cavities, in which the coarse and imperfectly masticated herbage is stored, triturated and partially dissolved, while waiting for the second mastication, or for its reception by the fourth or true stomach.

"*First Stomach.*—Of the four compartments or stomachs, the first (*paunch, rumen*) is incomparably the largest. It has an average capacity of 250 quarts, in the ox, and makes up about nine-tenths of the mass of the four stomachs. It occupies the entire left side of the abdomen, from the short ribs in front to the hip bones behind, so that if this side of the belly were punctured at any point, this organ alone would be entered. It is marked externally by a deep notch at each end, and by two grooves connecting these on the upper and lower surfaces respectively, together with smaller grooves diverging from these, on each side. These notches and grooves correspond to internal folds supported by strong muscular bands, and partially dividing the cavity into a right and left sac, and into anterior, posterior, and median compartments. The entire inner surface of this organ, excepting the muscular pillars, and a small portion of the left anterior sac bordering on the second stomach, is thickly covered by papillæ, most of which are flattened and leaf-like, with an elongated ovate outline, but some are conical or fungiform, especially in the left sac.

"*Second Stomach.*—The second stomach (*honey-comb-bag, reticulum*), though spoken of as a separate organ, is rather a simple prolongation forward of the anterior left sac of the rumen. It is separated from the rumen by a rather prominent fold, but the communicating opening is so large that the semi-liquid contents pass freely from the one cavity to the other during the movements of the stomachs. Its most prominent characteristic is the alveolated or honey-comb-like arrangement of its mucous membrane. These cells vary in size and depth, being largest at the lower part of the organ and smaller at the upper, or where it joins the paunch. They extend for a short distance on the surface of that organ as well. The larger cells are again subdivided by smaller partitions in their interior. The walls of these cells are covered throughout by small, hard-pointed papillary eminences. These cells usually entangle many small, hard and pointed bodies which have been swallowed with the food, and it is from this point that such bodies often pass to perforate vital organs, especially the heart.


*Fig.* 2.—THIRD AND FOURTH STOMACHS,

As drawn by Professor Law, showing the course of the Œsophagean Demi-canal.

1. Gullet.
2. Portion of the paunch, showing the villous surface.
3. Portion of the reticulum, showing the cells.
4. Œsophagean demi-canal, with its muscular pillars relaxed so as to show the opening into the gullet above and that leading into the manifolds below.
5. Opening from the demi-canal into the third stomach.
6. Third stomach laid open, showing the leaves.
7. Floor of the third stomach, along which finely-divided food passes to the fourth.
8. Fourth stomach opened, and showing the mucous folds.
9. Commencement of the small intestines.

"*Œsophagean Demi-canal.*—Connecting these organs with the gullet on the one hand and the third stomach on the other, is the demi-canal, one of the most interesting structures in the whole economy. It may be conceived of as the lower portion of the gullet, extending from right to left across the superior surface of the anterior left sac of the paunch and the reticulum as far as the entrance of the third stomach. But in place of its forming a perfect tube, as elsewhere, the lower half of its walls is removed so as to leave a large opening of about six inches in length, communicating with the rumen and reticulum. The margins of this opening are formed of thick pillars, made up largely of muscular tissue, in part forming loops around the ends of the canal, and in part diverging on the walls of the first two stomachs. This muscle encircles the entire ovoid opening, and, when contracted, brings its lips in close opposition, shutting off all communication between the gullet and first two stomachs, and securing a continuous, unbroken passage from the mouth to the third stomach. When, on the other hand, the muscular pillars of the demi-canal are relaxed, the canal remains open, and there is no barrier to communication between the gullet and first two stomachs, or between these stomachs and the third.

" *Third Stomach.*—The third stomach (*manifolds, omasum*), a little larger than the reticulum in the ox, lies over that organ to its right, and above the right anterior sac of the rumen. Its main characteristic is the leaf-like arrangement of its interior. From its walls on the convex aspect twelve or fourteen folds extend quite to the opposite side of the viscus. In the intervals between these are an equal number of folds of about half the length. On each side of these are others still shorter, and so on until the smallest, which appear as simple ridges on the mucous membrane. In this way the flat surfaces of the folds are brought into close relation at all points in place of leaving large intervals at the convex aspect of the organ, as would be the case if all were of the same length. These leaves are not simple folds of mucous membrane, but contain also muscular tissue continued from the coat of the stomach, and enabling the adjacent leaves to move on each other for the trituration of the intervening food. Each leaf is studded

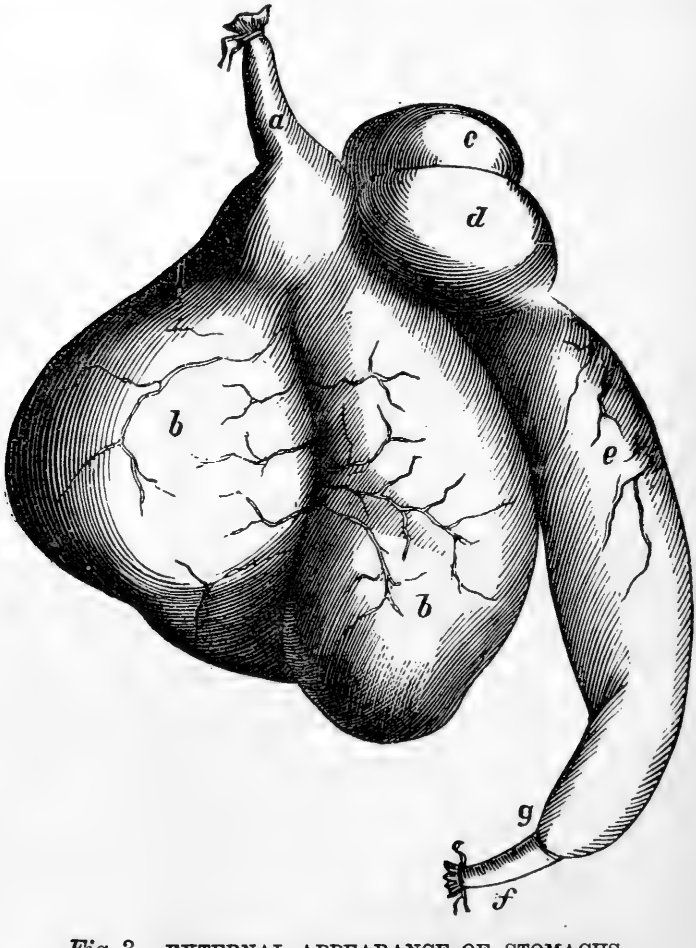



*Fig.* 3.—EXTERNAL APPEARANCE OF STOMACHS.

*a.* The œsophagus or gullet, entering the rumen or paunch.
*b, b.* The rumen, or paunch, occupying three-fourths of the abdomen.
*c.* The reticulum or honey-comb—the second stomach.
*d.* The omasum or manifolds—third stomach.
*e.* The abomasum or fourth stomach.
*f.* The commencement of the duodenum or first intestine.
*g.* The place of the pylorus, a valve which separates the contents of the abomasum and duodenum.

on both sides with hard conical papillæ hooked upward, and especially prominent towards the free margin of the fold in the vicinity of the passage from the demi-canal to the fourth stomach. Similar hooks with a corresponding direction are found in the lower part of the demi-canal, and all concur in drawing the food upward between the folds and retaining it until sufficiently fine to escape. This organ lies beneath the short ribs on the right side.

"*Fourth Stomach.*—The fourth or true digesting stomach (*rennet, abomasum*) is pear-shaped, with the thick end forward, and connected with the manifolds. It extends backward in the right flank along the lower border of the rumen, and terminates by a narrow opening in the small intestine. It is considerably larger than either the second or third stomach, but incomparably smaller than the first. Its outer surface shows a number of spiral markings running around it longitudinally, and corresponding to extensive loose folds of mucous membrane, as observed when it is laid open. Its outer surface is redder and more vascular than that of the other stomachs, but its inner lining or mucous membrane is especially soft, spongy and vascular, forming a marked contrast with the pale, opaque, thick and insensible mucous membrane lining the other stomachs. When magnified, this vascular surface presents throughout a close aggregation of small depressions or alveoli leading into the glandular follicles which secrete the gastric juice.

" *Functions.*—The progress of food through the different stomachs can now be followed. It is a wide-spread belief that all food taken by the ox passes first into the rumen, from which it is propelled into the reticulum, is then sent back to the mouth for the second mastication, and is finally swallowed a second time, passing in this case into the third and fourth stomachs. No such regular and invariable course is pursued. After the first mastication, in which the food receives a few strokes of the jaws, and is mixed with a quantity of saliva varying according to the hard or fibrous character of the aliment, it is swallowed and passes into the first and second, the third or even the fourth stomach. Flourens first showed this on the sheep, and his observations have been fully corroborated by subsequent observers. 1st. He fed green lucern to a sheep, and killing it immediately after, found this aliment mainly in the paunch, a small quantity in the reticulum, and none in the third and fourth stomachs. 2d. He fed oats with the same results. 3d. Small pieces of roots swallowed without mastication were found only in the first two stomachs. 4th. Finally, after feeding pulped roots, he found the greater part in the rumen, but a considerable amount also in the second, third and fourth stomachs. It follows that while all coarse, bulky or fibrous aliment passes at once into the first two stomachs, finely divided food may gain the third or even the fourth without retention in either of the preceding ones.

"Liquids have been found to follow a similar course with finely divided moist food, the greater part passing at once into the rumen and reticulum, while a certain amount passes at once through the œsophagean demi-canal to the third and fourth stomachs. Another feature of the passage of liquids is the propulsion of the fluid from the second stomach through the demi-canal into the third and fourth. This is effected through a series of contractions of the reticulum, and takes place while drinking is going on, the organ being rapidly filled up by the water descending from the mouth, as often as it may be emptied by its contractions. This may also serve to explain how liquids and finely divided food pass on from the first two stomachs to the third and fourth, without having been returned to the mouth for rumination. The enormous accumulation of food in the paunch is surprising. It is no uncommon thing to find 150 to 200 pounds, and this though the animal has been fasting for twenty-four hours. This mass represents but 40 to 50 pounds of solid dry food, the remainder being saliva carried with it in deglutition.

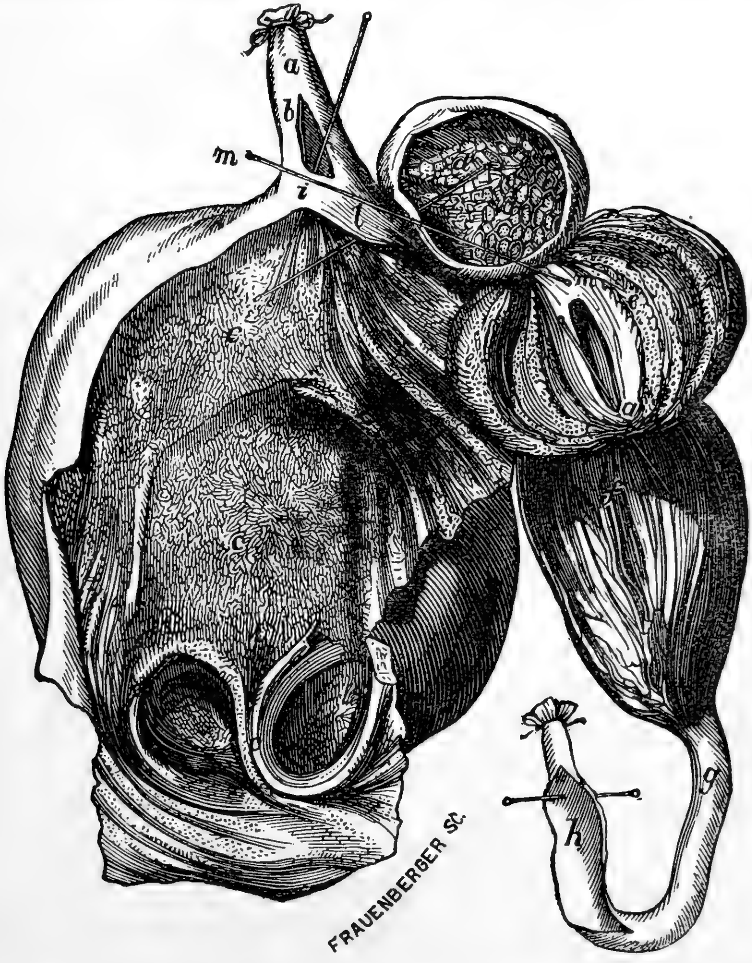



*Fig.* 4.—INTERNAL APPEARANCE OF STOMACHS (YOUATT).

*a.* The œsophagus or gullet.
*b.* The commencement of the œsophagean canal, slit open, with muscular pillars underneath.
*c, c, c.* The rumen, paunch or first stomach, slit open.
*d.* The reticulum or honey-comb, slit open.
*e.* The omasum or manifolds, slit open.
*f.* The abomasum, slit open.
*g.* The commencement of the duodenum or first intestine.
*h.* The duodenum, slit open.
*i, m, l.* Wands, showing the course of œsophagean canal, opening of stomachs, etc.

After drinking, the proportion of water is materially increased. In the normal condition, the solids float in the liquid and are kept loose, open and mobile, one part on another by its intermixture. The reticulum usually contains a certain amount of liquid, and but little solid food.

"These organs move by slow contractions from end to end, which gives a churning motion to the contents, and forces the liquids continually through the semi-solid mass. In this way, the transformation of starch into sugar by the action of the saliva is favored, and all soluble constituents (sugar, gluten, albumen, salts, acids, etc.), are dissolved out, and are sooner or later passed on into the fourth stomach with the liquid solvent. Besides these solvent and chemical actions, the food undergoes maceration, softening, and disintegration, and is thus prepared for subsequent easy and perfect mastication and digestion.

"*Rumination.*—Concisely stated, this consists in the return of food from the first two stomachs to the mouth, its mastication, and its swallowing and descent to any one or more of the four stomachs. Popular writers have been generally misled by the doctrine of Flourens on this matter. He opened the gullet in a sheep, allowing the escape of the saliva which should have floated the contents of the rumen, and when he found these contents firm and solid, and a little ovoid solid mass between the lips of the œsophagean demi-canal, he concluded that this was the form in which food was returned into the mouth. One fact should have forbidden such a conclusion—his sheep never ruminated nor brought up anything to ruminate. The truth is this, that the solid packed state of the food in the rumen, such as he found, is an insurmountable barrier to chewing the cud. Whether this is produced by suppressed secretion of saliva, by salivary fistula with the discharge of this liquid externally, or by the simple forced abstinence from water, the result is the same. Whenever the food fails to float loosely in the liquid, and becomes aggregated in a firm, unbroken mass, rumination becomes impossible.

"If we watch the ox ruminating it will be seen that when a cud is brought up, the act is immediately followed by a swallowing of liquid, after which the animal begins leisurely to chew the solid matters. These loose solids are floated up in a quantity of liquid, both having flowed into the demi-canal during the compression of the stomach, and been returned to the mouth by the contraction of this canal and of the gullet in a direction from below upward. On reaching the mouth the solids are seized between the tongue and palate, and the liquids returned. If the contents of the rumen are accumulated in firm masses, with no detached floating material, it is manifest that liquid only could be brought up. If, on the other hand, the liquids present are only sufficient to impregnate these masses without floating them, nothing whatever can be brought up. Like the sheep of Flourens, the subject ceases to ruminate. Colin demonstrated this use of the liquid by placing four stitches at the opening of the demi-canal, so as to prevent the entrance of pellets, or of anything but fluids and finely disintegrated solids. Yet the subjects continued to chew the cud as before.

"During rumination the already softened aliments are still more perfectly broken down by the teeth, and mixed with a new secretion of saliva, and are thus better prepared for a continuance of the chemical and mechanical changes which they have already been undergoing in the paunch.

"It has not been clearly made out to what stomach food is returned after rumination. But it may be fairly inferred that like finely divided soft food, after the first mastication, it passes in varying proportions into all four stomachs. What returns to the first two, is no doubt returned in part to the mouth, oftener than once, and in part followed the known course of other finely divided matters in being propelled into the œsophagen demi-canal and manifolds by the contractions of the reticulum.

"The conditions essential to rumination are: 1st, a sufficient plenitude of paunch; 2d, an abundance of water; 3d, perfect quiet—absence of all excitement; 4th, a fair measure of health.

"The use of the third stomach is merely to triturate and reduce still further the food which has been already largely disintegrated in the first two stomachs and in rumination. The muscular folds seize and retain the solid particles, and keep up the grinding process until the mass is too fine to be longer caught or retained by the barbed papillæ. The food compressed between the muscular folds loses the greater part of its liquid, so that the contents are normally firm and partially dry, though never quite so in health. When dried to the extent of adhering to the folds and bringing off the cuticular layer upon its surface, it is to be considered as abnormal.

"The uses of the fourth stomach are precisely those of the true stomach in other animals. Its acid gastric juice acting on the nitrogenous elements of the food, transforms them into peptones, a fine milky liquid, fitted to be absorbed and added to the vital fluids. The mucous folds in this stomach, covered as they are by peptic glands, greatly increase the secretions of the digesting fluid and enable the animal to digest promptly the food so beautifully elaborated and prepared by the first three stomachs and the act of rumination. These complicated processes to which the food is subjected, serve to account for the absence of fibrous elements in the dung, and for the finely attenuated state of that excretion; and also for the ease with which ruminants can subsist on coarse and comparatively innutritious fodder. It explains, too, the comparative immunity of the fourth stomach from disease, while the first three, like the stomach of the horse, are very obnoxious to disorder. The possibility of incredibly long fasts on the part of the ruminant, may be explained by the constant presence of a large mass of food in the paunch, for although rumination may be almost or quite suspended, yet if water is freely taken, small quantities are continually transferred from the first two stomachs to the third and fourth."

Gastric Digestion.—As before mentioned, it is in the fourth stomach that true digestion begins. The innumerable glands of the stomach secrete the gastric juice, and when food comes into this stomach the juice is poured out in large quantity. It has a sour taste and smell. It contains muriatic acid and a little pepsin. The latter acts strongly upon the albuminoids contained in the food. It makes them soluble in water, and thus in condition to enter into the circulation. The quantity of pepsin is very small, but appears to have the power of acting over and over many times in connection with the muriatic acid in rendering the albuminoid matter soluble. The soluble carbo-hydrates (as we have seen converted into sugar by the saliva) are absorbed by the blood-vessels of the stomach and enter into the circulation, and the soluble albuminoids or protein is absorbed by the lymphatic vessels of the stomach. But there is much of the nutriment in the food not liberated in the stomach, and all this passes through the pylorus into the intestines (at *G*, fig. 3). Let us examine cursorily:

Intestinal Digestion.—The alimentary canal is continued from the stomach, in the abdominal cavity, by a long tube doubled on itself in many folds, and ends at the posterior opening of the digestive apparatus. This long tube is the intestine. It is narrow and uniform in size in its anterior portion, called small intestine, but is irregularly dilated in its posterior part, and here called large intestine.

The small intestine in the horse (*D D*, fig. 1) is a cylindrical tube from 1 to 1¾ inches in diameter, and is about 24 yards long. The internal surface of the small intestine, like the stomach and other viscera, is provided with a muscular coat, and a mucous membrane; the former produces the peristaltic motion which moves its contents along toward the cœcum, and the latter is covered with glandular follicles which pour out a digestive fluid—an alkaline mucus. The small intestine in its duodenal portion receives through two orifices the bile and pancreatic juice, and these with the intestinal mucus, are constantly acting upon and complete the digestion of the food passing through it. It is also in this intestine that the nutritive principles of the food are absorbed and pass into the general circulation. This leads into the large intestine, which is divided, in its different portions, into the cœcum, the large colon, small colon and the rectum.

The cœcum in the horse (*F*, fig. 1) is about 3 feet in length, and has a capacity of a little over 7 gallons. This part of the large intestine furnishes a reservoir for the large quantities of fluid ingested by herbivorous animals. Here, what is left of the assimilable matters of the food, is dissolved out and enter into the circulation through the absorbents of the mucous membrane of the large intestine.

The *colon* (*E E*) is divided into two parts, the large and small colon. The former is from 10 to 13 feet in length, and there contracts into the small colon. It has a capacity for holding 18 gallons. The small colon is about twice the diameter of the small intestine, and about 10 feet in length. The large colon absorbs fluids and soluble nutritive matters. When the matters taken for food reaches the small colon, deprived of its assimilable principles, the excretory substances are here thrown out on the surface of the intestinal tube, and it now becomes excrement or fæces. These excrements, compressed by the peristaltic contractions of the muscular coat, are rolled up into little rounded masses, shoved into the rectum, and in due course expelled.

The rectum (*G*) appears to be merely the extremity of the small colon.

1. Intestines of Ruminants.—The small intestine of the ox is folded in a multitude of festoons, is twice the length of the small intestine of the horse—averaging about 120 feet—and is about one-half the size. The large intestine is about 30 feet in length, but is less in size than that in the horse. In the sheep the small intestine is about 70 feet long, and the large intestine 20 feet. Neither in the ox or sheep is there such a marked distinction between the small and large colon as in the horse.

2. Intestines of the Pig.—The average length of the small intestine of the pig is 72 feet, and the large intestine 18 feet. Their general disposition in the digestive cavity is somewhat similar to those of the ox, though only the last portion of the colon is included between the layers of the mesentary; for the rest of its extent it is outside that membrane, and forms a distinct mass.

The small intestine has a very large peyerian gland, occupying the latter portion of the canal as a band 5 to 6 feet long. This is an aggregation of secretory follicles. The pig is noted for its capacity to digest and assimilate a very large amount of food in proportion to its weight of body. Its alimentary canal shows how this large amount of concentrated food is prepared and assimilated.

Lawes and Gilbert made many interesting experiments in feeding oxen, sheep, and pigs, and they found that the pig utilized his food better than either of the other classes of animals. And in explanation they give the proportion of the stomachs, and the contents as constituting:

"In oxen about 11½ per cent. of the entire weight of the body.
"In sheep about 7½ per cent. of the entire weight of the body.
"In pigs about 1¼ per cent. of the entire weight of the body."

"The *intestines* and their contents, on the other hand, stand in the opposite relation. Thus, of the entire body, these amounted:

"In the pig to about 6¼ per cent.
"In the sheep to about 3½ per cent.
"In the oxen to about 2¾ per cent."

These facts, they think, explain how the ruminant can take food with so large a proportion of indigestible woody fibre, whilst the well-fed pig takes so large a proportion of starch—that in the latter the primary transformations are supposed to occur "chiefly after leaving the stomach, and more or less throughout the intestinal canal."

And as time is a most important element in feeding, it taking a given amount of food to support the life of the animal and waste of its tissues, and as the pig can digest and assimilate so much more food in a given time, in proportion to its weight of body than the ox or sheep, it has so much more nutriment to apply to an increase of its weight, and this may be considered as an explanation of its greater gain from a given amount of food.

## Other Organs Annexed to the Digestive Canal.

The most important of these are the two glands—the *liver* and *pancreas*, which pour into the intestines the bile and pancreatic juice—also a glandiform organ, the *spleen*, as to the office of which physiologists are in doubt.

The Liver is the largest gland in the body, and is situated in the abdominal cavity, to the right of the diaphragm and downward and adjacent to the stomach, and partly in contact with them. The weight of a healthy liver in a medium-sized horse is eleven pounds. In its external form, it is flattened before and behind, and irregularly lengthened in an eliptical form, thick in its center, and thin towards its borders, which are notched in such a manner as to divide it into three principal lobes. The front face is convex, smooth, and having a deep notch for the passage of the large vein, called vena cava. The back face is also smooth and convex, and is entered by the portal vein, hepatic artery, and nerves; and more biliary ducts leave the liver.

Viewing the liver in position, it is found that the front face is applied against the diaphragm, and the back face in contact with the stomach, duodenum, and colon.

The liver secretes bile and sugar. It secretes bile from the blood of the portal vein, which comes from the intestines charged with assimilable substances. It is supposed to assist in purification of the blood, in digestion and in the generation of animal heat, as the elements it absorbs are rich in carbon and hydrogen. The sugar formed in the liver finds its way into the blood, and is carried off by the veins. It is elaborated in hepatic cells by the transformation of starch, or a similar substance, by contact with a kind of animal yeast or diastase in the interior of these cells. The sugar is passed off in the veins and the bile is carried away in the biliary ducts to the gall bladder for storage till required. The bile is composed of soda in combination with glycocholic, taurocholic and several other acids with ammonia. The soda comes from the common salt of the food. The action of bile in digestion is largely upon the fat, which it decomposes and turns into an emulsion, separating it into very minute globules, similar to butter globules in milk.

Another office it is supposed to perform, is to change the undissolved starch into sugar and facilitate its absorption into the circulation. It is also thought to assist in preserving the albuminoids, with many offices not fully determined.

The liver is regarded as a filter to separate excrementitious matters from the blood, as well as supplying an important agent in digestion.

The Pancreas.—This organ has a close resemblance to the salivary glands. It is situated in front of the kidneys, and behind the liver. Its weight, in the horse, is about 17 ounces.

The pancreas receives its blood by the hepatic and great mesenteric arteries. Its secretion, or juice, has an alkaline action, and contains several ferments; a diastase capable of turning starch into sugar; trypsin, acting on the albuminoids, and a ferment that emulcifies fats. The latter office is stated by Chauveau to be its principal one. It seems certain that the action of the pancreatic juice is very important on several classes of food elements.

The Spleen.—This organ differs from the glands in not having an excretory duct. It has been called a vascular gland, but its uses are not fully understood. It is sickle-shaped, and is suspended near the great curvature of the stomach. The tissue of the spleen has a violet blue color, sometimes approaching to red, is elastic, tenacious and soft, yields to the pressue of the finger and retains the imprint. It is the seat of disease called splenic fever, caused by its engorgement of blood. It has been called a reservoir of blood from the portal vein. The substance of the spleen is easily dilated, and its elasticity favors this view. The red globules of blood are supposed to be destroyed in the spleen.

It does not appear to be indispensably necessary to life, as animals have lived, in apparent health, after its removal from the body.

CIRCULATION.—It is not necessary to our purpose to go into any extended explanation of this important animal function, but it will be sufficient to mention that this consists in the incessant motion of the blood, propelled by the heart through the arteries to all the inner and outer surfaces of the body, permeating every tissue; from thence returning by the veins to the heart, and thence to the lungs, where by contact with the oxygen of the air, it is purified and rendered fit to nourish the tissues, and returning from the lungs to the heart, it is sent again on its rounds to every part of the body. We explained in a previous chapter the appearance and chemical composition of the blood. We have pointed out how the blood is elaborated from the food in process of digestion, and then absorbed into the circulation.

The heart is composed of strong muscular fibre, and divided into four cavities, having valves which regulate the flow of blood. These muscles expand and contract with regularity, producing what we call "heart-beats." There are something like four of these "beats" to one inspiration of the lungs.

THE PULSE.—As nature is regular, these beats or the pulse becomes an indication of health or an abnormal state of the system, and it is therefore an accomplishment in a cattle-feeder to understand the pulse of different animals. This will give him a better knowledge of the real condition of the system than any outward appearance.

Dr. James Law (in his Veterinary Adviser) says: The pulse in full-grown animals at rest may be set down per minute as: Horse 36 to 46; ox 38 to 42, or in a hot building, with full paunch, 70; sheep, goat, and pig, 70 to 80. In old age it may be 5 less in large quadrupeds, and 20 to 30 in small ones. Youth and small size imply a greater rapidity. The new-born foal has a pulse three times as frequent as the horse, the six-months colt double, and the two-year-old one and a quarter. It is increased by hot, close buildings, exertion, fear, a nervous temperament, and pregnancy. In large quadrupeds there is a monthly increase of four to five beats per minute after the 6th month. Independently of such condition, a rapid pulse implies fever, inflammation or debility.

The pulse may be felt wherever a considerable artery passes over a superficial bone; thus on the cord felt running across the border of the lower jaw, just in front of its curved portion; beneath the bony ridge which extends upward from the eye; in horses, inside the elbow; in cattle, over the middle of the first rib, or under the tail.

The force of the pulse varies in the different species in health, thus it is full and moderately tense in the horse; smaller and harder in the ass and mule; full, soft and rolling in the ox; small and quick in sheep; firm and hard in swine. *In disease* it may become more *frequent, slow, quick* (with sharp impulse), *tardy* (with slow, rolling movement), *full, strong, weak, small* (when thread-like but quite distinct), *hard* (when with jarring sensation), *soft* (when the opposite), *oppressed* (when the artery is full and tense, but the impulse jerking and difficult, as if the flow were obstructed), *jerking* and *receding* (when with empty, flaccid vessel, it seems to leap forward at each beat), *intermittent* (when a beat is missed at regular intervals), *unequal* (when some beats are strong and others weak). Besides these a peculiar *thrill* is usually felt with each beat in very weak, bloodless conditions.

The jerking, intermittent, unequal and irregular pulses are especially indicative of heart disease. The *jerking* pulse is associated with disease of the valves at the commencement of the great aorta which carries blood from the left side of the heart, and is accompanied by a hissing or sighing noise with the second heart sound. The *intermittent* pulse implies functional derangement of the heart, but not necessarily disease of structure.

The *unequal* and *irregular* pulse is met in cases of fatty degeneration, disease of the valves on the left side, cardiac dilation, etc.

*Palpitation.*—The application of the hand over the chest, behind the left elbow, will detect any violent and tumultuous beating, irregularity in the force of successive beats, etc.

It is certainly very important that the skillful feeder should, by frequent practice, acquaint himself with the pulse in health and disease. For by this he may be able to apply the "ounce of prevention" which is "worth more than a pound of cure."

The best feeders cultivate assiduously the faculty of observation. Close observation for a few years, will cause him to detect at once the condition of the animal by its attitude and general appearance.

RESPIRATION.—To maintain life in animals, requires not only nutritive matters to be absorbed into the circulation from the digestive canal, but the oxygen of the air must enter with these nutritive elements into the circulation. The effect of the oxygen is to expel carbonic acid gas and to give a bright red color to the blood. It comes in contact with all the minute structures of the general capillary system, exciting an activity in the tissues, and, as is supposed, inducing a combustible action which evolves the heat of the animal body. And this constitutes the process of respiration.

The apparatus by which this process of respiration is carried on consists of the *nasal cavities*, *larynx*, *trachea*, and *lungs*.

THE NOSTRILS perform the important function of admitting the air to the nasal cavities on its way to the lungs. Their easy dilation allows the admission of a greater or less volume of air suited to the requirements of respiration. And in solipeds the nostrils constitute the only entrance by which air can be introduced to the trachea, by reason of the large development of the soft palate, which prevents the entrance of air by the mouth. These orifices are, for this reason, larger than in other domestic animals that make use of the mouth as well as nostrils for the admission of air.

The nasal cavities contain the olfactory membrane and nerves, which give the sense of odors, besides other less important membranes, and conduct the air to the *larynx*, which is a cartilaginous framework, forming a tube intended for the passage of air during the act of respiration. It has also the power of dilating and contracting to accommodate the volume of air introduced into or expelled from the lungs, and when partially paralyzed causes what is called "roaring." But the most interesting office of the larynx is as an air organ for the articulation of sounds.

The *trachea* is a flexible and elastic tube, formed of a series of cartilaginous rings, which connect with and continue the larynx and terminate above the base of the heart in two divisions called the bronchi.

Each of the two *bronchi*, or terminal branches of the trachea, join to and imbed themselves in the substance of the lungs. Their substance is cartilaginous like the trachea.

The *thorax*, or pectoral cavity, holds not only the lungs, but the heart and the large vessels that spring from or pass to the heart, with a part of the æsophagus, trachea and nerves. The thorax rests upon and is surrounded by the ribs, sternum and the dorsal vertebræ, and is above the diaphragm. It performs an important part in respiration. It is dilated and contracted by the movements of the diaphragm and ribs. The lung is applied against the thoracic walls, and follows this cavity in its movements, dilating and contracting with inspiration or expiration.

THE LUNGS.—This necessary organ of respiration is of a spongy texture, lodged in the thoracic cavity, divided into two independent halves or lobes—a right and a left, the left being a little smaller than the right lobe. The pulmonary tissue of the mature animal is of a bright rose color; in the fœtus its color is deeper because not yet inflated with air. The tissue is soft but very strong and remarkably elastic. It is very light, floats in water if healthy, and this is attributed to the air held in the lung vesicles. The lung of a fœtus will sink in water, but after once being inflated, the air cannot be expelled so as to cause it to sink. The relative weight of the lungs to body is much greater in the adult animal than in the fœtus, it being one-thirtieth in the former to one-sixtieth of the whole body in the latter.

It is demonstrated that the blood, after losing its bright red color and the properties which maintain the vitality of the tissues, returns from all parts of the body by the veins to the right side of the heart, and is propelled thence into the lung where it is regenerated by contact with the air. These air cells or vesicles in the lungs are wonderfully minute, being only from 1-3800 to 1-1600 part of an inch in diameter. And between these vesicles is an exceedingly thin, elastic tissue, with a few muscular fibres. The pulmonary veins carries the blood back to the heart after regeneration in the lungs. The principal thing to remember is, that the lung is the seat of the absorption of oxygen by and the expulsion of carbonic acid from the returned or vitiated blood, or the transformation of dark into bright red colored blood.

The lung is early developed in the fœtus, and its lobular texture is well defined through the whole period of fœtal existence.

*Respiratory Action of the Skin.*—The skin is the seat of a constant and important respiratory action, as it absorbs oxygen and throws off carbonic acid, and when this action is interrupted the health of the animal suffers. The true skin underlies the scarf skin, and is filled by capillary blood-vessels, and it is in its passage through these capillaries that the blood gives off carbonic acid and absorbs oxygen. The amounts thus given off and taken up are quite considerable. The excretions from the skin in the form of "insensible perspiration," also carries off large amounts of water.

This also is the means of relieving the body of surplus heat. Millions of pores permeate the skin, and large volumes of vapor are given off through these pores. These orifices are exceedingly minute, convoluted tubes, lying under the skin, and are found to be from one-fifteenth to one-tenth of an inch in length. Erasmus Wilson estimated the number of these tubes in every square inch of the surface of the body to be 2,800, and the total number of square inches on the surface of the body of an average sized man to be 2,500, therefore his skin is drained with 28 miles of these tubes, having seven millions of openings. Water, when converted into vapor by the heat of the body, expands to 1,700 times its liquid bulk, and in doing this absorbs a large amount of heat, and the watery vapor escapes through the pores of the skin, thus cooling the body.

This shows the immense importance of regulating the temperature of the atmosphere surrounding the bodies of animals, as all the heat of the body, as well as its growth, comes from the food.

ANIMAL HEAT.—It was formerly supposed by physiologists that animal heat was produced by the oxidation or combustion of the carbon of the food in the lungs, by means of the oxygen inhaled. But later investigations explain these phenomena in a different manner. Dr. Armsby, in his late work, explains this later theory concisely, thus:

"The distribution of oxygen through the body is accomplished by means of the circulation. Each little corpuscle carries its load of oxygen from the lungs through the heart and arteries into the capillaries. There the substances formed in the minute cells of the tissue by the decomposition of their contents under the influence of the vital force, diffuse into the blood, and here they meet the oxygen contained in the corpuscles, and, uniting with it, are burned, producing *animal heat.* Innumerable intermediate products are formed in this process, but the final result is in all cases the same. All the non-nitrogenous substances yield carbonic acid and water; the nitrogenous ones the same substances, and in addition *urea,* the characteristic ingredient in urine. Urea is a crystallizable body of comparatively simple composition, which together with small amounts of other substances, contains all the nitrogen and part of the carbon and hydrogen of the albuminoids, from which it is derived. In the urine of herbivorous animals it is, in part, replaced by *hippuric acid.* All these oxydations take place in the cells and capillaries of the body, and it is there, consequently, and not in the lungs, that animal heat is produced."

This latter theory, which seems the more philosophical, does not change any of the practical conclusions heretofore drawn in reference to the expenditure of food in the production of animal heat. It therefore does not introduce any practical new philosophy into the problem of feeding and growing animals.

Urinary Organs.—These organs—very important in the animal economy—are charged with eliminating from the blood with the surplus water, the excrementitious nitrogenous products resulting from the exercise of the vital functions.

*The kidneys,* the essential organs of urinary secretion, are two glandular organs, situated in the abdominal cavity, one on each side of the spinal column. The right kidney comes forward beneath the two last ribs, whilst the left only reaches the 18th rib. The right kidney is slightly the largest. The urinary secretion is supposed to be simply a filtration of these elements contained in the blood through the tissue of the kidneys.

*The ureters* are membranous canals, having about the diameter of a pipe-stem, which convey the urine from the kidneys to the bladder.

*The bladder* is a membranous, ovoid reservoir, located in the pelvic cavity, and occupying a space according to the quantity of urine it contains. The bladder serves a most useful purpose in retaining the urine to be voided at convenient periods.

*The urethra* is common to the urinary and generative organs.

## Excretions.

The decompositions and oxidations constantly going on in the body charge the blood with carbonic acid, urea and some other nitrogenous products. These must be excreted from the body or injury—even poisoning—would soon result.

We have seen how the blood is relieved of this excrementitious matter by filtering through the tissue of the kidneys and thence passing to the bladder. There has been various theories as to the *excretion of nitrogen*—whether the decomposed albuminoid matter in the body is all excreted with the urine and fæces, or whether some material portion of it is excreted from the lungs and skin. Boussingault, Regnault and Reiset all held the opinion that nitrogen, in a gaseous form, is excreted from the lungs and skin. This opinion was quite general until the experiments of Karl Voit appeared to furnish reasonable proof that urine and the solid dung contained all the nitrogenous matters excreted from the body. And later experiments also confirm Voit's conclusions. The present state of the evidence seems to establish the fact that all the nitrogen of the food, except what is appropriated to an increase of body, or the production of milk, is recovered in the visible excrements. This has been proved by experiments upon various animals, and is a matter of the highest importance in understanding a rational system of feeding.

Experiments have included oxen, milch cows, sheep, etc. We copy the following table from Dr. Armsby's Manual of Cattle-feeding. This includes oxen and milch cows at three different stations. The determination of the nitrogen in the excrement also includes that in the milk when the experiment relates to milch cows. The weight is given in grammes ($\frac{1}{28}$ of an ounce).

| PLACE. | Length of Feeding. | NITROGEN IN | | DIFFERENCE. | |
|---|---|---|---|---|---|
| | | Food. Grammes. | Excrements. Grammes. | Grammes. | Per cent. |
| Munich....... | 6 days | 241.5 | 238.53 | —2.97 | 1.2 |
| Möckern...... | 20 to 25 days | 120.5 | 122.0 | +1.5 | 1.2 |
| Möckern...... | 20 to 25 days | 121.0 | 117.5 | —3.5 | 2.9 |
| Möckern...... | 20 to 25 days | 117.4 | 113.1 | —4.3 | 3.6 |
| Möckern..... | 20 to 25 days | 114.5 | 120.0 | +5.5 | 4.8 |
| Möckern...... | 20 to 25 days | 114.8 | 108.4 | —6.4 | 5.6 |
| Möckern...... | 20 to 25 days | 121.4 | 113.2 | —8.2 | 6.7 |
| Hohenheim... | Nearly 6 weeks | 165.2 | 164.5 | —0.7 | 0.4 |
| Hohenheim... | Nearly 6 weeks | 169.1 | 169.8 | +0.7 | 0.4 |

Sheep were experimented with to determine this point at Weende Experiment Station, and, when allowance was made for the growth of the wool, the excrements fully accounted for all the nitrogen in the food.

Stohmann, at Halle Experiment Station, proved that the nitrogen of the food was all found in the visible excrements of the goat; and it may thus be considered as established that all the nitrogen of the food of our domestic animals is recovered in the excrements, together with the increase in the weight of the body.

Respiratory Products.—With a view of further determining the correctness of the conclusions above stated, Grouven experimented upon the direct products of respiration to determine whether any ammonia may pass off through the lungs or skin, and found a mere infinitessimal quantity of this gas thus excreted; thus confirming the previous conclusion.

And experimenters propose to determine the *gain* or *loss* of *flesh in an animal* by comparing the whole amount of nitrogen in the food with the whole amount of nitrogen in the excrements. If the nitrogen in the excrements is less than in the food, then the animal is gaining in flesh, but if more in the excrements, then the animal is losing flesh.

*Carbon is excreted* from the body partly in the urinary excretions, but more through the lungs and skin.

*Hydrogen is excreted* partly in the urea but mostly in the form of water.

Excretion of Ash Constituents.—The ash or mineral matter of the food is excreted in the urine and in the solid dung. Liebig held that phosphoric acid was generally not found in the urine of herbivorous animals because this liquid is nearly always alkaline, and fodder generally contains much lime which unites with the phosphoric acid, forming phosphate of lime. Phosphate of lime being insoluble in alkaline fluids, and thus phosphoric acid is not likely to be found in the urine except when there is more than can unite with the lime. Bertram found that when magnesia takes the place of the lime, phosphoric acid appears in the urine, even when that is alkaline. When the food is rich in phosphoric acid and comparatively poor in lime, the ash of the urine will be found 20 to 40 per cent. of phosphoric acid; for instance, when the food is milk or when animals are fed upon rich grains. But when ruminants are fed exclusively upon coarse fodder containing much lime, very little phosphoric acid is found in the urine.

It will thus be seen that the excretion of phosphoric acid in the urine will depend upon the kind of food given. When not found in the urine it is excreted in the solid dung; but this usually occurs when food is given that is poor in this element and comparatively rich in lime—and therefore in all rich feeding the phosphoric acid is principally excreted in the urine.

Of *potash* and *soda* contained in the food some 95 per cent. is excreted in the urine, likewise 20 to 30 per cent. of the magnesia, and nearly all of the sulphuric acid and chlorine, but only a very little lime.

All the rest of the ash constituents that are not used in the body or in the production of milk, together with the silica, are excreted in the dung.

We have endeavored in the above to give a short and clear explanation of animal excretions. Careful attention to these physiological facts will enable the stock feeder to understand the manurial value of the different foods, and also the comparative value of the liquid and solid excretions.

## Value of Manure.

The economic feeding of farm stock requires a careful consideration of the value of their manure. In the chief countries of Europe where agriculture is most intelligently conducted, the value of the manure is one of the chief factors entering into the problem of cattle, sheep and swine husbandry. Whilst in this country, with our so lately virgin soil, the value of the manure has only recently been seriously considered. But the clearest foresight, even in the newly-settled West, is now studying this question of compensation for fertility removed by constant cropping; and there, the principal location of our present meat production, and soon to be also of our dairy productions, this problem must be considered on the same basis as it is in the meat-producing regions of Europe.

We have just seen that the nitrogen and mineral matter of the food are all recovered in the visible excrement, except what is stored up in the body of the animal as an increase of its weight. In general terms—the disposition of the food consumed by an animal is as follows: The indigestible part passes nearly unchanged through the body—a part is assimilated into the body to replace the natural waste of the system, but is itself afterward disorganized and ejected; the rest is converted into the body of the animal as an increase of its substance—that is, the undigested food and the aliment which has undergone conversion into flesh and other tissues, and subsequent disorganization, constitute the excrements or manure. The richer in nitrogen, phosphoric acid and potash the food is, the more valuable must be the manure. And it thus follows, that the actual money value of a food is not to be found merely in the amount of flesh which it makes, but also in the value of the manure produced from it.

As the richest food produces the richest manure, and as all the fertilizing elements of the food which are not required for replacing waste or producing growth in the animal are found in the manure, so that many English feeders seem quite indifferent as to the proper adjustment of the ration to the actual needs of the animal—satisfied that whatever is not returned in growth and laying on of fat is found in the manure heap—they often feed to steers 8 to 12 pounds of oil cakes when the animal cannot utilize more than 6 pounds of this highly nitrogenous food. Although the manure is richer for this excess of nitrogenous food which passes in an undigested state, yet the economy of the practice is quite similar to that of feeding judiciously 100 pounds of oil cake, and at the same time spreading 100 pounds more over the manure pile for its enrichment. An economical consideration of meat and manure production would seem to require that the feeding ration should be, at least, approximately adjusted to the needs and capacity of the animal, and that the manure should be the excrementitious matters resulting from the most economical feeding.

Science should teach the proportion of the various ingredients of food required for the most economical production of milk, meat and wool, and it is the value of the manure produced by such feeding that we are considering.

The most valuable result in manure, under a rational system of feeding, will be produced at the point of the greatest proportional production from a given amount of food. A scanty ration which will be almost wholly used as the food of support, will seldom enter into a system of profitable feeding.

There have been different estimates of the value of the manure resulting from the consumption of a given quantity of food by farm animals. That most industrious experimenter, Sir J. B. Lawes, some years ago, laid down the figures of value in the following table:

Showing the estimated value of the manure obtained on the consumption of one gross ton (2,240 lbs.) of different articles of food; each supposed to be of good quality of its kind.

| Description of Food. | Estimated Money Value of the Manure from one gross ton of each Food. | | | Value of net ton, 2,000 lbs., in our Currency. |
|---|---|---|---|---|
| | £ | s. | d. | $ c. |
| 1. Decorticated cotton-seed cake | 6 | 10 | 0 | 27.67 |
| 2. Rape cake | 4 | 18 | 0 | 21.52 |
| 3. Linseed cake | 4 | 12 | 0 | 19.54 |
| 4. Maltdust (sprouts) | 4 | 5 | 0 | 18.22 |
| 5. Lentils | 3 | 17 | 0 | 16.44 |
| 6. Linseed | 3 | 13 | 0 | 15.65 |
| 7. Vetches | 3 | 13 | 6 | 15.76 |
| 8. Beans | 3 | 13 | 6 | 15.76 |
| 9. Peas | 3 | 2 | 6 | 13.35 |
| 10. Locust beans | 1 | 2 | 6 | 4.83 |
| 11. Oats | 1 | 14 | 6 | 7.40 |
| 12. Wheat | 1 | 13 | 0 | 7.08 |
| 13. Indian corn | 1 | 11 | 6 | 6.76 |
| 14. Malt | 1 | 11 | 6 | 6.71 |
| 15. Barley | 1 | 9 | 6 | 6.27 |
| 16. Clover hay | 2 | 5 | 0 | 9.65 |
| 17. Meadow hay | 1 | 10 | 0 | 6.43 |
| 18. Oat straw | 0 | 13 | 6 | 2.90 |
| 19. Wheat straw | 0 | 12 | 6 | 2.68 |
| 20. Barley straw | 0 | 10 | 6 | 2.26 |
| 21. Potatoes | 0 | 7 | 0 | 1.51 |
| 22. Mangolds | 0 | 5 | 0 | 1.08 |
| 23. Swedish turnips | 0 | 4 | 3 | .91 |
| 24. Common turnips | 0 | 4 | 0 | .86 |
| 25. Carrots | 0 | 4 | 0 | .86 |

Even English farmers, who have heretofore valued manure much higher than American farmers, have often mentioned Dr. Lawes' table as placing too high an estimate upon the manurial value of food, because, as they said, the same elements could be more cheaply purchased in commercial fertilizers. But it may be doubted if this is true of the present market value of the three elements, nitrogen, potash and phosphoric acid. We therefore give another table showing the amount of each of these elements in 1,000 pounds of the different foods, and then calculating the value of one ton at the prices mentioned at the head of the columns. These prices are 18 cents for nitrogen, 6 cents for potash and 10 cents for phosphoric acid. These are considerably lower than the prices estimated in commercial fertilizers. We give this here as a convenient table for reference :

## MANUFACTURED PRODUCTS AND REFUSE.

| SUBSTANCES. | Dry Matter. | Nitrogen. | Potash. | Phosphoric acid. | Value per ton. |
|---|---|---|---|---|---|
| | | 18 *cts.* | 6 *cts.* | 10 *cts.* | |
| | lbs. | lbs. | lbs. | lbs. | |
| Cotton-seed cake (decorticated) .......... | 900 | 62.0 | 21.0 | 29.5 | $30.74 |
| Cotton-seed cake (undecorticated)........ | 885 | 39.0 | 20.1 | 22.9 | 21.03 |
| Rape cake............................... | 900 | 48.0 | 13.2 | 24.6 | 23.78 |
| Linseed cake......................... | 880 | 45.0 | 14.7 | 19.6 | 21.88 |
| Palmnut cake ......................... | 930 | 25.0 | 5.5 | 12.2 | 12.10 |
| Linseed meal (extracted)................ | 903 | 59 8 | 17.0 | 25.6 | 28.68 |
| Poppy-seed cake ....................... | 885 | 47.8 | 22.0 | 40.0 | 27.84 |
| Hemp-seed cake......................... | 901 | 44.7 | 27.6 | 37.6 | 26.92 |
| Walnut cake ........................... | 863 | 52.2 | 17 7 | 23.4 | 25.59 |
| Sunflower-seed cake ................... | 897 | 55.9 | 26.8 | 35.4 | 30.42 |
| Malt sprouts .......................... | 905 | 38.0 | 19.5 | 17.2 | 19.46 |
| Wheat bran ......................... | 865 | 22.0 | 14.8 | 32.3 | 16.15 |
| Rye bran............................ | 875 | 23.2 | 19.3 | 34.2 | 16.43 |
| Rye flour ............................ | 858 | 16.8 | 6.5 | 8.5 | 8.52 |
| Millet meal........................... | 860 | 18.3 | 2.3 | 5.5 | 8.32 |
| Sugar-beet cake....................... | 308 | 18.0 | 3.6 | 1.0 | 3.45 |
| Buckwheat bran ....................... | 860 | 27.3 | 10.0 | 17.0 | 8.52 |
| **GRAINS AND SEEDS.** | | | | | |
| Beans ................................ | 855 | 41.0 | 12.0 | 11.6 | 18.52 |
| Peas ................................. | 857 | 36.0 | 9.8 | 8.8 | 15.87 |
| Rye .................................. | 851 | 17.6 | 5.4 | 8.2 | 8.62 |
| Oats ................................. | 870 | 20.6 | 4.5 | 6.2 | 10.27 |
| Wheat ................................ | 856 | 18.8 | 5.4 | 8.0 | 9.01 |
| Barley ............................... | 860 | 17.0 | 4.9 | 7.3 | 8.16 |
| Maize ................................ | 886 | 16.6 | 3.6 | 6.1 | 7.72 |
| Millet, with husk .................... | 870 | 23.2 | 4.7 | 9.1 | 10.73 |
| Millet, without husk ................. | 869 | 20.0 | 2.3 | 6.6 | 8.79 |
| Buckwheat ............................ | 860 | 14.4 | 2.1 | 4.4 | 6.29 |
| Sorghum .............................. | 860 | 16.0 | 4.2 | 8.1 | 7.88 |
| Flaxseed ............................. | 905 | 36.0 | 12.3 | 15.4 | 17.51 |
| Vetches .............................. | 864 | 44.0 | 6 3 | 7.9 | 18.17 |
| Hemp seed ............................ | 878 | 26.0 | 9.7 | 17.5 | 14.02 |
| Rape seed............................. | 890 | 31.0 | 8.8 | 16.4 | 15.49 |
| Poppy seed............................ | 853 | 28.0 | 7.1 | 16.4 | 14.21 |
| **HAY.** | | | | | |
| Meadow hay ........................... | 857 | 15.5 | 16 8 | 3.8 | 8.35 |
| Timothy .............................. | 856 | 15.5 | 17.2 | 6.8 | 9 00 |
| Dead ripe hay ........................ | 856 | 12.0 | 5.0 | 2.9 | 5.56 |
| Red clover, in blossom ............... | 840 | 19.7 | 19.5 | 5.6 | 10.55 |
| Red clover, ripe...................... | 840 | 15.0 | 12.2 | 3.5 | 7.56 |
| White clover.......................... | 840 | 23.8 | 10.6 | 8.5 | 11.53 |
| Lucern or alfalfa .................... | 840 | 23.0 | 15.2 | 5.1 | 11.00 |
| Green vetches......................... | 840 | 22.7 | 30.9 | 9.4 | 13.75 |
| Green oats ........................... | 855 | 14.7 | 24.1 | 5.1 | 9.20 |
| Green peas............................ | 833 | 22.8 | 29.6 | 9.7 | 13.69 |

GREEN FODDER.

| Substances. | Dry Matter. | Nitrogen. | Potash. | Phosphoric acid. | Value per ton. |
|---|---|---|---|---|---|
| | | 18 *cts.* | 6 *cts.* | 10 *cts.* | |
| | lbs. | lbs. | lbs. | lbs. | |
| Meadow grass, in blossom | 300 | 4.8 | 6.0 | 1.5 | $2.24 |
| Young grass | 200 | 5.6 | 11.6 | 2.2 | 2.01 |
| Timothy | 300 | 5.4 | 6.1 | 2.3 | 1.94 |
| Oats, coming into head | 180 | 3.6 | 7.1 | 1.7 | 1.94 |
| Oats, in blossom | 230 | 3.0 | 6.5 | 1.4 | 1.61 |
| Rye, in blossom | 300 | 5.3 | 6.3 | 2.4 | 2.51 |
| Hungarian millet | 320 | 5.3 | 8.6 | 1.3 | 2.54 |
| Red clover | 200 | 5.2 | 4.6 | 1.3 | 2.27 |
| White clover | 190 | 5 0 | 2.4 | 2.0 | 2.15 |
| Swedish clover | 185 | 5.2 | 3.5 | 1.0 | 2.18 |
| Lucern—alfalfa | 247 | 7.0 | 4.5 | 1.5 | 2.94 |
| Green vetches | 180 | 4.9 | 6.6 | 2.0 | 2.35 |
| Green peas | 185 | 5.1 | 5.6 | 1.8 | 2.34 |
| Green rape | 150 | 4.6 | 4.4 | 1.2 | 2.03 |

STRAWS AND ROOTS.

| | | | | | |
|---|---|---|---|---|---|
| Bean straw | 840 | 10.0 | 25.9 | 4.1 | 7.52 |
| Wheat straw | 857 | 4.8 | 5.8 | 2.6 | 2.94 |
| Barley straw | 850 | 5.0 | 9.7 | 2.0 | 3.36 |
| Oat straw | 830 | 5 0 | 10.4 | 2.5 | 3 54 |
| Potatoes | 250 | 3.4 | 5.6 | 1.8 | 2.55 |
| Mangolds | 115 | 1.9 | 3.9 | 0.7 | 1.29 |
| Swedes | 107 | 2.4 | 2.0 | 0.6 | 1.22 |
| Carrots | 142 | 1.6 | 3.2 | 1.0 | 1.16 |
| Turnips | 83 | 1.8 | 2.9 | 0.6 | 1.11 |
| Corn Stalks | 850 | 8 0 | 33.2 | 7.6 | 4.19 |

The foregoing table of different fodders and their value as manure, after passing through the stomachs of animals, will present, at a glance, the importance of carefully husbanding the manure made upon the farm. It shows that when the three important elements in farm manure are estimated at even lower prices than is given for commercial fertilizers, the value of the manure from one ton of any given food is greater than the estimate made by Dr. Lawes, and which has been considered by English farmers as too high. This estimate will only hold good when the manure, liquid and solid, is completely saved. And we do not give this table as fixing the absolute value of the manure from these feeding stuffs, as the quality of foods differs under varying circumstances; but we do believe that these values are quite as reliable as those given for commercial fertilizers. We shall have frequent occasion to refer to this table.

# CHAPTER IV.

## STOCK BARNS.

ONE of the most important questions relating to a system of economical meat, milk and wool production is that of the best construction of barns for the various kinds of farm animals. Even in the comparatively mild climate of England, the best feeders have found it a great economy to provide a warm shelter in winter Many experiments have been there tried upon cattle and sheep. But sheep are usually supposed to be the best provided by Nature with protection against cold; yet Mr. Nesbit relates a case, coming under his observation, where a farmer in Dorsetshire placed 30 sheep under a warm shed, and a like number of sheep, of the same weight and condition, were fed in the open field, without shelter of any kind. Each lot was fed with turnips, *ad libitum,* and coarse fodder. This continued through the cold season, and the result proved that those without shelter gained one pound per head each week, whilst those under shelter, although they ate less food, increased three pounds per head per week.

It must be admitted that the large amount of water in turnips would cause this diet to show most unfavorably in the open air, giving a greater contrast than a diet of dry food. But that most experienced cattle and sheep feeder, Mechi, has given very strong testimony in favor of shelter for all farm animals. In the case of the cow, all dairymen have noted the immediate effect of cold upon the secretion of milk. A sudden change to a lower temperature, or a rain-storm, will often reduce the yield of milk 25 to 40 per cent. in a few days. If we had as complete a test in the case of fattening cattle, we should probably find the difference in gain quite as great. Mr. Charles Eaton, who managed a large number of cattle on the great Alexander farm, in Champaign County, Ill., one cold winter, found that all the corn which steers could eat (about 40 lbs. per day) in the open air, only sufficed to keep them from losing weight.

While in some of the feeding districts in the West, land and corn are sometimes so cheap that many good farmers think they can better afford the corn than the shelter ; but this period will soon end. As land becomes more valuable they will find it quite too unremunerative to expend a large amount of corn in keeping cattle, with very little gain in weight, during the winter season. It is not wholly the loss of food that should be considered, but the postponement of ripe market condition, and the fact that when cattle are at a stand-still they are taking on an unthrifty habit, which prevents them, for a time, from rapid gain on the best grass in spring. And there can be no doubt that, when the exact saving by warm shelter shall be determined by an accurate comparison between out-door and in-door winter-feeding, it will show a large economy in favor of building the best cattle-barns and feeding in a uniform temperature.

The few comparative tests that have been made in the West between open air and barn-feeding, which have seemed to show very little gain from the warm temperature of the barn, have ignored the effect of restraint upon wild animals. The animals used for these tests had never been handled or subjected to restraint until placed in stable. This confinement and sudden change of habit produced such nervous irritation as to nearly balance the beneficial effect of a warmer temperature. A convincing test must take animals handled from calfhood and used to the restraint of a stable in winter. Such animals, compared with animals reared and constantly fed in the open air, will show a difference in amount of food and gain that all intelligent feeders will be inclined to heed.

Barns may be built on a large scale, and fully equipped for the best system of feeding, at ten to twenty dollars per head of cattle they will accommodate. Now, let us suppose that a steer, weighing 1,000 lbs. on the first day of November, will gain 150 to 200 lbs. more, on the same food, in a warm stable, than in the open air, during the five cold months of winter, and this 200 lbs. gain will render the whole carcass worth from ¾ to 1 cent more per pound, and the whole gain could not be less than $12 to $15 per head, which would, in many cases, pay the whole cost of the barn. A strict comparison between summer and winter feeding, in the open air, will show a greater difference than this, and when we perfect the system of barn feeding, we shall be able to make as great progress in winter as in summer feeding. We know there are other considerations besides the cost of barns to be taken into account, and the chief of these is the labor required to feed animals in barn over those in the field, but we shall consider all these and be able to show that there is a large balance in favor of the best system of barn feeding.

## Form of Barn.

Economy and convenience of space—that form and arrangement requiring the least amount of labor to feed and care for a given number of animals—durability as well as economy in the cost of the structure, are the most important requisites in barn building. The early forms of American barns were devised when everything was done by hand, and they were built low to accommodate hand-pitching; were filled with interior beams and posts, which much obstructed the pitching in and out of hay and grain, and, being so low, were expensive in so much roof and foundation for so small an amount of cubic feet of space. A large barn was built in the form of a long paralellogram, with 16-feet outside posts, so that, when a stable was made in the first story, it left only a low scaffold over it for the storage of fodder; and, when the stable was in the basement, the 16-feet posts furnished a small amount of room for the storage of hay, considering the size of the barn. A drive-way through such a long barn leaves but narrow space on each side, and it takes up too large a proportion of the room. Later thought has substituted 24-feet posts instead of 16 feet, and this nearly doubles the capacity for storage, with slight addition to the cost of the barn. A mow 24 feet high will settle so much solider than a 16-feet mow, that its capacity is fully 80 per cent. greater, whilst the cost of the barn is only the cost of 8 feet longer posts and boards—a mere trifle. And as the present system of handling hay and grain with the horse-fork enables the farmer to fill a mow of any height with equal facility, all barns should be built with 24 or more feet posts. The writer finds 28-feet posts none too high for convenience, and furnishing so much extra room for a great variety of uses, that he is led to strongly recommend the building of high barns. A man who builds such a barn will be likely to do his work more thoroughly, his roof and foundation costing no more than for a low barn.

The *square* is a convenient and comparatively economical form of barn; but this form cannot be used for one of much size, because of the difficulty and expense in getting long timber, and the difficulty of sustaining the roof, without interior posts and beams, when the side is over 50 feet. The use of the horse-fork is much more convenient where the interior space is unobstructed by posts or beams above the floor-beams, for, in that case, the grapple on the traverse end of the pitching rope may be moved in any direction, and the forkful dropped at any spot desired. This arrangement requires very little mowing away, and thus saves a large amount of labor. The high barn gives plenty of room for the swing of the fork, and all the railway tracks, contrived to run over purlines, become useless.

### The Octagon.

In doing work in barn, concentration is an important point. The shorter the lines of travel, the easier the work is done; therefore, barns that are square or circular have shorter lines of travel than the oblong form, and the circular or octagonal form can be built with comparatively short timber, besides affording every facility for a self-supporting roof, or a roof resting simply upon the plates or outside rim—and, thus constructed, the interior space of the barn is entirely free of posts and beams, except the floor-beams, upon which to rest the scaffold to utilize the space over the floor. And a barn of this shape, with a floor through the center, has every line of travel equidistant from the center, and one floor accommodates all parts of the barn alike. Besides, the octagonal form admits of building any sized barn, up to 90 feet diameter, without any timber more than 39 feet long. A 90-foot octagon has a circumference or outside wall of 298⅛ feet, and each side is only 37 feet 3½ inches long. This barn will comfortably stable 114 head of cattle in its basement, and contains, with 28-feet posts (besides a 14-feet floor through the second story) 160,860 cubic feet of space for storing crops. It would store 250 tons of hay, and 5,000 bushels of grain in the straw. It would require an oblong barn 40 by 180 feet long, with same height of posts, to have the same capacity for stabling cattle and room for crops. This long barn would have a circumference of 440 feet, or an outside wall

142 feet longer than the octagon. This 142 feet of wall, running through both stories, would require 3,550 square feet of siding above the basement, and about 1,300 cubic feet of basement wall more than the octagon. The latter form would also save a large amount of interior timbers.

If it is desired to build a larger circular barn than 90 feet diameter, it would be advisable to build a duo-decagon (12-sided) or a sex-decagon (16-sided) barn. These forms are just as easily constructed, and, where the diameter is large, dividing the circumference into 16 sides makes the timber for each side short, and it only requires 16 outside posts—one at each corner. If the diameter is 110 feet, each side will be about 22 feet on a sixteen-sided barn. It is sufficient to extend girths from corner-post to corner-post, and side it up and down. The basement of this latter barn would accommodate 150 head of large cattle, and contain 242,000 cubic feet of space in the second story. This would hold 500 tons of hay, or 300 tons of hay and 8,000 bushels of grain in the straw. This form of barn has a remarkable capacity for its circumference. It has nearly 100 feet less outside wall than the barn 40 by 180 feet long, yet has a capacity for storage nearly double; but this latter barn would take more lumber to build than the large sixteen-sided barn. The circle incloses the largest area, for its circumference or outside wall, of any form; but the true circle is too expensive to build, and the octagon approaches the circle in economy of outside wall, and is as easily built as the square. The octagonal or 16-sided form is much less affected by the wind, and may be built higher than the long barn in windy situations.

This matter of barn building is of so much importance to the improved system of stock feeding, that we shall discuss it as suited to small and large operations, and propose to show how 1,000 or more head may be fed economically and safely under one roof.

We give in fig. 5 the elevation of an octagonal barn of 80 feet diameter, built by the author in 1875, inclosing 5,304 square feet, having posts 28 feet long—with a capacity to the top plates, in the story above the basement, of 148,514 cubic feet. This octagon has an outside wall of 265⅓ feet and was built to replace four barns destroyed, having an aggregate outside wall of 716 feet, and yet this barn has about 25 per cent. greater capacity than all four barns lost, showing the great economy of this form in expense of wall and siding.

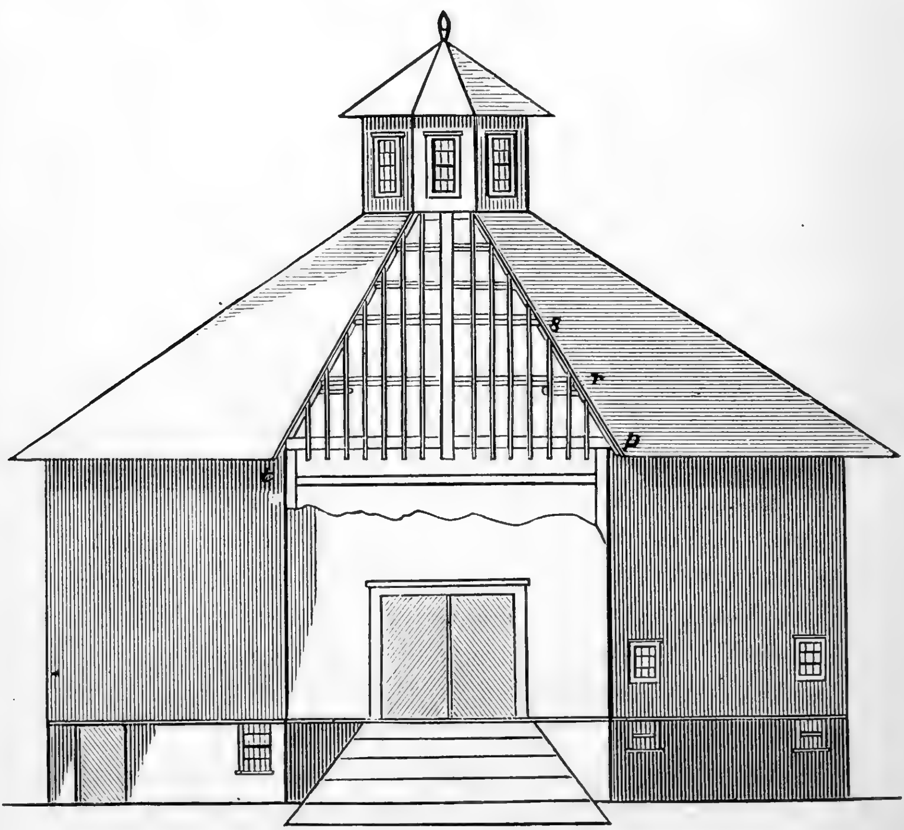



*Fig.* 5.—OCTAGON BARN (NORTH ELEVATION).

EXPLANATION.—*p*, plate ; *r*, tie-rod and bridging between rafters ; *s*, purlin rim ; *t*, hip rafters.

If we compare it with an oblong barn 50 × 108 feet, the latter will inclose the same number of square feet, and have the same capacity at the same height, but requires 51 feet more outside wall.

It is easy to make the roof of the octagon self-supporting, as it is in the form of a truss. The plates perform the office of the bottom chord, and the hip rafters of the top chord, in a truss. The strain on the plates is an endwise

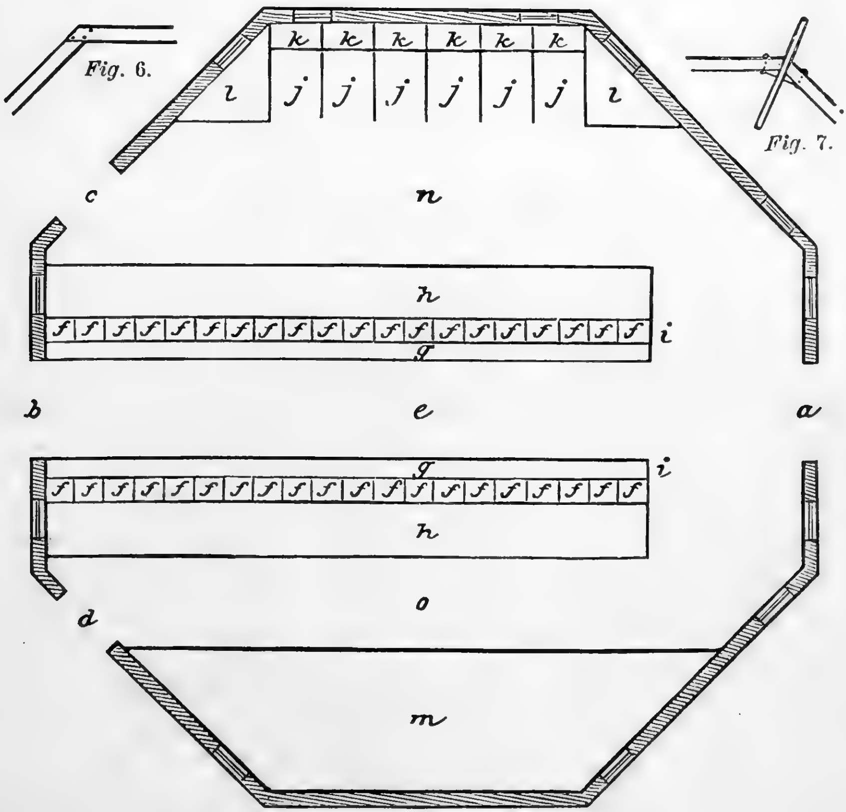



*Fig.* 6.

*Fig.* 7.

*Fig.* 8.—OCTAGON BASEMENT (NORTH SIDE).

EXPLANATION.—*a b c d*, doors of basement; *e*, drive-way through the center; *n c*, south drive-way for cart to carry out manure; *o d*, north drive-way; *m*, spare room for root cellar or any other purpose; *l l*, lying-in stall for cows: *k k k k k k*, horse mangers; *j j j j j j*, horse stalls; *f f*, forty cow stalls or stanchions—there should be no separation between these spaces and *h*; *g g*, cow mangers; *h h*, an open grated platform for cows to stand on, the manure falling through upon a concrete floor below.

pull, the bottom of the roof cannot spread, and the rafters being properly bridged from the middle to the top, cannot crush, and the whole must remain *rigidly* in place. Its external form being that of an octagonal cone, each side bears equally upon every other side, and it has great strength without any cross-ties or beams, requiring no more material or labor than the ordinary roof. The plates are halved together at the corners, and the lips bolted together with four half-inch iron bolts (see fig. 6); a brace 8 × 8 inches is fitted across the inside angle of the plate corner, with a three-fourths-inch iron bolt through each toe of the brace and through the plate, with an iron strap along the face of the brace, taking each bolt, the nut turning down upon this iron strap (see fig. 7). Now the hip rafter (*t*), 6 × 12 inches, is cut into the corner of the plate, with a shoulder striking this cross brace, the hip rafter being bolted (with three-fourths-inch iron bolt) through the plate into the corner post (see fig. 6). Thus the plate corner is made as strong as any other part of the stick. There is a purlin rim (see fig. 5, *s*) of 8 × 10 inch timber, put together like the plate-rim, bolted or fastened with an iron stirrup under the middle of the hip rafters, which plate-rim supports the intermediate rafters. The hips may be tied to the intermediate rafters by long rods half way between the plate and the purlin, if deemed necessary from the size of the roof (*r*). The north section of the roof (fig. 5) is represented as uncovered, showing the plate (*p*), purlin (*s*), tie-rod (*r*) and bridging between plate and purlin and the two sets of bridging above purlin, etc. It will be noted that, in this form of roof, the roof-boards act as a powerful tie to hold it all together, each nail holding to the extent of its strength, thus supplementing the strength of the plate-rim or bottom chord.

It will be seen by fig. 5 that there is a drive-way, fifteen feet wide, through the center of the principal story from north to south. There is a line of "big beams" on either side of this drive-way, 13 feet high, across which a scaffold may be thrown to enable us to occupy the high space over this floor. The posts being 28 feet high and roof rising 22⅔ feet, the cupola floor is 50 feet above the drive-way floor below. The space above these "big beams" is quite clear of any obstruction, and a horse pitching-fork may be run at pleasure to any part. The bay for hay on the left side of this floor is 80 feet long, and has an area of 2,051 square feet, and is capable of holding, when filled to the roof and over the floor, 200 tons of hay. This bay, extending along the floor 80 feet, may be divided into as many parts as required for different qualities of hay, and each part be quite convenient for filling and taking out.

On the right-hand side of the floor is a scaffold, eight feet high, having the same area (2,051 square feet) for carriages, farm tools and machines below, and above the scaffold is—a height of 18⅓ feet to top of the plates—a large space for grain, affording ample room for the separate storage of each kind to the aggregate of 3,000 bushels or more. It will be seen that the large space in this barn is all reached and filled from one floor, saving much labor in changing from one floor to another.

## The Basement.

Fig. 8 shows the basement as we use it, yet there are many different ways in which it may be divided for stock and other purposes. We build the basement wall of concrete. It is not only the warmest and best wall for basement stables, but is much cheaper than the stone wall laid by a mason, the concrete requiring no skilled labor, only such skill as is required to mix mortar and tend a mason.

The drive-way through the basement is from west to east, being the feeding floor between two rows of cattle, with heads turned toward the floor. The floor is fourteen and a half feet wide, out of which come two rows of mangers two and a half feet wide, leaving a space of ten feet for driving a wagon through or running a car carrying food for the cattle. There are places for twenty cows or other cattle on each side, leaving a space of sixteen feet at the west end to drive a cart around behind the cattle on either side to carry away the manure and pass out at a side stable door, eight feet wide. The horse stalls are arranged on the south side, but may be placed on either of several other sides, or on all. By placing tails to wall and heads on an inner circle, drawn twelve feet from the wall, with feed-box room three feet wide for each horse, with ample room at the rear, sixteen horse stalls may be arranged on southwest, south and southeast sides. But for 200-acre farms generally, no more than forty head of cattle and six horses would be kept, and for such our ground plan would be most convenient, because it furnishes easy access with a cart, both for supplying fodder and carrying away the manure. On our plan, we have much space on the north, northwest and northeast sides, which may be used for various purposes, such as root cellar, sheep-fold for fifty sheep, or for stowing away tools, working-wagons and implements.

It will be seen that the basement is not sunk in the earth, but on the north and south sides it is graded up to the floor of the second story, so as to make an easy drive-way into the barn. The base line, as represented on the drawing, is four feet below the general level of the land on the north side, but there is an open channel of water, into which every part is drained, on the south side. The earth on the east and west sides is scraped up on the north and south sides to grade up the drive-ways into second story. This basement is lighted by six windows of twenty lights, $8 \times 12$ glass, and six of ten lights each.

## Basement Laid out on a Circle.

We give, in fig. 9, a representation of an octagonal basement, laid out, in the interior, on a circle, containing fifty-two stalls for cows or cattle, with heads towards the interior. For a fancy breeding establishment these stalls might be elevated one or more feet, showing all the animals at one view, and with the feeding car on track (*c*), and the car for running out manure on track (*a*), the labor would be

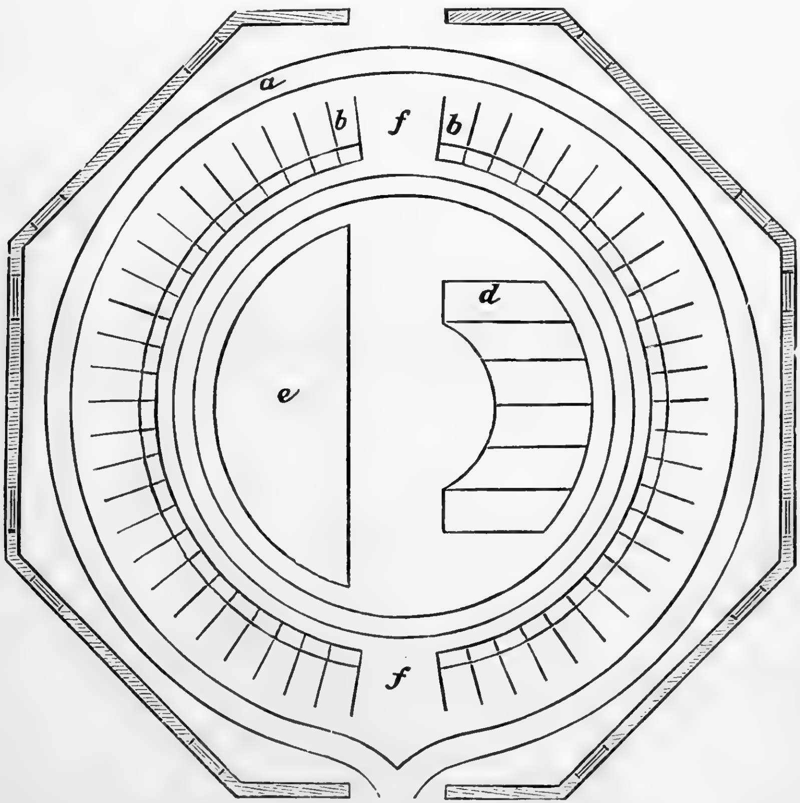



*Fig.* 9.—OCTAGON BASEMENT.

EXPLANATION.—This represents an 80-foot octagon basement laid out on a circle; *b b* represents 52 cow or cattle stalls, heads toward inner circle; *c* represents a circular track for a feeding car to run around in front of the cows or cattle; *a*, circular track for a manure car to carry off offal; *d* represents one method of placing horse stalls convenient to drive-way; *e*, vacant space to be used for any purpose; *f f*, drive-way.

made convenient. This leaves a 52-foot interior circle which may be put to any purpose required. The track (*c*) takes out six feet, still leaving a circle of forty-six feet diameter. The horse stalls (*d*) are laid out partly on a circle, but are placed at right angles with the drive-way. One strong point to be made in favor of the circular plan is, that by means of the cars running across the drive-way, food dropped through the floor above upon the car can be run to every animal in the basement. The horse stalls would also be very convenient of access from the drive-way. One side of the drive-way might be fitted up with box stalls for brood mares or colts, or calf-pens. We give this plan merely as suggestive, and not as the best arrangement. Every one may divide the space as he sees fit. Of course, it will be more expensive to fit up on a circle, but to one who fancied it, a few dollars would be, perhaps, no objection. This plan has been adopted, since we devised it, by some fancy breeders, as affording the best arrangement for showing many animals and for convenient display at sales.

The plan of basement given in fig. 8 would, generally, be preferred, and if wanted for a large dairy barn there is room for two parallel floors with two rows of cows to each floor, giving one long and one short row of cows to each floor, affording ample room to drive a cart behind each row of cows to take away the manure. One drive-way would answer for both inside rows of cows; also leaving room for a narrow calf-pen on the outside wall behind each outside row of cows. This would be occupying the basement to its full capacity, but, usually, on a 250-acre farm, which this size of octagon would accommodate, not more than fifty head of cattle and horses are kept, and our first plan of basement would be the most convenient, leaving ample space for a great variety of uses.

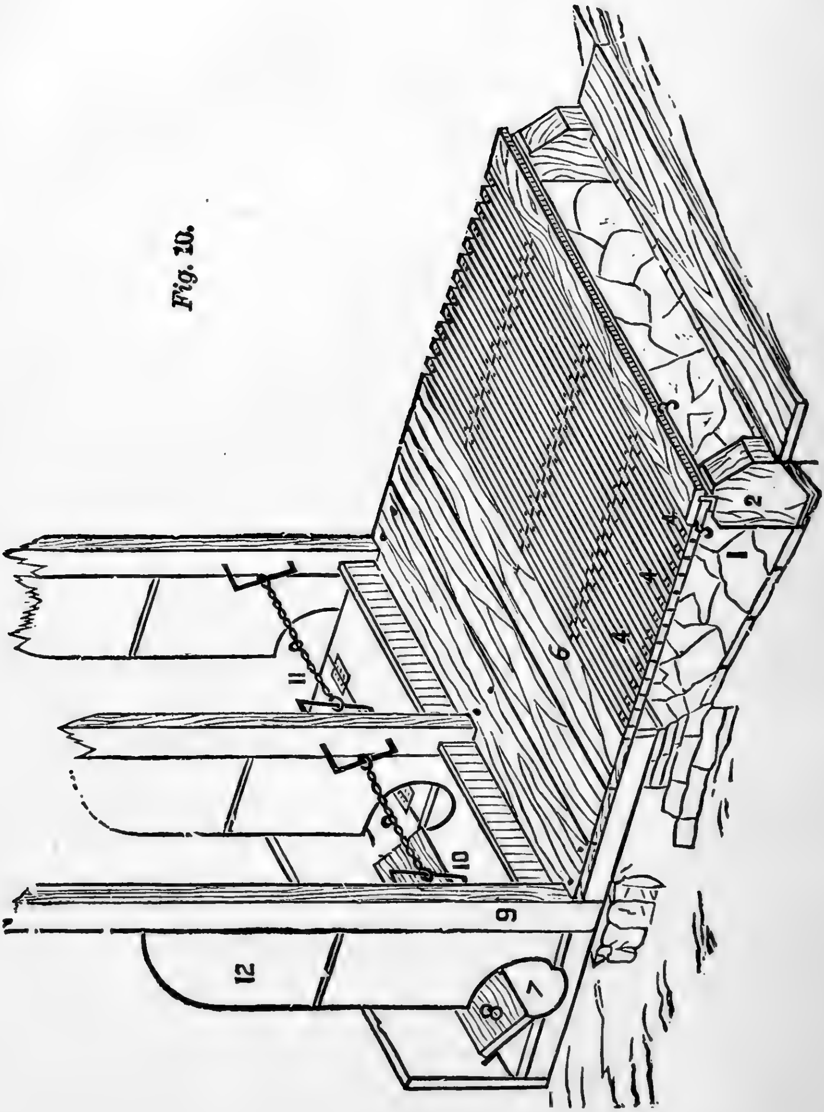
## SELF-CLEANING STABLE.

In the basement, fig. 8, the platforms *n n*, and the stalls marked *f f*, are made self-cleaning; and fig. 10 shows how this is accomplished.

All dairymen and cattle feeders have felt the necessity of some device that should lessen the daily labor of cleaning the stable, and especially that should succeed in really keeping the cow clean—a most necessary requisite to clean and wholesome milk. There have been various plans of using a gutter behind cows or other cattle; but in all of them the cow was liable to get soiled upon the flank, and the tail could fall into the gutter and render the milking most offensive. If, therefore, a platform can be made which requires nothing to aid it in keeping the cow clean, provides for her comfort, is self-acting, durable and cheap, there would seem to be little left to accomplish in this matter.

The *platform* (fig. 10), invented by the author, does all this, and has been in use in his stable for the last ten years. It occupies both platforms in the octagonal basement, represented by fig. 8. The platform consists partly of wood and partly of iron. The wooden part is situated next the manger (marked 6), 3 feet 6 inches wide, and raised 12 inches. Behind this an iron grating, resting on an angle-iron sill (marked 3), supported on stone posts at the back side and on the wooden platform in front, 4 feet wide. The gutter under this iron platform is 4 feet wide and 18 inches deep and concreted water tight, with a space of 10 inches under the angle-iron sill, through which the manure is removed. This gutter practically holds the droppings of cows for three weeks, except when muck is used to deodorize it, when it is filled in two weeks. The depth of this gutter is quite sufficient to hold all the liquid.

*Fig. 10.*



The construction of the grating will easily be understood. Iron joists, ½ by 2 inches (marked 5), set edgewise, reaching from angle-iron sill to wooden platform, placed 18½ inches apart. Across these, at right angles, are laid wrought-iron bars (marked 4), ⅜ by 1½ inches, fastened to the joists by quarter-inch round iron staples striding the joists and coming up through the flat bar and riveted. These flat bars, on which the cattle stand, are placed 1⅝ inches apart, twelve of them in number for this width of platform, with a plank some 10 inches wide covering the angle-iron.

It will be seen that the cow must stand with the fore-feet upon the plank platform, and hind-feet upon the flat iron bars of the grating. The droppings fall directly through the openings into the gutter below when the manure is thin; and in winter, when dry food is given, the droppings are pressed through by the movements of the hind-feet. The cow stands across the bars, and always has two bars to stand upon, some large cattle's feet reaching the third bar. Cows that have stood upon this platform for nine years have always remained clean, healthy and comfortable. The circulation of air under the platform appears to prevent diseases of the feet.

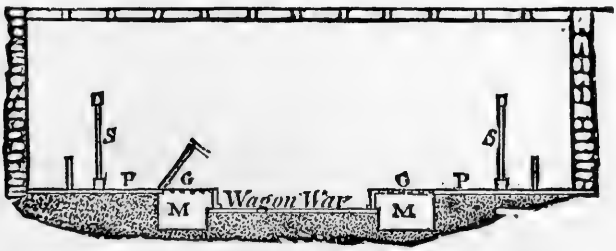



*Fig.* 11.

This platform, above described, was the first one put into use. It was stationary. The next improvement was to put it on hinges, doing away with the stone posts, and substituting short angle-iron posts instead, as represented in figs. 11 and 12. This form was put into the stables of Burrill & Whitman, at Little Falls, N. Y. Fig. 12 should represent the hind-feet of the cow as standing near the middle of the grating, instead of the edge, as the tread of the hind-feet is required to press the solid droppings through in winter. Fig. 11 explains itself, except that it may be well to mention that the hinges are made by drilling a hole near the ends of the iron joists, and then using a wood-screw eye-bolt to attach the grating to the wooden platform. These gratings are made in sections for two or three cows each. One man can turn them up on the hinges, leaving the manure in the pit below uncovered, and easily shoveled into a wagon to be taken to the field. These sections are placed end to end, and the bars are level and continuous, so that they may be brushed off with a stiff broom as fast as a man can walk.

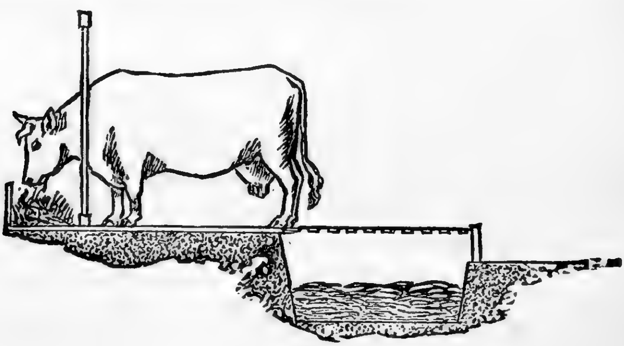


*Fig.* 12.

The next style of this grating is represented by fig. 13, which explains its own construction. The change consists in omitting the legs and angle-iron sill in the rear, and carrying up the wall, on the rear side of the gutter, to a level with the under side of the grating, and allowing the back side of the grating to rest upon a thin timber on the top of the wall.

This last style of grating has been further improved by removing the plank from the back side, leaving the top of the grate level, and the stable floor even with it. The gutter is now water-tight to the top, and the grating lighter and cheaper, more convenient and equally durable. In its present form the grate has been very successful in a large number of stables.

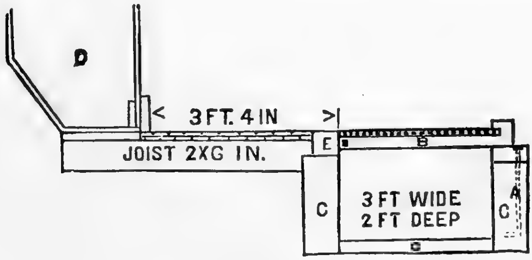



*Fig.* 13.

EXPLANATION.—*A*, iron anchor; *B*, grated floor; *C*, concrete; *D*, manger; *E*, sill.

It will be seen that this plan of stable completely saves all the liquid and solid manure—a matter of the highest importance. In handling this manure it is carried directly from the stable to the field, and thus prevents any loss by leaching and evaporation in yard. The writer has found, by practical figures, that the saving in manure, by this gutter-system, and direct application to the field, amounts to five dollars per cow per year.

In order to still further reduce the labor of handling the manure, and to make a more perfect distribution of it over the field, the writer employs the manure spreader; and the labor is now so remarkably economized, that the only manual labor relating to the manure, now performed, consists in shoveling it from the gutters into the manure-spreader—no cleaning of stable; no handling of manure, except in loading it; and the distribution is more complete than can be done by hand-spreading.

This iron grating must be credited also with: 1st, preventing all rotting of the wood-work of the stables, as all urine passes at once through the bars, and cannot wet the joists and sills of the barn. 2d. Its durability must be very great, or that of a dozen wooden stables. 3d. Its cost is very moderate—the latter form costing only $6 per cow.

Dry earth or muck should be kept in the basement near this platform, and a little thrown each day on the grating, falling through upon the manure, and thus preventing all smell and fixing the ammonia, rendering manure and dry muck equally valuable. Any dry earth, such as cleaning of ditches or headlands, will answer every purpose, when dry and pulverized. This will double the amount of manure, and all be more valuable than manure kept in the common way.

Fig. 10 also illustrates a new mode of fastening and watering cattle in stable, which are explained on pages 514–516 in Appendix to the Third Edition.

## The Octagon Adapted to all Sized Farms.

A little examination of this form of barn will not only show its adaptation to large farms, but to farms of all sizes—from the smallest to the largest. A farmer has but to calculate how much room he wants for cattle, how much for horses, how much for sheep, how much for hay and grain, how much for carriages, wagons, tools, or any other purpose, and he can inclose just the number of square feet needed, and with the shortest outside wall. He may be liberal in his allowance of room, for it costs less, in proportion, as the size is increased. Suppose he requires for a fifty-acre farm 2,090 square feet of room; this would require a fifty-foot octagon or a 40 × 52 rectangle. Now he would require timber forty feet long for the latter, while he could build the octagon with timber for the sills and plates only twenty-two feet long, and this would be the longest timber, except posts, which would be better twenty-four or twenty-five feet long. Each side would be only 20⅝ feet, and the wall for the basement 165 feet long, whilst the other would be 184 feet long, saving 19 feet of wall and siding by the octagon, requiring but eight corner posts, and no intermediates, as the girths would be less than twenty feet long. He would require no interior posts or beams, except those for scaffolds. All the ordinary purlin posts and beams would be saved, and the labor on them. It is easy, also, to see that a few feet added to each side would furnish room for another fifty acres, and so on to any size desired. This form of building, properly understood, would lead farmers to abandon the building of a separate barn for each specific purpose, and to provide for all their necessities under one roof. If several barns are placed so as to be convenient, the danger, in case of a fire, is about the same as in one barn, for all would burn in either case.

## A Fifty-foot Octagon.

To instance a size of barn, ample for a fertile farm of 50 acres, to accommodate crops, tools and stock, we select the octagon of 50 feet diameter. This requires a basement 8 feet in the clear, in which all the stock on the farm will be kept; with a drive-way through the basement 12 feet wide, fifteen cows or cattle could stand on each side with their heads to the drive-way or feeding-floor, and, using 2 feet on each side of this floor for a manger, would leave a track for cart or wagon of 8 feet. Behind each row of cattle would be room for 4 horse stalls of good width; but as such a farm would not be likely to have use for more than 4 horse stalls, the space on the other side would be used for lying-in stalls for cows and calf-pens, etc. Here is abundance of room for all the stock 50 to 75 acres can keep, and everything is under one roof.

Let us now look at the main building above the basement. Posts are 24 feet long; and as many small farmers may wish to look at the cost of this barn in detail, we will give specifications of materials and cost, at the present low figures, which may be raised or lowered according to locality:

SCHEDULE.

| | *Feet.* |
|---|---|
| 8 sills, 8 × 10—22 feet | 1,176 |
| 4 cross-sills, 8 × 10—26 feet, spliced | 692 |
| 8 corner posts, 8 × 10—24 feet | 1,280 |
| 8 plates, 8 × 10, 22 feet | 1,176 |
| 4 floor beams, 8 × 10—26 feet, spliced | 692 |
| 4 door posts, 6 × 8—13 feet | 208 |
| 4 posts, under floor-beams, 8 × 10—13 feet | 346 |
| 2 scaffold beams, 8 × 19—26 feet, spliced (these go under one floor-beam, 8 feet above the floor) | 346 |
| 34 girths, 4 × 5—20 feet (5 tiers on six sides and 2 over each door | 1,132 |
| 2 girths, 4 × 8—20 feet, over doors | 106 |
| 8 hip-rafters, 5 × 10—34 feet | 1,134 |
| 8 middle rafters, 3 × 8—32 feet | 512 |
| 16 intermediate, 3 × 6—26 feet | 624 |
| 16 intermediate, 3 × 6—20 feet | 480 |
| 16 intermediate, 2 × 6—14 feet | 224 |
| 16 intermediate, 2 × 6—9 feet | 128 |
| 24 joists, 3 × 10—14 feet (lower floor) | 840 |
| 34 joists, 3 × 10—17 feet (lower floor) | 1,335 |
| 17 joists, 3 × 8—17 feet (scaffold) | 578 |
| Plank for barn floor, 12 × 50 feet (2-inch) | 1,200 |
| Floor under scaffold, 1½ inches | 1,125 |
| Floor under bay, 1 inch | 750 |
| Floor under scaffold, 1 inch | 750 |
| 44 braces, 4 ×6, 7 feet long | 616 |
| Roof boards | 3,100 |
| Total rough lumber | 20,551 |

Four thousand five hundred feet 6-inch, well-seasoned, dressed and matched pine, one-fourth added—5,650 feet—for siding and cornice.

SUMMARY OF COST.

| | |
|---|---|
| Wall, 1,487 cubic feet (concrete) 10c. per cubic foot | $147.70 |
| 20,551 feet coarse lumber, $8 | 164.40 |
| 5,550 feet pine siding, $17 | 96.00 |
| 500 lbs. nails, $3 | 15.00 |
| Sash and glass | 25.00 |
| Carpenter work and board | 275.00 |
| Painting two coats (oxide of iron and oil) | 25.00 |
| 23 thousand shingles | 75.00 |
| Total cost | $823.10 |

Let us now look at the capacity of this barn. The bay, including half of the scaffold over the floor, will store 50 tons of hay. The scaffold on the other side of the floor, having the same square feet as the bay, and a height of 15 feet to the top of the plate, will hold 1,000 bushels of grain in the straw, or a like bulk of other fodder.

The best place for the GRANARY in this barn, or any other, is over the main floor, at one end. Let some strong joists be laid across the floor-beams, and a matched floor, 14 feet long, and of the width of the floor to outside of beams, be laid on these joists. Fasten some standards on the outside of the floor-beams, two feet apart, reaching eight feet above this floor; side these up on the inside with matched pine. Now divide the space between these two sides into three parts, by erecting standards for two partitions, eight feet high. These partitions will be four feet apart, and, when sided up with matched stuff, will give three divisions or bins, which, being $4 \times 14 \times 8$ feet high, will hold 360 bushels each. If more bins are wanted, these can be divided in the middle, making six bins, $4 \times 7 \times 8$ feet high, holding 180 bushels each. These bins should all be floored over, with lids on top, through which the grain is emptied. Now make a draw in the bottom of each bin, so that the grain may be drawn down through a cloth spout into bags. The grain is easily elevated into these bins by horses, with the ordinary pitching rope and pulley; and the space occupied by this granary is not needed for other purposes. We have found this arrangement of grain bins to save much labor during the year. The space under the scaffold—735 square feet—will give room for buggies, tools, etc. The floor over it being made dust-tight, it will be as clean as any barn built for the same purpose. Let the small farmer scan closely this form and size of barn, and see if he can get more conveniences for as much money.

## Basement Walls for Stables.

The stable is, perhaps, the most important single feature about the barn, as upon the merits of this will largely depend the profits of feeding animals; and as more crops are grown for feeding animals than for feeding man, everything in the construction of a stable bearing upon the comfort and growth of animals should be carefully considered.

The season of greatest growth in our domesticated animals is when the temperature of the air is 60° and upwards. If, therefore, we would try to imitate Nature at its best, we must build our stables in which the winter temperature shall approximate 60°. This may be done by building our basement walls of material having very little conducting power. Double walls, having a space of dead air between them, effect this purpose the best; but as such walls are most expensive, we may adopt a concrete wall, which has an infinite number of minute air spaces, rendering it comparatively non-conducting. A thick stone wall, in which some stones reach across the wall, will be found covered with frost on the inside in winter, and often with moisture in summer. But the concrete wall is never penetrated with frost, and is never damp, when properly constructed. This wall has another important advantage besides its minimum of conducting power, rendering the stable cool in summer and warm in winter—it is the cheapest substantial wall where sand, gravel and rough stone, or sand and gravel, or sand and rough stone, are not too far off. It can be built in most parts of the country at 10 cents per cubic foot of wall. And as this wall does not require to be as thick as an ordinary stone wall, because a water-lime concrete is much firmer and stronger than quick-lime, as used by masons, for every stone is bedded in water-lime cement, which soon becomes as hard as stone. The writer has a wall 8½ feet high, under a large barn, which has stood the heaviest wind and a great pressure, although it is only 15 inches thick at bottom and 12 inches at top. This is heavy enough for any-sized octagon, because in this form one side braces against every other side. In a concrete wall under a very long barn it would be proper to have a short pier built against the inside every 50 feet to prevent a side swaying in a strong wind.

In building the concrete wall the service of a mason is quite unnecessary. You need only good, common laborers, one of whom is learned in mixing the materials in proper proportions. Anyone who is capable of tending a mason can mix the materials and superintend placing them in the boxes.

### Preparations for Laying Out the Wall.

If there is moisture to come to the wall, water-lime must be used, and it is well to carry two or three feet above the ground with concrete. The place should also be excavated one or two feet beyond the proposed wall, so as to leave an air-space on the outside, giving the wall a chance to dry and become hard. If, in any case, you go into the slate rock, which is always full of seams charged with moisture, you must not allow the concrete to be built against this rock, for the moisture in the rock coming into the thin mortar will cause the milk of lime to run out and leave an infinite number of fine pores through which water will run; but if no water is allowed to come to it while drying, it will be water and air-tight. It is also well to have a drain cut lower than the bottom of the wall, on the outside, to carry off any water that might otherwise come against it, which will render the basement dry.

### How to Lay Out an Octagonal Wall.

The shape of this wall may give some trouble to get it so exact as to receive the lower rim of timber or sills. It should come even with the outside of the sills. The plan we adopt is so simple and easily carried out that it is here given as a guide. The foreman in building this form of a barn will always have a working plan. Let him get the exact measure from the center to one corner. Now let him make a measure of this exact length, with a three-eighths hole at one end—that is, from the center of this three-eighths hole to the other end should be the exact length from the center of the octagon to one corner. Now, having found the center of your proposed space to be walled in, drive a stake here firmly into the ground, saw it off four inches high, bore, and drive a three-eighths pin into the top of this stake, and place the hole bored in one end of the measure on this pin. Now bring the opposite end where you wish the first corner, and drive a peg at the end of the measure to make the first corner. Then take the pattern your carpenter has made for the sill (and he should always have an exact pattern, so that he may make no mistake) and put the outside corner on the center of this first peg, letting one man hold it while the measure is swung round to the other end of this sill pattern; and when the ends of the measure and pattern are brought together you have the second corner, at which you will drive another peg. Now move your sill pattern to the second peg, and carry your measure to the other end for the third corner, and so on till you come around to the first peg driven. If the work is well done you cannot avoid placing all your corners equi-distant from the center and in accurate octagonal form.

## Constructing the Boxes for the Wall.

Having determined the place and excavated for the wall, construct the boxes as follows: Take $3 \times 4$ scantling for the standards, a little longer than the wall is high, place these on each side of the proposed wall, as far apart as the thickness of the wall and the thickness of the plank for the boxes. The plank should be 14 inches wide, 1½ inches thick, and of a length to accommodate the wall. If the wall is 32 feet long, then 16-feet plank will be the right length. If these standards are placed 15 inches apart, the plank inside the standards would leave 12 inches for the wall. These standards are held the proper distance at the bottom by nailing a thin piece of board across under the lower end, and fastening the tops with a cross-piece. The wall is built over these pieces at the bottom, and they are left in the wall. The standards are plumbed, and made fast by braces outside. Now, it will be seen that these planks can be moved upon the inside of the standards as fast as the wall goes up. The planks on the outside of the wall will, of course, be longer than those on the inside, by the thickness of the wall. The door frames and window frames will have jambs as wide as the wall is thick, and will make standards for that place. The door frames must be placed before the wall is begun. There will be a pair of standards at each end of the plank; but the pair in the middle of the wall will hold the ends of both planks. To hold the planks from springing out between the standards, take a piece of narrow hard-wood board, two feet long, bore a two-inch hole at each end, having fifteen inches between them; put a strong pin, two feet long, through these holes some ten inches. Now, these pins will just fit over the outside of the box-plank, and by putting a brace between the upper ends will hold them tight against the plank, preventing their springing out. Two of these clamps will be required for each set of planks 16 feet long. Now, when the box-planks are placed all around the wall, begin and fill in the concrete mortar and stone, as hereinafter described; and when you get round, if water-lime is used, you may raise the plank one foot and go around again, raising the wall one foot each day, if you have men enough. You will place the window frames in the boxes when the wall is raised high enough to bring the top of the frame to the top of the proposed wall. The jambs and sills of the window frames will be as wide as the door frames.

## Proportions for Water-lime Concrete.

If you have only sand to use, mix five parts with one of water-lime, thoroughly, while dry; then wet into a thin mortar and use immediately. But if you also have gravel, mix the sand and water-lime, four to one, then mix into this five or six of gravel, make into a thin mortar and use at once. This will make a concrete of about nine to one. If you also have stones to lay with it, put these stones into the boxes and cover with this mortar, and all the stone you put in will save so much mortar, and make your wall stronger while new. If you use only sand and stone, then mix the water-lime one to five, and lay the stone with it. The way is to put a layer of an inch of mortar in the bottom and then a layer of stone, then of mortar and so on, letting the mortar come over the edge of the stone.

If the stones are not permitted to come quite to the outside of the wall, the mortar over them will prevent them conducting moisture or frost through. The mortar should be tamped in, so as to fill every crevice.

There should be plenty of light in such a basement, for the health of the animals. Light is much more important than is generally supposed. The light of such a stable should be as great as in the living room of a dwelling-house.

## New Way of Building Long Barns.

We have shown the great economy and convenience of the octagonal over that of the oblong form. There can be no doubt that the circular form brings the labor into much smaller compass, this form of barn requiring less travel in feeding the animals and less labor in storing the crops. But the writer knows how tenaciously the farmers hold to old ways and opinions; and since they will largely build the oblong form, it may be of service to show them how cheaply they may avoid many of the interior posts and beams which so obstruct labor in filling such barns.

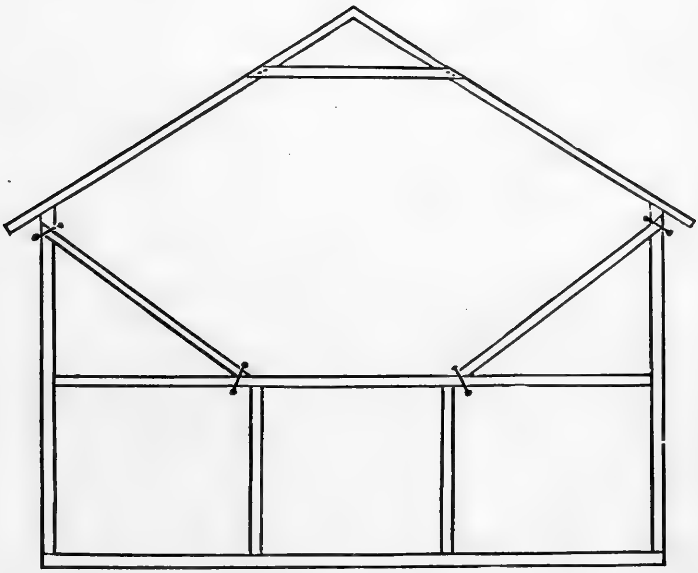


*Fig.* 14.

If the barn is 40 feet wide and the posts 25 feet long, all the purlin posts and beams may be left out, and these obstructions thus avoided by using a long, strong brace from the top of each cross-beam, over the floor, to near the top of each outside post. If the floor of the second story runs lengthwise of the barn, each bent will have a cross-beam, the top of which will be 13 feet above the floor, running across the barn from outside post to outside post. Now, instead of the ordinary short brace from the top of this beam to the outside post, the brace should be 6 × 8 inches square, of hard, strong wood, and have 12 feet run from the post on top of the beam, and 10 feet run up the post, reaching nearly to the top. (See fig. 14.)

These braces should be framed into a shallow boxing at each foot on beam and post, and firmly held in its place by a ¾-inch iron bolt through the foot of the brace and beam or post, and the nut turned up on a broad washer on foot of the brace. The nut may be tightened when the timber shrinks. This will hold the foot of the brace very firmly, and the brace, being so long, will hold the top of the post rigidly in place and prevent the plates from spreading.

Then let the roof be between a quarter and a third pitch; the rafters, $3 \times 6$ inches, and spread not more than 28 inches from center to center. Collar-beam each pair of rafters, 4 feet below the ridge, with $1\frac{1}{4} \times 4$-inch stuff, well nailed. This will hold the roof as safely as purlins, and it will be practically free from obstructions above the beams. It is true these cross-beams over the floor will be somewhat in the way, as compared to the self-supporting roof of the octagon; but there is always room to elevate the horse-fork between the beams, and, there being no obstruction above, the fork may be run to the roof without hinderance.

These strong braces from beam to post running to the back side of the bay, and at right-angles with the floor, will not at all obstruct filling or pitching out from the bay.

Let us call attention to the great economy as well as convenience of this improvement of the long barn. If this long barn be $40 \times 180$ feet, to compare with a 90-foot octagon, it would require 12 bents; and, consequently, there would be 24 outside posts, requiring 24 strong braces, bolted as described. The labor of framing these 24 braces would be less than framing the 24 purlin posts. Forty-eight bolts, 16 inches long, required to hold the braces, would cost, with washers, 16 cents each, or $7.68 only, for this large barn. Now, let us see what timber it would save. Twelve cross-purlin beams, 8 × 8, 20 feet long—1,284 feet; 360 feet of 8 × 8 timber, for long purlin plates, being 1,920 feet of lumber; 48 six-foot braces at foot and top of the posts—576 feet; amounting in all to 3,780 feet of lumber, costing $40 or more, according to location; and the labor of framing the timber and putting together would be at least as much more. The average saving by the improved method would be $100.

It will be seen that from this long floor the barn can be completely filled to the ridge with the horse-fork, and would require but little labor in mowing away.

In this form the barn may be made any length desired, and may afterwards be extended at will. This form of long barn requires the smallest amount of timber and lumber consistent with its length; but the travel from each end of this barn to the center is 90 feet, whilst in the 90-foot octagon it is but 45 feet, each having the same capacity.

This barn is supposed to have a basement for the animals. But to make the basement of this barn as convenient in space for carrying away the manure as the octagon it would require to be 44 feet wide.

The great point about this form of oblong barn is the facility of lengthening it at pleasure, and its comparative freedom from interior posts or obstructions.

## Barn for 1,000 Head of Cattle.

Having discussed the best form of barn, and described a cheap and convenient method of building oblong barns, which may be lengthened at any time to suit convenience, without any change in its present form, giving reasons for preferring the octagonal form, except for barns 40 feet square or less, we now proceed to describe two forms for a barn that will accommodate large feeding operations upon western farms, where the large feeders shall be convinced of the greater economy of controlling the temperature in which their cattle are kept in winter by warm barns, instead of exposing them to the cold, external air, with its storms of wind, rain and snow, and expending a large amount of food to produce the heat which is lost by this exposure. The time will certainly come when there shall be an accurate comparison between the two systems of out-door and in-door feeding in winter. As heretofore stated, all the comparisons made between these two modes of feeding have been with cattle unaccustomed to in-door feeding, and the nervous excitement counterbalanced the benefit of the warmer temperature, there remaining only the saving in food. This period of out-door feeding has occurred in every state during the first half-century of its growth, but has gradually disappeared as land and food became dearer.

If a large number of cattle are to be fed on one farm large barns will be more economical than small ones. But if it is proposed to feed one thousand head of cattle under one roof, the form of this barn will have much to do with its cost, as well as the expense of labor in feeding. If it were constructed in one long barn, with two rows of cattle, or 500 head in a row, the barn must be 1,625 feet long, or nearly 100 rods. This would be quite too long drawn out. We must seek for a form of barn radiating from a center, with eight double rows of cattle. This will give a distance of only 203 feet each way from the center, allowing 3 feet 3 inches for each steer.

### Octagon Eight-winged Barn.

But as room will be required at the center for many purposes, in feeding so many cattle, we must have an octagonal center, each side of which is wide enough for a wing to radiate 30 feet wide. This will require an octagonal center 80 feet in diameter, giving sides about 33 feet 2 inches long. Now, eight wings, 30 feet wide and 200 feet long, each having room for 126 head of cattle, will contain in all 1,008 head. From this octagonal center it will be just 200 feet to the most distant animal in either of the wings. Each wing will be opposite a like wing on the other side of the octagonal center, and consequently there may be a continuous floor from each through the center and the opposite wing, and from the center either of the eight wings is equally accessible. The reader will see at a glance how compact and conveniently reached all these thousand cattle are. Each wing should stand upon a basement wall, 8 feet high (the basement story occupied with the cattle), and it may be built as capacious as the feeder requires for winter storage. The fodder or grain over the basement can be easily dropped through upon the feeding floors below, so that the convenience in handling food for the cattle could not be greater. But there are some drawbacks in this eight-winged barn which we will point out, and see if they can be avoided by any other plan.

These long wings have the prime objection of the narrow, oblong barn—too much outside wall, and too much timber for the space inclosed. This could be improved by building the wings 60 feet wide, giving room for two double rows of cattle, so that each wing should contain 252 cattle, instead of 126. This would dispense with one-half of the wings, and still hold the same number of cattle. But the sides of an octagonal center will not admit of so wide a wing; we must, therefore, have a quadrangular center of 62 feet diameter, with four wings, 62 feet wide and 200 feet long, radiating from the four sides of the quadrangle.

This will be a

## SQUARE-CROSS BARN,

having all its extreme parts equidistant from the center. It will be the same distance from this quadrangular center to the extreme animal in either wing as from the octagonal center. This form will, therefore, be equally convenient. By doubling the width of the wings, we dispense with eight long sides, 200 feet each, or 1,600 feet; and as the ends of the four wings are the same length as the eight wings, the saving in outside wall is 1,600 feet. And if these sides are 20 feet high, and boarded up and down with a two-inch batten, it will take 36,933 feet to cover these sides thus dispensed with. It will also save all the outside and interior posts of the four wings dispensed with, as it will require no more posts in a wing 60 feet wide than in one 30 feet wide. This will make a saving of about 22,000 feet; and the outside sills and plates on these eight long sides will be saved, amounting to 24,000 feet, besides girths and braces—amounting in all to a saving of 100,000 feet. The roofs and floors will cover the same number of square feet as in the eight wings, and cost about the same. It would also save 14,400 cubic feet of wall. The whole saving by building the wings 60 feet wide could not be less than two-fifths of the whole cost of the barn; and the convenience and economy of labor must be even greater than with the eight narrow wings. This square-cross barn has the capacity to feed, conveniently and comfortably, one thousand head of cattle; and it now remains to notice some of the details of construction.

The quadrangular center, 62 feet in diameter, may be built with large corner-posts, say 14 × 14 inches square, 37 feet long, and the plates and girths of the wing may be framed into these posts; but it probably would be better that the wing should have separate corner-posts, and they be bolted to the posts of the center. The quadrangular center should be high enough above the wings to clear the ridge of its roof. This would require the posts of the center building to be 17 or 18 feet longer than the wing posts, as the ridge of the wing roof should rise at least 17 feet in 60 feet, and come up under the cornice of the center building. As these wings will cost about the same money with posts 16 feet long as with posts 20 feet, and the latter height will hold about 40 per cent. more, and as this storage room will be wanted for so many animals, it will be better to provide room in abundance, and make the posts 20 feet long.

The floor in the wing above the basement will run lengthwise of the building, and will be 16 feet wide, so that the posts on either side of the floor, running up to the cross-beam over the floor, may stand on a sill running lengthwise over the basement, and eight feet from the center, supported by the stanchion timbers. These two sills will be strongly supported the whole length by the stanchion posts, placed only 38 inches from center to center, and will consequently hold the whole interior structure above. The bays on each side of the floor will be 22 feet wide, and there will be no loss in so wide a floor, as the hay may be mowed one or two feet upon each edge of the floor if more room is desired. There will be 12 bents, the outside posts being about 18 feet 2 inches from center to center. The top of the cross-beams, running from side to side of the barn, will be 13 feet above the sill, and will be spliced at the post, or between the posts, on either side of the floor. On three of the bents the cross-beams should be carried up nearly to the plates, and the posts at the side of the floor must also be carried up to support the beam. The three bents (every third one) will tie the barn together, and, being so far apart, will not obstruct pitching with the horse-fork. These high beams, besides being pinned to the outside posts, should have a stirrup around the post, coming back ten inches upon the beam, with a ⅝-inch bolt through the stirrup and the beam turned up tight with a nut; and, if the beams are well spliced in the middle, this will hold the barn firmly from spreading at the plates. Now, to prevent this long wing from rocking or swaying by a strong broadside wind, these bents with the high beams should have a long, stiff brace, running from the foot of the post on the side of the floor to the outside post, just under this high beam. Such a long brace on each side will hold the barn rigidly from rocking. And whilst speaking of braces, let it be remembered that a brace is valuable just in proportion to its length. The braces from the outside posts up to the plates should have a four-foot run. They will assist very much in sustaining any weight upon the plates. It is not intended to have any purlins in these wings to support the roof, even though they be 60 feet wide. The brace on top of the beam, as described on page 112, for the long barn, will have a run, on beam from post, of 12 feet, running up the post just under the plate, and fastened by bolt, as there described. This will hold the plates absolutely rigid, and the roof will not spread them. The rafters will be as there described, only they should not be placed more than two feet apart, and the collar-beams should be 1¼ × 5 inches, and placed six feet below the ridge, with every other pair of rafters double collar-beamed ; that is, with a collar-beam nailed upon each side of the rafters. This will make a strong shingle roof. The collar-beams will be some 20 feet long, and will be about as good a support to the roof as purlin beams. The collar-beams would be as high as the barn would be likely to be filled, so that no room will be lost, and the barn will be practically free from obstructions to pitching with a horse-fork.

In the bents, where the cross-beams are raised nearly to the plates, there must be a beam framed into the posts on each side of the floor, 13 feet above the sills, to correspond with the other beams over the floor, upon which scaffolding may be placed for using the room over the floor. It remains only to be mentioned that the interior sills are four cross sills, 40 feet apart, to tie the barn together at the bottom, and two sills running lengthwise, one on each side of the floor—that is, the center of each of these long sills is placed eight feet from the center of the barn. The joists for the bays will run from these long sills, on each side of the floor, to the outside sill—about 21 feet, and these joists may be supported near the center by a row of stanchion timbers. Each of these long sills come over a row of stanchion timbers in the basement below.

The reader will see that these wings above the basement are built in the simplest manner, using no surplus material, and as cheap as may be consistent, with substance and durability.

## Basement for Cattle.

We will now examine the construction of the basements to these long wings. The wall under each of these wings, if built of concrete, 15 inches thick at the bottom, 12 inches at top, and 8 feet high, being 462 feet long, would contain 4,204 cubic feet, and could be built in most places for 10 cents per cubic foot, or $420 per wing. The wall under the center would be 1,504 cubic feet, and cost $150; the wall under the entire square-cross barn would cost $1,830. These long sides would require something to stiffen the wall sidewise; but a pier built against the wall on the inside would be in the way, and on the outside would look unsightly, so, to avoid the necessity for such piers, let a T be made of strong iron, say ¾ × 2 inches. The long end of the T should be about 20 inches, and built into the wall, and the cross lie across the top of the wall directly under the sill. The top of the T should project beyond the sill on each side far enough to have a ¾-inch hole punched, into which to insert a piece of the same flat iron, six inches long, rounded at one end. This will attach the wall to the sill. There should be four of these T's for each side—one near each cross-sill, 40 feet apart. This will hold the whole wall to the beam and prevent any swaying. These long sides will give room for inserting plenty of windows for light, the frames placed in the boxes, and the concrete built over them. The sash may be hung on a pivot in the center, so as to open easily to give ventilation at certain seasons; but the fresh air should be introduced through the wall near the bottom, through hard-burned earthen or pottery pipes, 15-inch bore, just long enough to reach through the wall. These pipes may be laid in the boxes bedded in the concrete, and the concrete tamped down upon them. They may be placed ten feet apart and will not weaken in the wall. Close covers may be fitted to the inside, so as to shut them at will; and with proper ventilators to discharge the heated and vitiated air through the upper part of the barn, there will be a constant circulation of fresh air through the basement.

One other point must be mentioned in reference to the wall. A concrete wall contains a large amount of moisture, and if the sills are to be placed on before the wall becomes quite dry, which is usually the case, the moisture will pass up into the green timber of the sill, form a coating of lime on it, and prevent the sap from escaping, and the result is a rapid decay of the timber. To prevent this, take well-seasoned pine boards, 12 inches wide, coat one side with gas tar, and bed this tarred side in the mortar on top of the wall. The sills are laid on this leveled board, and no moisture can come through this board into the sill to rot it. This point is important—has been determined in our practical experience.

## Laying out the Basement.

These long stables must be laid out so as to render the labor as convenient as possible. There must be easy access to every animal in the stable, and this becomes more important when one thousand cattle are to be provided for. Cattle are most easily attended when placed in double rows, with their heads turned towards one feeding floor.

In this long basement, the first row of stanchion posts will be placed 8 feet from the wall, on the side of the first feeding floor, 14 feet wide. On the other side of the feeding floor is the second row of stanchion posts, coming up under one of the long sills, described above. Two and one-half feet being occupied by mangers on each side of this floor, will leave nine feet for a drive-way. Along this floor may pass a cart or a wagon, with green food in summer, or fodder in winter. The third row of stanchion posts will be 16 feet from the last, under the second long sill, on the side of second feeding floor; and the fourth row will be 14 feet from the third, on the other side of the second feeding floor, and 8 feet from the other wall. Here two rows of cattle stand, with tails to the wall, and the two middle rows stand tail to tail, facing upon opposite floors. The largest animals should be placed in middle rows, as there is the most room. These stanchion posts are placed 3 feet 2 inches from center to center, and the cattle are best fastened to the center of a chain stretching from staple to staple driven into each stanchion post. These chains slide up and down on these staples, as shown in fig. 10. The mangers may be placed 20 inches from the ground, and, with long staples, the cattle may lie down comfortably. One of the best ways to feed cattle, with plenty of bedding and muck for deodorizing, is to let them stand three or four months on their manure, and, the mangers being placed high, the manure may accumulate two feet deep under them, and they may keep quite clean, with the bedding and muck, and the manure will be trodden so hard as to ferment very little. When a lot of cattle is sold, then wagons may be driven through to carry off the manure. We have seen cattle fed in this manner, carded occasionally, and kept quite clean standing on their manure for four months.

These feeding floors, as described, stretch through the whole length of the barn. A feeding-car passes through two wings, and, by having a turn-table, may pass through any wing. Feed may be dropped through a chute on the side of the upper floor into the car wherever placed on any feeding floor. This form of barn gives every facility for any style of feeding, cutting and cooking the food, or cutting and grinding—a large engine, placed in the center, would do all the work; and this also offers the best facility for soiling this thousand head in summer.

## Sheep Barns.

There have been a variety of forms in sheep barns recommended—some contending that sheep should never be wintered in inclosed barns, that sheds are a sufficient shelter, and all the confinement that sheep can stand with health.

But in all the Northern and Eastern States the best shepherds have discarded the open shed as a protection in the cold season, and now advise barns that can be closed completely or as securely as barns for cattle, when the weather requires it—not forgetting ample means of ventilation.

Sheep require roomy stables, but they are as much benefited as other stock by a nearly uniform temperature. It is therefore profitable to provide warm and well-ventilated stables, basements, not sunk in the earth, preferable. Perhaps the style of long barn, we have described, is as well adapted to sheep as to cattle. Sheep require ample room to store fodder, and this long barn, 40 feet wide, with a basement walled in with concrete, would furnish a stable of remarkably even temperature, and affording every desired facility for ventilation. The concrete wall furnishes a much drier basement than a mason-laid stone wall, which often conducts moisture and frost to the inside, whilst the basement with concrete wall is as dry as if wooden-walled.

The advantage of the new style long barn is that it may be extended at any time without any change in its construction. Such a barn 40 × 40 would accommodate 150 merinos or 100 long-wools. This basement, with a double rack and trough through the center, dividing it into two apartments, will furnish room for 75 on each side, or if 40 × 60 feet, would provide room for 225 merinos or 150 Cotswold or Leicesters.

This barn, with its floor lengthwise, furnishes a very convenient means, by its door-trap through the floor, of dropping the fodder into the double rack below. Here is also abundant room for storing a full supply of fodder, and of grain or other feed for fattening purposes. The floor over a sheep stable should be dust tight, keeping the wool free from dust; and one of the best ways to make a floor dust-tight is to place pine lath under the joints of the boarding across the joists, and a piece on the joists under each board. The lath laps on each board three-quarters of an inch, and thus makes a tighter floor than one that is matched. The lath is nailed to the under side of the floor between the joists.

### DOUBLE SHEEP RACK.

The form of rack from which to feed sheep is somewhat important. It should be so constructed as to save all the fodder, and to prevent the hay-seed and dust from getting into the wool. The author has constructed a double rack and trough which is represented in fig. 15. This is an end view and will readily be understood.

Scantling 5 feet 8 inches long are placed about 30 inches apart.

*a.* Plank 1½ × 8 inches for the bottom of the trough.

*b.* Sliding board, reaching down and nailed to the bottom board of the trough, about six inches from the outside.

*c.* Rack slats 1½ × 2 inches nailed to the sliding board 6 inches from the bottom, rising 3 feet from the bottom of the rack, and nailed at the top to a scantling (*d*) 2 × 2½ inches. The rack slats lean from the trough 4 inches at top to prevent hay-seed from falling upon the head, and are only 3 inches apart.

*d.* A scantling 2 × 2½ inches to which the rack slats are nailed at the top.

*e.* Front side of the trough 8 inches wide.

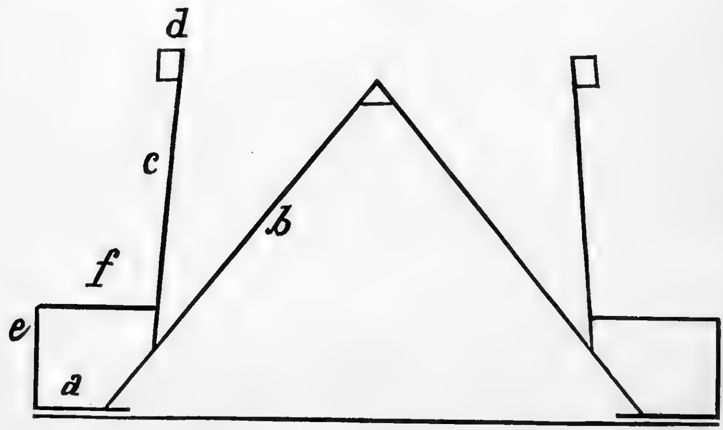



*Fig.* 15.—END VIEW OF DOUBLE RACK AND TROUGH.

*f.* Bar across the top of the trough to the rack slat to divide the trough and prevent sheep from getting into it. These bars are placed across at every third slat, and may be placed at every second slat, if a narrower division is found best.

Both sides of this rack are precisely alike. It will be seen that nothing can be wasted, for all short bits of fodder and seed will slide between the slats into the trough, a little meal or bran placed upon this refuse will cause it all to be eaten. This rack furnishes a place for feeding grain as well as hay. This double rack placed through the center of the basement above described, will divide it into two apartments, and receive its fodder from the opening in the floor above.

If this rack is to be used against a wall it can be made single by dividing it perpendicularly in the middle. It can be made single as well as double. If it is to be used as a short rack, and the end not placed against a wall, then the end must be boarded or slatted.

This rack would be equally convenient in the yard, where it is appropriate to feed in the open yard. The trough in the illustration is supposed to be 12 inches wide and 8 inches deep, but it may be made wider if desired. We think this rack and trough will be found to prevent the sheep, as far as possible, from rubbing off their wool in eating their food, and that it also prevents the waste of food, and besides saves labor in feeding by providing for feeding grain and coarse fodder together.

On the Western plains very little attention is paid to shelter for sheep. Yet we think even there a temporary shelter should always be provided, and if the ranch is large, and little, if any, winter fodder is provided, there should be several warm sheep corrals, made with poles and thatched with wild grass or straw. These may be arranged so as to protect the sheep from wind and snow-storms. Such precaution will often save a large part of the flock, and always bring them through in better condition. Temperature has much to do with the necessity for food. Exposure to hard storms makes a heavy draft upon the food to keep up animal heat, and if food is short the heat must come from the store of fat laid up in the body.

The need of shelter is less in the South, but the temperature there often falls so low as to render shelter a matter of economy to the mutton and wool-grower. Shelter, as a means of preserving animal heat, is cheaper than food, even in the South.

# CHAPTER V.

## PRINCIPLES OF ALIMENTATION.

THE true and complete office performed by the food in the growth and development of our domestic animals has been quite too little considered by many even of our advanced feeders. Let us instance intelligent Short-horn breeders.

Much has justly been written in praise of the Short-horn as the highest and most perfect bovine type of human food; but, we fear that in the minds of many, too great faith is placed upon the constitution and blood of the animal, and too little upon the process by which this perfected type has been produced. They seem to think that this perfected animal has power to change the elements of its food, and add an aroma and flavor to its flesh which was not contained in its food. At the meeting of the National Short-horn Breeders' Convention, at Cincinnati, a learned member, in an elaborate paper, proposed, as the best means of improving the flavor and quality of the flesh of each breeding animal, to slaughter some of its offshoots—discarding those whose flesh is not of the desired quality, and he made no suggestion of the necessity of appropriate food as affecting flavor; but he instanced the antelope and other wild animals as possessing the same flavor of flesh to-day as a thousand years ago; from which we suppose that he regarded the flavor of the flesh as dependent entirely upon the constitution and fixed character of the animal, and not upon the food. But, what would be the effect of domesticating the antelope, and changing its food from that of the broad range and great variety of sweet and aromatic herbs, to the prepared pasture of a few simple grasses, and the allowance, for short periods, of one or two of our cultivated grains? Would it take a thousand years, or any considerable fraction of it, to change the flavor of its flesh? No animal has the power of extracting a flavor from food which it does not contain. The animal creates nothing—simply elaborates and appropriates what it finds in its food. We are not left to mere theory upon this question. Numerous trials in domesticating wild species are on record. The wild turkey and wild goose undergo a transformation in a few years so that the flavor of the flesh can scarcely be told from that of the domestic variety, while high feeding has increased the fat and weight of the bird. The domesticated partridge follows the same law. The deer, under domestication, loses the peculiar wild flavor of its flesh.

In England large numbers of deer are kept in the parks. Mr. Joseph Harris, writing of a visit he made to England in 1879, said: "I saw thousands of deer in the different parks. But they have abundance of rich grass in the summer, and during winter they are furnished with hay whenever necessary. Now, I am very fond of venison; and so, on our return home on the steamer Gallia, one day, when we had a saddle of venison for dinner, I ordered some, expecting a great treat. But it was not venison at all. It was cut from the carcass of one of those English half-domesticated deer that run in the parks and are furnished a regular supply of food. But it was not what we call venison in this country. It lacked flavor—was more like mutton. The flesh was light colored, and there was half an inch or more of external fat, precisely as there is on well-bred and well-fed sheep."

This is a demonstration of the effect of food. The Cheviot sheep of Northumberland hills and Scottish highlands, feeding upon many wild grasses and aromatic herbs, have a peculiar flavor of flesh which recommends their mutton; and the small sheep upon the Welsh hills possess a great reputation for flavor, and bring a higher price than the sheep of the lowlands. But a change made for a few years with each also changes the comparative quality. The Swiss cow, feeding upon her high-flavored native grasses upon the Swiss mountains, yields higher-flavored milk, butter and cheese than the same cow when fed upon the lowlands.

The intelligent dairyman knows that the quality of his milk is dependent upon the food provided for his cows. He does not expect to produce rich milk from straw, whatever may be the strain of blood in his cows. The finest Jersey is not expected to produce delicious flavored milk upon leeks and garlic; but you might as well attempt to breed a cow that would give as delicious flavored milk upon leeks, cabbages, onions and turnips as upon the sweetest June grasses, as to expect to succeed in breeding animals the flavor of whose flesh will be independent of the quality of their food.

It is quite true that an animal of fixed characteristics will select and appropriate such elements in its food as its system requires for the reproduction of all its peculiarities; but the animal which has produced nicely-marbled and highly-flavored flesh under circumstances of appropriate food and conditions, cannot long continue to do this under changed food and conditions.

If you wish to imitate the flavor of the wild animal you must furnish the food of the wild animal.

These facts are dwelt upon to show the folly of attempting to breed an animal that shall be independent of the quality of its food. If you find offshoots from animals, both male and female, of the highest possible quality of flesh, it will be well to breed from them, because "like produces like," under the same circumstances; but the animal is always dependent upon its food for its quality of flesh. Although one animal, from its constitution, has greater power of utilizing its food elements, and of selecting or rejecting different elements than other animals of the same species, yet it cannot elaborate or utilize what is not there.

## Early Maturity.

Having found that the animal must depend primarily upon its aliment for growth and quality, the next important consideration is how this aliment should be given—whether the growth should be slow or rapid—should take the longest natural period required by a scanty diet, or the shortest possible attainment of maturity under the most judicious and skillful feeding. That we may form a safe opinion upon this question, it is requisite to examine some of the circumstances attending growth and maturity. While the animal is young and immature, its appetite, digestive and assimilative functions are most active; and these functions grow less and less active after maturity. After the period of perfect development, the natural habit of the animal is to eat and digest only so much as is necessary to supply the waste of its tissues; and, consequently, its weight remains nearly stationary. Another most important point is, that while the animal is young, and in an active stage of growth, the percentage of waste in its system is much less than at and after maturity. The food of support, or what is necessary to supply the constant waste of the system, and keep the animal without loss, has accumulated to a large item at maturity. It then becomes very clear, that the interest of the feeder requires that the shortest possible time should be given to the growth of an animal intended for food. It must be evident that in careless and unskillful feeding the cost of simply supplying the waste of the system during four years' feeding of steers will be as great as to produce animals of the same weight at 24 to 30 months; or, in other words, skillful feeding of young animals will produce twice as much weight at 24 as at 48 months, on the same food.

"But," say some, "your steer cannot be mature at 24 months." It is true that the marks of full development are that the permanent teeth are complete, the animal fully grown, and all its physical qualities perfect. The ox perfects its teeth at four to five years, the pig at two to two and one-half years. These times of dentition occur in a state of nature, when the animals seek their own scanty food, or under the care of a slipshod and penurious feeder. But the improved breeds, after years of skillful feeding, mature in from one to two and one-half years earlier.

M. Regnault, at a cattle fair in France, in 1846, found a bull only two years old that had all his permanent teeth, and all the points of development and maturity in perfection; and was from this fact led to make investigation of the effect of careful and judicious breeding and feeding in hastening the maturity of animals. He says:

"Thanks to a better system of management and feeding of cattle, and to judicious and advantageous crossings, it is certain that many of our bovine race have experienced in their form, and especially in their precocious development, unmistakable changes for the better. Whatever may be the cause of this remarkable aptitude of certain breeds to acquire their growth early, it is evident that such precocious development cannot be confined to any particular organs. If every one has not equally participated in it, at least they are all more or less affected by it. Above all, the digestive system—the part called in to play an important part in producing such an aptitude for early development, since all must essentially result from the nature and action of alimentation—must be one of the first to undergo modifications."

Here, it appears, that thirty-six years ago perfect development was found at two years; and the French scientist states clearly that perfect teeth must, as a general rule, be accompanied with full development of all the parts. So this precocity, when it becomes established, must continue, under favorable circumstances, as a permanent characteristic of the animal. A study of the facts accompanying early maturity shows that the animal is as completely developed in all its parts as if it had been produced, under the old style of feeding and management, at the end of four instead of two years. This quite disproves the objection that all things require a certain amount of time to perfect their construction and growth—that whatever is rapidly produced must be wanting in completeness and perfection.

Objectors have regarded this as a demonstration; but it is merely an assumption. All the processes of digestion and assimilation are chemical processes. Combustion is also a chemical process; but will any one say that the slow combustion of wood by rot and decay in the open air is any more perfect combustion than its rapid reduction to ashes by fire?

In the natural state the animal gathers its coarse, fibrous food by long and toilsome exertion; and its small percentage of nutriment is assimilated into the tissues of its body. But, under the best system of growing animals, the food is given in a more soluble and assimilable condition, and in as large quantities as the animal can digest, which can all be utilized in much less time. Is it reasonable then, as a matter of theory, to suppose that its digestion and assimilation will be less perfect?

Our present excellent varieties of wheat are supposed once to have been only wild grasses, with their thin and skinny seeds. Does any one think our varieties of wheat have degenerated?

The magnificent pippin, with all our improved apples, are supposed to have sprung from the wild crab, and each of these improved products ripen earlier than the parent stock. Are they less perfect? The illustration may be carried into every department of vegetable and animal growth

It thus appearing that the quality of the flesh must depend upon the quality of the food; and that all food produces a greater profit when fed to young than mature animals—thus showing the great importance of early maturity as an element in the profit of growing animals for their flesh.

But so far we have treated the subject more from the standpoint of general principle and theory than of definite experiments, which appeal more forcibly to the practical stock-feeder's judgment, and are more likely to control his action. It may be laid down as an axiom, that

### Profitable Feeding must be done Before Maturity.

Let us fortify this position by facts and experiments.

As we have seen, the digestive and assimilative organs of the young animal are in the greatest activity; and thus the stock-grower must take advantage of this period to produce the best result in feeding. Careful experiments show a constant increase in the food required to produce a pound of live weight, as the animal increases in size and age.

Two separate experiments were tried at the Michigan Agricultural College Farm, in 1866–68. In the former, three pigs, and in the latter, six pigs were fed upon milk. The pigs were from four to six weeks old at the commencement of the experiment. The average amount of milk to produce one pound of live weight, was: first week, 6.76 pounds; second week, 7.75 pounds; third week, 12.28 pounds; fourth week, 10.42 pounds. The professor says the cause of its requiring a greater amount of milk the third week to produce a pound live weight, is explained by a "derangement of the digestive organs during this week, as shown in a tendency to constipation." He also remarks that "the milk to produce a pound live weight constantly increases."

The experiment of 1868 was continued afterward for twenty weeks, upon corn meal. This experiment was divided into five periods of four weeks each. The amount of corn meal required to make one pound live weight is: first period, 3.81 pounds; second period, 4.05 pounds; third period, 4.22 pounds; fourth period, 5.24 pounds; fifth period, 5.98 pounds.

In 1869 another experiment was tried, with a larger number of pigs, and very nearly the same result in respect to amount of meal required to produce one pound of live weight, and substantially the same increase in quantity of feed required to produce one pound of live weight as the pigs grow larger and older.

An examination of the meal experiment will show that in the fifth period, when the pigs were from twenty-four to twenty-eight weeks old, it took 75 per cent. more of meal to make a pound of live pork, than in the first period, when the pigs were from eight to twelve weeks old. And other experiments have shown that this ratio of increase in food to make a pound live weight, substantially goes on with the age and weight of the pig.

In 1874 the writer tried a similar experiment with ten calves fed upon skim-milk. The calves and the milk fed were weighed and calculated for each week. The first week it required 11.02 pounds of milk for one pound of gain; second week, 12.18 pounds; third week, 13.17 pounds; fourth week, 13.40 pounds; fifth week, 14.60 pounds; sixth week, 15.05 pounds; seventh week, 16.71 pounds; eighth week, 16.80 pounds; ninth week, 17.01

pounds; tenth week, 16.08 pounds; eleventh week, 16 pounds; twelfth week, 15.90 pounds.

The calves gained very unequally, individually, owing to the constitution of each calf. Some gained much more rapidly than others, and also gained quite unequally in different weeks; but the result stated is the average of the ten. We regarded this experiment as very instructive; not only as showing the constant increase in cost of putting on a pound live weight, but as showing the value of skim milk in growing calves. It will be observed that the amount of milk began to decrease the tenth week. This was caused by the calves learning to eat grass. They increased more rapidly after learning to eat grass, when given at the same time what milk they would drink. It may be interesting to some of our readers to state, that we find skim milk worth from 30 to 50 cents per 100 pounds to feed calves up to the age of six months. By the aid of milk, with abundance of grass, they may be made to weigh from 450 to 600 pounds at that age; and a continuance of this liberal feeding, although grain is substituted for milk, may produce yearlings of 800 to 1,000 pounds weight, instead of little more than half that weight under a scanty system of feeding. The experiments of Sir J. B. Lawes, of Rothamstead, England, also prove that the cost of putting on weight is in proportion to the age and size of the animal. This fact appears very plain and indisputable to any one who has studied it; and yet, a want of its practical adoption among stock-growers, causes a loss of not less than $50,000,000 per year in the United States. And this would only be $11.50 per head for the 4,341,824 head received at seven principal live stock markets of the country in 1881. A close examination would have shown that more than $50,000,000 in food had been thrown away in this slow and unprofitable growth. We do not mean that all of them had been grown in disregard of the law of early maturity; but seven-tenths of them had, no doubt, suffered from ignorance of this law we have illustrated.

And next we should

### Study the Nature of the Animal we Feed.

Stock-growers often neglect this injunction. Forgetting the natural habit of the animal, and anxious to make the most rapid progress, they ply it with too concentrated food, and thus cause fever and other diseases in the system. Ruminating animals are possessed of capacious stomachs, calculated to manipulate bulky and fibrous food. Nature never intended that they should be fed upon concentrated food alone. The grains grow upon stalks having twice the weight of the seeds, and animals naturally eat both seeds and stalks together. The ruminating animal requires to eat grain with the coarse, fibrous stalk, in order that it should go to the first stomach, have the benefit of the macerating process of the rumen, and be raised, remasticated and mixed with the saliva. Some six different experiments have proved to me that corn meal, shelled corn, rye, oats and other fine feed do not, to any material extent, go to the first stomach when fed to cattle alone. One or two experiments by others have seemed to contradict these; but we have only to refer the Western feeder of corn in the ear to the droppings of his cattle, to prove most conclusively that the corn does not go to the first stomach. For, if the corn descended into the rumen, and was raised and remasticated, how could the large proportion of kernels found whole in the droppings escape unbroken? We have seen them so thick over droppings that there was hardly an inch space between them. This must be considered not only a wasteful way of feeding grain, but injurious to the health of the cattle so fed. But in many parts of the Eastern States, quite as little knowledge of the nature of the ruminant is shown, by feeding fine corn meal alone.

This, being moistened with saliva, passes to the third and fourth stomachs in the solid form of the house-wife's dough. The gastric juice cannot penetrate and circulate through this; and, consequently, the meal is often found in the manure, very little changed. Some respectably-read physiologists will inform you that the muscular coat of the stomach (see page 49), by its contraction, gives a gentle motion to the contents of the stomach, intermixing these with the gastric juice, but in the case of the plastic corn-meal dough, this muscular action could only succeed in rolling it over, but could not break it, or render it porous for the entrance or absorption of the gastric juice. But if this meal is fed with cut hay or straw, so that both must be eaten together, the bits of hay or straw separate the particles of meal, so that the gastric juice can circulate through the mass as water does through a sponge. When thus fed, the meal goes with the cut hay to the rumen; is there softened, raised and remasticated. The Western feeder may save much of this loss of feeding corn in the ear, by running his unhusked corn—stalks, ears and all—through a straw-cutter, cutting one-quarter of an inch in length, and then feeding all together. This will cause all to be remasticated, and the corn very fairly digested.

We have practised this mode of feeding as an experiment, and found no corn to pass in the droppings unbroken. It would effect a saving to Western feeders of at least 20 per cent. over their present mode of feeding in shock. This point will be further discussed in its proper place.

Violence is also done to the nature of the horse when he is fed upon grain alone. We have seen a horse that so well understood his own wants that, when fed ground grain, would take a mouthful of meal and then a mouthful of hay, and mix them together himself while eating. This horse understood animal physiology better than his master.

Improper feeding of grain is a most fruitful source of disease among horses.

But no class of animals is so much abused from a want of proper understanding of their nature as swine. The fact that they are grass-eating animals as much as the ox or the horse, seems to be ignored entirely by the largest class of pig-feeders. Pigs are put upon corn at weaning age, and kept upon it until slaughtered, if cholera does not cut them off in advance. The pig needs for health a little grass or clover hay mixed with the grain diet, as much as other grass-eating animals. We have tested pigs upon meal and grass, and, at the same time, others upon meal alone, in summer, and upon meal and nicely-cured clover hay, softened with boiling water, in winter, and have always found from 25 to 40 per cent. in favor of the mixture of grass or clover. But this subject will be further discussed under its proper head.

We have seen how very important in the economy of feeding is the element of time, and that the "storing system," or keeping animals at a standstill for the purpose of feeding at some future period, is always attended with a great loss of food. Let us now attempt to give some practical suggestions on

## How to Feed Young Animals.

As the reader has seen, we believe much in the teachings of Nature, and that a feeder can never mistake when he follows her as closely as circumstances will permit. If then we take the four great classes of farm stock, cattle, horses, sheep and swine, we find that Nature furnishes for their early growth a very perfect food—milk. She provides, in this elixir for young life, every element required to build the bones and extend the frame—to grow the muscles, tissues and nerves—to lubricate the joints, cushion or pad with soft suet the exposed parts of the frame, and to round out into lines of beauty and harmony the whole animal; and if we would study the open secrets of Nature in her dealings with the young animal, we must look into the combination of elements in milk. The following is an average of the composition of the milk of the cow, mare and ewe:

| | | Cow. | Mare. | Ewe. |
|---|---|---|---|---|
| Caseine, or flesh-formers | | 4.05 | 3.40 | 4.50 |
| Butter, | Food of respiration and fat | 3.80 | 2.50 | 4.20 |
| Milk sugar, | | 4.55 | 3.52 | 5.00 |
| Salts or ash | | .60 | .53 | .68 |
| Water | | 87.00 | 90.05 | 85.62 |
| | | 100.00 | 100.00 | 100.00 |

It will be observed that each of these analyses shows food rich in nitrogen, or muscle-forming nutriment. The calf receives food in the nutritive proportion of one of nitrogenous to 3.37 of carbonaceous elements. Liebig says:

"The young animal receives, in the form of caseine (cheese), the chief constituent of the mother's blood. To convert caseine into blood, no foreign substance is required, and in the conversion of the mother's blood into caseine no elements of the constituents of the blood have been separated. When chemically examined, caseine is found to contain a very large proportion of the earth of bones, and that in a very soluble form, capable of reaching every part of the body."

This shows clearly the great office performed by caseine in the growth of the young animal. It furnishes the nitrogen in the formation of the muscles, nerves, brain, skin, hair, hoofs and horns, and furnishes it in so soluble a form that it can reach every part of the body. J. F. W. Johnston gives two analyses of the ash in 1,000 pounds of milk:

| | I. | II. |
|---|---|---|
| Phosphate of lime | 2.31 | 3.44 |
| Phosphate of magnesia | 0.42 | 0.64 |
| Phosphate of iron | 0.07 | 0.07 |
| Chloride of potassium | 1.44 | 1.83 |
| Chloride of sodium | 0.24 | 0.34 |
| Free soda | 0.42 | 0.45 |
| | 4.90 | 6.77 |

Here we find that something over one-half of the ash of milk is composed of phosphate of lime and magnesia, which accounts for the rapid growth of the calf in frame when full-fed upon milk. Here is found every mineral constituent required for every purpose in the living organism. Phosphate of lime is found in the muscles, skin, hair, hoofs and horns, as well as in the bones. The sugar of milk is admirably adapted as fuel in keeping up animal heat; and this is often illustrated in the ability of the calf to withstand cold, frequently showing that it feels cold less than its mother. Then the oil of the milk furnishes fat ready formed for use, and needs only to be appropriated by the young animal to be changed into animal fat. Thus milk is a perfect food, possessing every element required to build up the animal body. But the young animal uses milk only for a limited time, when other food must be substituted for it. The choice of this food, which is to replace the milk, requires some thought and skill, and the time when this substitution is to take place is an important element in determining the choice. A moment's reflection will show the great impropriety of substituting food for the young animal very different in its elements from milk, its natural food. Whatever food, then, is to be used, besides milk, for the calf, colt, lamb or pig, should be chosen because it possesses the important elements in common with milk, and in nearly a like proportion. The young animal must not suffer a check in its growth when the change takes place, if the greatest profit is to be realized from it. In order that we may decide upon the best foods to be given in lieu of milk, let us examine the composition of most of our cereal grains and some by-products that may be used for that purpose. The following analyses of grains, and partial products of grains, represent a fair average of their constituents:

| | Water. | Organic matter. | Albuminoids. | Carbo-hydrates. | Crude fibre. | Fat. | Ash. | Digestible Nutrients. | | | Nutritive ratio. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Albuminoids. | Carbo-hydrates. | Fat. | |
| Wheat | 14.4 | 83.6 | 13.0 | 67.6 | 3.0 | 1.5 | 2.0 | 11.7 | 64.3 | 1.2 | 5 8 |
| Rye | 14.3 | 83.7 | 11.0 | 69.2 | 3.5 | 2.0 | 2.0 | 9.9 | 65.4 | 1.6 | 7.0 |
| Barley | 14.3 | 83.1 | 9.5 | 66.6 | 7.0 | 2.5 | 2 6 | 8.0 | 58.9 | 1.7 | 7.9 |
| Oats | 14.3 | 82.7 | 12.0 | 55.7 | 9.3 | 6.0 | 3.0 | 9.0 | 43.3 | 4.7 | 6.0 |
| Indian corn | 14.4 | 83.5 | 10.0 | 68.0 | 5.5 | 7.0 | 2.1 | 8.4 | 60.6 | 4.8 | 8.6 |
| Millet | 14.0 | 83.0 | 14.5 | 62.1 | 6.4 | 3.0 | 3.0 | 9 5 | 45.0 | 2.6 | 5.4 |
| Peas | 14.3 | 83.2 | 22.4 | 52.3 | 9.2 | 2.5 | 2.5 | 20.2 | 54.4 | 1.7 | 2.9 |
| Beans | 14.5 | 82.0 | 25.5 | 45.5 | 11.5 | 2.0 | 3.5 | 23.0 | 50.2 | 1.4 | 2.2 |
| Flax-seed | 12.3 | 82.7 | 20.5 | 55.0 | 7.2 | 37.0 | 5.0 | 17.2 | 18.9 | 35.2 | 4.9 |
| Oil-cake | 11.5 | 80.0 | 28.3 | 41.3 | 11.0 | 10.0 | 7.9 | 24.8 | 27.5 | 8.9 | 2.0 |
| Wheat-bran | 13.1 | 81.8 | 16.0 | 48.0 | 17.8 | 3.8 | 5.1 | 12.6 | 42.7 | 2.6 | 3.9 |
| Rye-bran | 12.5 | 83.0 | 14.5 | 53.5 | 15.0 | 3.5 | 4.5 | 12.2 | 46.2 | 3.6 | 4.5 |
| Middlings | 12.5 | 83.0 | 13.9 | 63.5 | 4.8 | 3.3 | 3.0 | 10.8 | 54.0 | 2.9 | 5.7 |

The above table will give the reader a good idea of the composition of most of the foods that may be selected to feed young animals, in lieu of a part or the whole of the milk. These grains are, of course, given ground into meal. But if we examine the table with a view of comparing the composition of each with that of milk, we shall find most of them deficient in albuminoids, or muscle-forming matter. It will be remembered that the nitrogenous element of cow's milk is nearly one-third of the whole dry matter, or one to two of the carbonaceous (oil and sugar of milk); and that in the milk of the mare and the ewe, the nitrogenous is a little more than one-third of the dry matter.

But this is simply comparing the absolute weight of the two classes of elements in food, and not fixing the nutritive ratio. As we have seen in a former chapter, these two classes of elements are necessary to the maintenance of animal life. The nutritive ratio signifies the ratio of digestible albuminoids to digestible carbo-hydrates. The carbo-hydrates are starch, gum, sugar, etc. Fat or oil is also a carbo-hydrate, but it is estimated as having a heat-producing and nutritive power 2.4 times as great as ordinary carbo-hydrates. In finding the nutritive ratio of a food, then, the digestible fat, multiplied by 2.4, is added to the digestible carbo-hydrates, and this sum divided by the digestible albuminoids.

If we take the above analysis of cow's milk, as an example (milk being in solution, it is all digestible), fat is 3.80, this multiplied by 2.4 gives 9.12, and this added to the milk sugar, 4.55, makes 13.67 as the carbo-hydrates of milk, and this divided by the caseine or albuminoids, 4.05—the result is 3.37 as the nutritive ratio of milk, read 1: 3.37—that is, milk has 1 of albuminoids to 3.37 of carbo-hydrates.

The above table gives the digestible nutrients and the nutritive ratio of each of the foods named. It will be seen, that of all the foods in the table, oats, peas, beans, flax-seed, oil-cake, wheat-bran, rye-bran, millet and middlings come the nearest to milk in relative proportions of muscle-forming and heat and fat-producing elements. And if we examine, also, the mineral elements in these different foods which build up the frame, we shall also find flax-seed, oil-cake, peas, beans, oats and bran the richest in phosphate of lime and magnesia, and the other mineral elements necessary in the animal economy. Indian corn has only 2.1 per cent. of ash, and this not rich in phosphate of lime, etc. It has less of mineral constituents required by the growing animal than barley or oats—the former having 2.6 per cent. and the latter 3 per cent. We desire to direct attention to corn, as an improper food to be given, alone, to young animals. We have seen that it has 8.6 of carbonaceous to 1 of nitrogenous food, while milk has only 3.37 of carbonaceous to 1 of nitrogenous. Corn is quite too heating and fattening, and too poor in muscle-forming and bone-building food to be given alone to young animals—in fact, it is much better to discard it altogether in feeding animals under six months old.

Milk, the natural food of the young, has a large proportion of oil, which prevents constipation and thus promotes health, besides its most important office of lubricating the joints, padding and cushioning the muscles. When skimmed milk is substituted for full milk the animal is soon found to suffer from constipation, and this is often alternated with diarrhea. Here the skill of the feeder may restore the cream, removed as a delicacy in human food, by adding a cheaper oil to replace it in the skimmed milk. Our table shows flax-seed to contain 37 per cent. of oil, and this oil is found to be very digestible and agreeable to the animal stomach. A little flax-seed boiled to a jelly and stirred into this skimmed milk restores it so nearly to its original condition, that calves thrive and fatten upon it most satisfactorily. The oil in the flax-seed costs but a small fraction of the value of the cream removed. This is an example of the principle of mixing foods complementary to each other. Peas and beans are strong in albuminoids and bone-building elements, but deficient in oil, are therefore constipating, and should have a little boiled flax-seed mixed with the ground meal. Wheat middlings are generally preferable to bran for the young, because containing less indigestible woody fibre, it is less irritating to the stomach. The feeder should study the composition of foods, and learn to combine those of different qualities, so as to make a well-balanced ration. This skill enables him to utilize everything grown upon the farm, and thus add to his profits.

# CHAPTER VI.

## STOCK FOODS.

It seems proper to consider, preliminarily, the different foods which may profitably be used by the stock-feeder in the widely-varying conditions of soil and climate found in our country, stretching over twenty-five degrees of latitude and fifty-seven degrees of longitude. We do not profess to be able to describe all foods actually used over this immense territory, but we have endeavored to give as many of those foods, decided in practice to be valuable, as possible, and especially all those that have been brought to the chemical test of analysis. Many new plants are constantly coming into profitable use after experiment, and the list has been considerably enlarged during the last decade. The last twenty years have been remarkably fruitful in chemical researches, the laboratory being the leader of agricultural progress, especially in Germany. The Germans have studied the analysis and feeding-value of cattle foods more carefully, perhaps, than the agriculturists of any other country. Their numerous Experiment Stations have given them a great advantage in this respect, as these have joined science and practice together—worked out the actual results in feeding and compared them with the analysis. These experiments have not been carried far enough to determine food-values with absolute accuracy, but they are much in advance of our previous knowledge of the digestibility of foods. They have attempted to determine the money value, in the German market, of the nutritive ingredients in some of the most important stock foods in that country. Most of these are also fed in this country, and their figures, although not determined for this country, will, at least, be interesting to our readers. They figure the value of a food from the relative proportion of the three classes of digestible matters it contains; that is, the albuminoids, carbo-hydrates and fat. The Germans base the value of a food, not upon the actual amount of albuminoids, carbo-hydrates and fat it contains on analysis, but on the amount of each, *digestible;* and this is determined mostly by feeding experiments, but partly by calculation. It is considered highly important to know just the proportion that the digestible albuminoids bear to the digestible carbo-hydrates—and this proportion is called the *nutritive ratio.*

As we have seen in a previous chapter, the composition of animal bodies and vegetable bodies is the same. Every element in animal bodies must be contained in the food given. The albuminoids make the blood and tissues—the carbo-hydrates serve to keep up animal heat, and the surplus goes to lay on fat. Animals require more of the one or the other according to age and condition—therefore a knowledge of the composition of the different foods becomes of the highest importance to the successful feeder.

The investigations in Germany have stimulated American chemists to the analysis of American cattle foods, and within the last decade very many careful analyses of our wild and cultivated grasses and leguminous plants, as well as of our grains and waste products of their manufacture, have been made.

Our Department of Agriculture has done much in this field during the last few years. Yet it is but just to say that the Connecticut Experiment Station lead off in the effort to acquaint our farmers with the German work in this field.

We will first give the careful work of our American chemists in the analysis of our cattle foods. The following table is the work of our painstaking chemist of the Department of Agriculture, Professor Peter Collier.

In the investigation of our wild grasses it is the most extensive work that has been performed in this country. This table does not include all the analyses made of native grasses, but is intended to include all those of much value as agricultural plants. Some of these may prove of less value than supposed, and others left out may prove of more value than now believed.

This table gives an interesting investigation into the chemical composition of grasses at different stages of growth, and will be important as a reference in the consideration of the proper time for cutting grasses as cattle food.

ANALYSIS OF GRASSES AND FODDER PLANTS MADE IN THE YEARS 1878, 1879 AND 1880, BY DR. COLLIER, CHEMIST TO THE DEPARTMENT OF AGRICULTURE.

| VARIETIES. | Locality. | Nitrogen × 6.25. | Water. | Ash. | Fat. | Carbo-hydrates. | Crude fibre. | Albuminoids. | Nutritive ratio. |
|---|---|---|---|---|---|---|---|---|---|
| LEGUMINOUS PLANTS. | | | | | | | | | |
| Common vetch, *vicia sativa* | Dep.Gr. | 29.33 | 14.30 | 7.71 | 4.53 | 35.26 | 13.06 | 25.14 | 1: 1.24 |
| Japan clover, *Lespedeza striata* | Ala. | 15.08 | 14.30 | 3.88 | 3.76 | 44.82 | 20.32 | 12.92 | 1: 3.8 |
| Beggar Lice, *Desmodium molle* | S. C. | 18.96 | 14.30 | 6.65 | 2.38 | 38.70 | 21.72 | 16.25 | 1: 2.5 |
| Red clover, *Trifolium pratense*, before head | ........ | 24.50 | 7.68 | 8.58 | 7.03 | 46.06 | 11.15 | 24.50 | 1: 2.0 |
| Red clover, head formed | ........ | 23.10 | 9.45 | 8.05 | 5.25 | 42.30 | 11.85 | 23.10 | 1: 2.1 |
| Red clover, full bloom | ........ | 17.50 | 8.55 | 7.60 | 4.38 | 47.42 | 14.55 | 17.50 | 1: 3.0 |
| Red clover, after bloom | ........ | 16.58 | 8.36 | 6.64 | 4.23 | 45.94 | 18.25 | 16.58 | 1: 3.0 |
| Red clover, in seed | ........ | 14.00 | 8.15 | 6.75 | 3.65 | 49.90 | 17.55 | 14.00 | 1: 3.8 |
| Red clover, after math | ........ | 24.85 | 6.00 | 10.55 | 3.72 | 41.78 | 13.10 | 24.85 | 1: 1.8 |
| Vetch, *vicia sativa*, before bloom | ........ | 34.81 | 6.05 | 12.05 | 3.90 | 31.96 | 11.23 | 34.81 | 1: 1.0 |
| Vetch, in full bloom | ........ | 27.65 | 7.85 | 10.68 | 4.05 | 35.69 | 14.08 | 27.65 | 1: 4.0 |
| Vetch, bloom and seed | ........ | 23.10 | 7.86 | 11.44 | 3.63 | 35.42 | 18.55 | 23.10 | 1: 1.7 |
| Lucern—alfalfa, *Medicago sativa*, before head | ........ | 27.30 | 7.30 | 10.72 | 3.88 | 38.80 | 12.00 | 27.30 | 1: 1.6 |
| Lucern—alfalfa, before bloom | ........ | 19.60 | 8.28 | 8.92 | 3.95 | 41.40 | 17.85 | 19.60 | 1: 2.3 |
| Lucern—alfalfa, in bloom | ........ | 15.75 | 6.65 | 6.25 | 2.63 | 47.94 | 20.78 | 15.75 | 1: 3.2 |
| Beans, green | ........ | 28.02 | 4.50 | 4.50 | 2.43 | 57.65 | 2.90 | 28.02 | ...... |
| Beans, ripe | ........ | 25.09 | 6.60 | 3.80 | 1.93 | 59.15 | 3.43 | 25.09 | ...... |
| Beans, pods, very young | ........ | 13.63 | 8.50 | 8.80 | 1.96 | 47.58 | 19.53 | 13.63 | ...... |
| Beans, pods, green | ........ | 3.88 | 8.70 | 7.00 | 1.33 | 52.96 | 26.13 | 3.88 | ...... |
| Beans, pods, mature | ........ | 3.50 | 7.60 | 7.20 | 1.36 | 58.74 | 21.60 | 3.50 | ...... |
| Peas, green | ........ | 4.37 | 78.06 | .88 | .55 | 14.48 | 1.66 | 4.37 | ...... |
| Peas, same dry substance | ........ | 19.91 | ..... | 4.01 | 2.52 | 65.98 | 7.58 | 19.91 | ...... |
| Peas, pods, green | ........ | 1.54 | 83.17 | .88 | .53 | 14.97 | 2.91 | 1.54 | ...... |
| Peas, same dry substance | ........ | 9.17 | ..... | 5.22 | 3.14 | 65.18 | 17.29 | 9.17 | ...... |
| MISCELLANEOUS PLANTS. | | | | | | | | | |
| Ribwort plantain, *Plantag[illegible]anceolata* | N. H. | 10.64 | 14.30 | 6.42 | 3.82 | 47.52 | 18.82 | 9.12 | 1: 5.6 |
| Mexican clover, *Richardso[illegible]a scabra* | Ala. | 5.98 | 14.30 | 7.16 | 2.65 | 45.18 | 25.59 | 5.12 | 1: 9.3 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| GRANSINEÆ. | | | | | | | | | |
| California broom grass, *Bromus carinatus* | Ill. | 9.92 | 14.30 | 9.32 | 2.30 | 42.67 | 22.91 | 8.50 | 1: 5.3 |
| Common cheat or chess, *Bromus secalina* | N. H. | 7.71 | 14.30 | 6.10 | 3.49 | 49.11 | 20.39 | 6.61 | 1: 8.2 |
| Crowfoot grass, *Eleusina Indica* | Texas. | 13.60 | 14.30 | 6.49 | 1.83 | 29.15 | 26.58 | 11.65 | 1: 2.6 |
| Bermuda grass, *Cynodon dactylon* | Miss. | 10.69 | 14.30 | 8.49 | 1.83 | 46.06 | 20.16 | 9.16 | 1: 5.2 |
| Smut grass, *Sporobolus Indicus* | Miss. | 12.35 | 14.30 | 6.03 | 2.80 | 44.28 | 22.00 | 10.59 | 1: 4.4 |
| Crab grass, *Panicum sanguinale* | Ala. | 9.78 | 14.30 | 10.81 | 2.42 | 36.59 | 27.50 | 8.38 | 1: 4.7 |
| Guinea grass, *Panicum jumentorum* | Ala. | 8.89 | 14.30 | 7.75 | 1.34 | 41.98 | 27.01 | 7.62 | 1: 5.7 |
| Barnyard grass, *Panicum Crusgalli* | Ala. | 7.77 | 14.30 | 5.98 | 1.84 | 46.44 | 24.78 | 6.66 | 1: 7.2 |
| Texas Millet, *Panicum Texanum* | Texas. | 5.48 | 14.30 | 8.65 | 2.12 | 47.07 | 23.16 | 4.70 | 1: 10.5 |
| Tall panic grass, *Panicum virgatum* | Ind. T. | 5.12 | 14 30 | 4.70 | 2.85 | 48.81 | 24.95 | 4.39 | 1: 11.8 |
| Johnson's grass, *Sorghum halapense* | Ala. | 11.80 | 14.30 | 6.92 | 2.43 | 44.77 | 21.47 | 10.11 | 1: 4.7 |
| Wood grass, *Sorghum nutans* | Texas. | 3.20 | 14 30 | 7.86 | 1.40 | 43.12 | 30.58 | 2.74 | 1: 16.2 |
| Fowl meadow-grass, *Poa serotina* | Wis. | 8.82 | 14.30 | 4.46 | 2.95 | 49.00 | 21.73 | 7.56 | 1: 6.9 |
| English blue grass, *Poa compressa* | N. H. | 6.27 | 14.30 | 3.63 | 2 43 | 56 40 | 17.87 | 5.37 | 1: 10.9 |
| Quack grass, *Triticum repens* | N. H. | 11.48 | 14.30 | 7.99 | 3.02 | 48.22 | 16.63 | 9.84 | 1: 5.2 |
| Native red top, *Agrostis exarata* | Wis. | 10.61 | 14.30 | 5.10 | 1.97 | 48.53 | 21.01 | 9.09 | 1: 5.6 |
| Marsh grass, *Spartina cynosuroides* | Grounds | 9.81 | 14.30 | 6.19 | 2.93 | 46.07 | 22.10 | 8.41 | 1: 5.8 |
| Reed meadow-grass, *Glyceria aquatica* | Vt. | 8.13 | 14.30 | 6.26 | 1.89 | 48.64 | 21.94 | 6.97 | 1: 7.3 |
| Mountain oat grass, *Avena Striata* | Vt. | 8.75 | 14.30 | 4.25 | 3.43 | 48.10 | 22.42 | 7.50 | 1: 6.9 |
| Gama grass, *Tripsacum dactyloides* | Miss. | 8.60 | 14.30 | 5.30 | 2.05 | 48.26 | 22.72 | 7.37 | 1: 6.8 |
| Grama grass, *Bouteloua oligostachya* | Grounds | 8.58 | 14.30 | 6.69 | 2.67 | 49.58 | 19.41 | 7.35 | 1: 7.1 |
| Pigeon grass, *Setaria setosa* | Texas. | 8.49 | 14.30 | 7.78 | 1.28 | 41.68 | 27.68 | 7.28 | 1: 5.9 |
| Foxtail, pigeon grass, *Setaria Glauca*, very young | ........ | 16.24 | 4.55 | 10.35 | 2.23 | 45.93 | 20.70 | 16.24 | 1: 3.0 |
| Foxtail, pigeon grass, early flowering | ........ | 8.58 | 5.05 | 6.90 | 2.53 | 52.49 | 24.45 | 8.58 | 1: 6.4 |
| Water grass, *Paspalum loeve* | Texas. | 8.11 | 14.30 | 6.60 | 2.36 | 46.13 | 23.66 | 6.95 | 1: 7.0 |
| Blue joint grass, *Andropogon furcatus* | Grounds | 8.05 | 14.30 | 4.36 | 2 59 | 49.87 | 21.98 | 6.90 | 1: 7.6 |
| Broom grass, *Andropogon scoparius* | Ala. | 5.65 | 14.30 | 5.00 | 1.35 | 53.39 | 21.12 | 4.84 | 1: 11.3 |
| Crowfoot grass, *Dactylotoenium Ægypticum* | Ga. | 8.05 | 14.30 | 6.08 | 1.66 | 56.21 | 14.85 | 6.90 | 1: 8.4 |
| Tall red top, or purple, *Tricuspis sesleroides* | Texas. | 6.30 | 14.30 | 4.40 | 1.73 | 41.84 | 32.33 | 5.40 | 1: 8.1 |
| Wild oat grass, *Danthonia compressa* | Vt. | 7.98 | 14.30 | 3.06 | 3.02 | 46.80 | 25 98 | 6.84 | 1: 7.3 |
| Feather grass, *Leptochloa mucronata* | Texas. | 7.70 | 14.30 | 10.08 | 1 76 | 40.06 | 27.20 | 6.60 | 1: 6.3 |
| CULTIVATED GRASSES. | | | | | | | | | |
| June grass, *Poa pratensis* | Wis. | 11.54 | 14.30 | 4.46 | 2.45 | 44.96 | 23.94 | 9.89 | 1: 4.8 |
| Blue grass, *Poa pratensis* | N. H. | 7.50 | 14.30 | 4.69 | 4.24 | 57.08 | 19.26 | 6.43 | 1: 8.6 |
| Sheep fescue, *Festuca ovina* | N. H. | 6.53 | 14.30 | 4.31 | 3.65 | 72.14 | ..... | 5.60 | ...... |
| Orchard grass, *Dactylis glomerata* | N. H. | 8.41 | 14.30 | 7.23 | 2.99 | 46.92 | 21.35 | 7.21 | 1: 7.0 |
| Red top, *Agrostis vulgaris*, panicle not out | ........ | 12.25 | 7.15 | 7.60 | 3.50 | 50.03 | 19.47 | 12.25 | 1: 4.4 |
| Red top, panicle out | ..... . | 12.60 | 7.40 | 6.80 | 3.75 | 50.12 | 19.33 | 12.60 | 1: 4.3 |
| Red top, early bloom | ...... .. | 11.88 | 6.65 | 7.05 | 3.38 | 50.84 | 20.20 | 11.88 | 1: 4.6 |
| Red top, full bloom | ........ | 10.31 | 6.45 | 6.80 | 2.68 | 53.16 | 20.60 | 10.31 | 1: 5.4 |

ANALYSIS OF GRASSES AND FODDER PLANTS—*Continued.*

| VARIETIES. | Locality. | Nitrogen × 6.25. | Water. | Ash. | Fat. | Carbo-hydrates. | Crude fibre. | Albuminoids. | Nutritive ratio. |
|---|---|---|---|---|---|---|---|---|---|
| Timothy, *Phleum pratense*, spike invisible | ........ | 11.55 | 7.85 | 8.00 | 4.20 | 50.05 | 18.35 | 11.55 | 1: 4.7 |
| Timothy, spike visible | ........ | 10.85 | 8.80 | 5.85 | 3.10 | 52.22 | 19.18 | 10.85 | 1: 5.1 |
| Timothy, before bloom | ........ | 9.63 | 6.80 | 9.15 | 3.38 | 50.51 | 20.53 | 9.63 | 1: 5.6 |
| Timothy, early bloom | ........ | 9.63 | 5.60 | 5.70 | 3.63 | 54.01 | 21.43 | 9.63 | 1: 6.0 |
| Timothy, full bloom | ........ | 9.28 | 6.30 | 5.30 | 3.35 | 55.22 | 20.55 | 9.28 | 1: 6.3 |
| Timothy, early seed | ........ | 11.38 | 5.95 | 9.90 | 3.20 | 47.09 | 22.48 | 11.38 | 1: 4.4 |
| Orchard grass, *Dactylis glomorata*, panicle not out | ........ | 15.05 | 5.75 | 9.70 | 3.88 | 47.94 | 17.68 | 15.05 | 1: 3.4 |
| Orchard grass, panicle closed | ........ | 9.63 | 7.35 | 7.65 | 2.90 | 50.99 | 21.48 | 9 63 | 1: 5.6 |
| Orchard grass, full bloom | ........ | 8.92 | 6.40 | 7.55 | 3.03 | 50.32 | 23.78 | 8.92 | 1: 6.0 |
| Orchard grass, after bloom | ........ | 7.52 | 8.84 | 8.21 | 2.58 | 48.00 | 24.85 | 7.52 | 1: 6.7 |
| Meadow foxtail, *Alopecurus pratensis*, before head | ........ | 14.35 | 8.75 | 8.40 | 4.28 | 47.60 | 16.62 | 14.35 | 1: 3.6 |
| Meadow foxtail, before bloom | ........ | 12.25 | 9.83 | 7.12 | 4.02 | 46.58 | 20.20 | 12.25 | 1: 4.1 |
| Meadow foxtail, in bloom | ........ | 9.98 | 7.70 | 7.15 | 3.10 | 50.12 | 21 95 | 9.98 | 1: 5.3 |
| Meadow foxtail, after bloom | ........ | 7.88 | 8.58 | 7.41 | 3.20 | 49.69 | 23.18 | 7.88 | 1: 6.7 |
| Meadow soft grass, *Holchus lanatus*, very young | ........ | 11.20 | 9.45 | 9.04 | 4.10 | 49.33 | 16.88 | 11.20 | 1: 4.8 |
| Meadow soft grass, late bloom | ........ | 6.81 | 7.43 | 7.62 | 3.60 | 51.39 | 23.15 | 6.81 | 1: 8.1 |
| Sweet vernal grass, *Anthoxanthum odoratum*, very young | ........ | 9.80 | 7.50 | 5.91 | 3.95 | 56.96 | 15.88 | 9.80 | 1: 6.2 |
| Sweet vernal grass, full bloom | ........ | 8.75 | 7.65 | 6.55 | 3.10 | 54.90 | 19.05 | 8.75 | 1: 6.6 |
| Sweet vernal grass, after bloom | ........ | 12.44 | 6.45 | 6.80 | 4.55 | 49.96 | 19.80 | 12.44 | 1: 4.4 |
| Sweet vernal grass, after bloom, brown | ........ | 6.63 | 6.80 | 5.40 | 3.80 | 54.07 | 23.30 | 6.63 | 1: 8.7 |
| Italian rye grass, *Lolium Italicum*, before head | ........ | 20.12 | 7.00 | 12.35 | 4.55 | 39.10 | 16.88 | 20 12 | 1: 2.2 |
| Italian rye grass, after head | ........ | 13.13 | 8.25 | 10.45 | 3.50 | 44.72 | 19.95 | 13.13 | 1: 3.7 |
| Italian rye grass, full bloom | ........ | 13.65 | 5.82 | 10.38 | 2.18 | 48.72 | 19.25 | 13.65 | 1: 3.7 |
| Italian rye grass, after bloom | ........ | 10.68 | 7.82 | 8.08 | 3.67 | 49.60 | 20.15 | 10.68 | 1: 5.0 |
| Common darnell rye grass, *Lolium perenne*, before head | ........ | 10.85 | 7.00 | 8.05 | 3.33 | 53.67 | 17.10 | 10.85 | 1: 5.3 |
| Common darnell rye grass, head well out | ........ | 10.32 | 7.05 | 7 40 | 3.38 | 52.75 | 19.10 | 10.32 | 1: 5.4 |
| Common darnell rye grass, before bloom | ........ | 8.40 | 6.60 | 7.85 | 3.50 | 51.30 | 22.35 | 8.40 | 1: 6.5 |
| Common darnell rye grass, after bloom | ........ | 7.00 | 7.95 | 6.90 | 2.43 | 52.32 | 23.40 | 7.00 | 1: 7.8 |

The foregoing table of analyses, by Prof. Collier, of our wild grasses, including many considered as troublesome weeds, is a most valuable contribution to the chemistry of cattle foods, and a few years more of equal industry, in this section of the Department of Agriculture, will leave but few of our known fodder plants unanalyzed.

The great diversity of our soil and climate will often render a grass valuable in one section which is found of no economical value in another locality. Chemistry, by showing the proportion of nutritive constituents in a grass, which is found to grow good crops in any section of country, will enable any one to determine its economic value for cultivation in that locality. Every grass must be brought to a practical test in cultivation before its value can be determined for any locality, but a knowledge of its chemical analysis will give an experimenter confidence in the probable value of his labor.

A large number of the grasses in this table seem to be specially adapted to the Southern States. We shall only glance at a few of them:

Desmodium—tick-seed, beggar-ticks—is a deep-rooted leguminous plant, which has attracted much attention in the South as a plant that may take the place of clover, in the rotation, on soil that will not sustain clover. It takes its name from the rough seed-pods, which adhere to clothing. Its analysis shows it to be fully equal, in the proportion of nitrogen and other nutritive constituents, to clover. The reports are that it flourishes even on the sand barrens of the Atlantic seaboard. It is found excellent as pasture and as hay—having an effect similar to clover when plowed under. It is annual.

Japan Clover.—This is another leguminous forage plant, lately established in Southern States, and supposed to have been brought in tea-boxes from Japan or

China. Said not to flourish north of 36°; but grows strongly on soils supposed to be exhausted by cultivation, stands the severest droughts, its long tap root reaching moisture; is perennial and retains its foothold without re-seeding, is much relished by stock as pasture and as hay. This is also excellent for plowing under, but having less nitrogen than *Desmodium.*

MEXICAN CLOVER.—This has been considered a troublesome plant in cultivated fields in Florida, but has lately been found very valuable as a green soiling plant. It grows rapidly and is very succulent and relished green by all stock. It is grown by the orange planters among their groves as a shade and mulch in the hot season, cut and fed green to stock. It is so watery as to be difficult of curing into hay. The reports are that it produces much more forage than clover, growing more than four feet high and thick set, and on soil too poor for clover. It appears to be a very valuable plant where it succeeds, and is likely to grow well along the whole seaboard of the gulf. It is a native of Mexico and South America.

SATIN GRASS (*Muhlenbergia glomerata*).—This grows in wet meadows, and is also found on sandy barrens in the Northern and Western States. Its analysis shows it to be a valuable grass if it can be grown in respectable quantity. It is reported from Colorado and Kansas as an excellent grass for hay. Having a creeping root, it must produce a good strong sward for pasture. It has the largest proportion of nitrogen of any of the wild grasses analyzed. It certainly merits a thorough test. Another variety of this, *M. Diffusa,* drop-seed grass, has a reputation in Kentucky, Tennessee and North Carolina as a pasture grass.

SHRADER'S GRASS is found valuable for winter grazing. It grows early and is leafy, producing much pasturage. Its analysis shows it very nutritious.

Bermuda Grass is a low, perennial creeping grass, with abundant short leaves at the base, but a slender, nearly leafless flower-stalk. It is the chief reliance for pasture in the South. Its creeping root renders it difficult to eradicate in cultivated fields. But, thriving in arid, barren drift-sands of the seashore, it is appreciated and prized as a great resource. It has the capacity to withstand great heat and drought, being green and fresh when blue grass is dried up. The analysis shows it to be very nutritious. It is not reproduced from seed, but sections of its roots covered shallow with the plow.

The Crab Grasses (*Panicum sanguinale, P. filliforme, P. proliferum, P. divaricatum, Eleusina Indica,* etc.) are all found to thrive in the southern climate and to assist greatly in pasturage; and it will be seen by their analyses that they are well adapted to produce growth and flesh upon animals.

Texas Millet (*Panicum Texanum*), is an annual grass, growing two to four feet high, very leafy, grows best in the hottest part of the season, and reported to make most excellent hay. It is said in Texas to produce a larger crop than millet, and to be well liked by all stock.

Quack Grass (*Triticum repens*), considered a most troublesome weed and a pest in cultivated fields, is seen in analysis to be a very nutritious grass, and, in hay, cattle are very fond of it. Its nutritive ratio shows it to be superior to timothy, and creeping roots attach it so strongly to the soil as to render it a success in all localities. We have seen it so heavy in patches as to yield at the rate of two tons per acre. In a permanent pasture it is one of the most valuable grasses, and not at all objectionable in a meadow. It is impartial, spreading its virtues and vices over all soils and climates.

Wire Grass—English Blue Grass (*Poa compressa*).—This grass is sometimes mistaken for *Poa pratensis*, June grass, but is easily distinguished from the latter by its shorter and flattened stalk, shorter leaves, shorter and narrower panicle, with fewer branches. It has a remarkably solid stalk and produces a very heavy hay for its bulk. It does not produce a large crop, yielding, even on rich land, not more than 1½ tons per acre; but it has a value, per weight, 15 per cent. more than timothy hay. It never kills out by freezing, and its creeping root makes it very desirable as a pasture grass. It affords early and late pasturage. Its analysis gives it a high position in the scale of nutritious grasses.

Gama Grass.—This is a tall perennial grass, growing from three even to six feet high, with broad leaves, somewhat like Indian corn. It is found native at the South, from the mountains to the coast. When cut before seed-heads appear, it is said to make a nutritious hay. It starts immediately after cutting, and affords three or four green crops in a season. Cattle and horses are fond of it cured into hay. The roots are very strong and run deep, which gives it vitality to stand drought. It must be a most valuable grass for soiling.

Grama Grass (*Bouteloua oligostachya*).—This name is given to several species of *Bouteloua* found on the great plains on the eastern slope of the Rocky Mountains and the high table-lands of Texas. They are valuable grazing grasses. They grow in bunches with a mass of short leaves at the base. Its value is so great for the plains that efforts have been made to cultivate it on the moister lands of the sea-coast without success.

We shall have occasion to refer to some other of these grasses in application to pasture, meadow and soiling.

AVERAGE COMPOSITION, DIGESTIBILITY AND MONEY VALUE OF FEEDING STUFFS, AS GIVEN BY DR. WOLF FOR GERMANY, WITH A FEW AMERICAN ANALYSES.

| KIND OF FODDER. | Water. | Ash. | ORGANIC SUBSTANCES. Albuminoids. | Fibre. | Other Carbo-hydrates. | Fat. | DIGESTIBLE NUTRIENTS. Albuminoids. | Carbo-hydrates, including fibre. | Fat. | Nutritive ratio. | Value per 100 lbs. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| HAY. | % | % | % | % | % | % | % | % | % | as 1: | $ |
| Meadow hay, poor | 14.3 | 5.0 | 7.5 | 33.5 | 38.2 | 1.5 | 3.4 | 34.9 | 0.5 | 10.6 | 0.48 |
| Meadow hay, better | 14.3 | 5.4 | 9.2 | 29:2 | 39.7 | 2.0 | 4.6 | 36.4 | 0.6 | 8.3 | 0.55 |
| Meadow hay, medium | 14.3 | 6.2 | 9.7 | 26.3 | 41.4 | 2.5 | 5.4 | 41.0 | 1.0 | 8.0 | 0.64 |
| Meadow hay, very good | 15.0 | 7.0 | 11.7 | 21.9 | 41 6 | 2.8 | 7.4 | 41.7 | 1.3 | 6.1 | 0.75 |
| Meadow hay, extra | 16.0 | 7.7 | 13.5 | 19.3 | 40.4 | 3.0 | 9.2 | 42.8 | 1.5 | 5.1 | 0.85 |
| Red clover, poor | 15.0 | 5.1 | 11.1 | 28.9 | 37.7 | 2.1 | 5.7 | 37.9 | 1.0 | 7.1 | 0.59 |
| Red clover, medium | 16.0 | 5.3 | 12.3 | 26.0 | 38.2 | 2.2 | 7.0 | 38.1 | 1.2 | 5.9 | 0.70 |
| Red clover, very good | 16.5 | 6.0 | 13.5 | 24.0 | 37.1 | 2.9 | 8.5 | 38.2 | 1.7 | 5.0 | 0.79 |
| Red clover, extra | 16.5 | 7.0 | 15.3 | 22.2 | 35.8 | 3.2 | 10.7 | 37.6 | 2.1 | 4.0 | 0.89 |
| White clover, medium | 16.5 | 6.0 | 14.5 | 25.6 | 33.9 | 3.5 | 8.1 | 35.9 | 2.0 | 5.0 | 0.76 |
| Clover hay, damaged by rain | 14.5 | 6.6 | 15.8 | 52.7 | 23.4 | 3.3 | .... | .... | ... | .... | .... |
| Hay of pure red clover | 16.0 | 5.6 | 13.4 | 25.4 | 36.4 | 3 2 | .... | .... | ... | .... | .... |
| Lucerne, medium | 16.0 | 6.2 | 14.4 | 33.0 | 27.9 | 2.5 | 9.4 | 28.3 | 1.0 | 3.3 | 0.71 |
| Lucerne, very good | 16.5 | 6.8 | 16.0 | 26.6 | 31.6 | 2.5 | 12.3 | 31.4 | 1.0 | 2.8 | 0.86 |
| Swedish clover, Alsike | 16.0 | 6.0 | 15.0 | 27.0 | 32.7 | 3.3 | 8.6 | 34.8 | 1 8 | 4.6 | 0.76 |
| Hop clover | 16.7 | 6.0 | 14.6 | 26.2 | 33.2 | 3.3 | 9.2 | 36.4 | 2.0 | 4.5 | 0.81 |
| Trefoil | 16.7 | 5.1 | 12.2 | 30.4 | 32.6 | 3.0 | 6.2 | 34.9 | 1.4 | 6.2 | 0.64 |
| Seradella | 16.7 | 7.5 | 13.5 | 22.0 | 35.6 | 4.7 | 8.5 | 36.2 | 2.8 | 5.1 | 0.81 |
| Fodder vetch, medium | 16.7 | 8.3 | 14.2 | 25.5 | 32.8 | 2.5 | 9.4 | 32.5 | 1.5 | 3.9 | 0.77 |
| Fodder vetch, very good | 16.7 | 9.3 | 19.8 | 23.4 | 28.5 | 2.3 | 15.1 | 31.1 | 1.4 | 2.3 | 0.99 |
| Peas, in bloom | 16.7 | 7.0 | 14.3 | 25.2 | 34.2 | 2.6 | 9.4 | 33.1 | 1.6 | 4.0 | 0.77 |
| Lupine, medium | 16.7 | 4.6 | 17.1 | 28.5 | 30.9 | 2.2 | 11.3 | 37.3 | 0.7 | 3.4 | 0.86 |
| Lupine, very good | 16.7 | 4.1 | 23.2 | 25.2 | 28.6 | 2.2 | 17.2 | 36.0 | 0.7 | 2.2 | 1.10 |
| Fodder rye | 14.3 | 5.1 | 0.4 | 23.1 | 44.5 | 2.8 | 6.6 | 44.3 | 1.3 | 7.2 | 0.72 |
| Timothy | 14.3 | 4.5 | 9.7 | 22.7 | 45.8 | 3.0 | 5.8 | 43.4 | 1.4 | 8.1 | 0.70 |
| *Dr. Collier's Analyses:* | | | | | | | | | | | |
| Early meadow grass (*Poa annua*), in blossom | 14.3 | 2.4 | 10.1 | 25.9 | 47.2 | 2.9 | 6.0 | 42.5 | 2.1 | 7.9 | 0.74 |
| Orchard grass, in blossom | 14.3 | 4.6 | 11.6 | 28.9 | 40.7 | 2.7 | 6.9 | 40.3 | 1.9 | 6.5 | 0.74 |
| Sweet-scented vernal grass, in blossom | 14.3 | 5.4 | 8.9 | 31.2 | 40.2 | 2.9 | 5.9 | 40.1 | 2.1 | 7.6 | 0.70 |
| Blue grass (*Poa pratensis*), in blossom | 14.3 | 5.1 | 8.9 | 32.6 | 39.1 | 2.3 | 5.9 | 40.0 | 1.6 | 7.5 | 0.68 |
| Sheep fescue (*Festuca ovina*) | ..... | 3.6 | 8.8 | 25.1 | 57.1 | 3.6 | 8.8 | 57.1 | 3.6 | 6.9 | 0.85 |
| Red top (*Agrostis vulgaris*), in blossom | 6.4 | 6.8 | 10.3 | 20.6 | 53.1 | 2.6 | 10.3 | 53.1 | 2.6 | 5.4 | 0.82 |
| Meadow foxtail (*Alopecurus pratensis*), after blossom | 8.5 | 7.4 | 7.8 | 23.1 | 49.6 | 3.2 | 7.8 | 49.6 | 3.2 | 6.7 | 0.62 |
| Meadow soft grass (*Holchus lanatus*), very young | 9.45 | 9.0 | 11.2 | 16.8 | 49.3 | 4.1 | 11.2 | 49.3 | 4.1 | 4.8 | 0.85 |
| Meadow soft grass, late bloom | 7.4 | 7.6 | 6.81 | 23.1 | 51.3 | 3.6 | 6.8 | 51.3 | 3.6 | 8.1 | 0.73 |
| Fowl meadow grass (*Poa seratina*) | 14.3 | 4.4 | 8.8 | 21.7 | 49.0 | 2.9 | 7.5 | 49.0 | 2.9 | 6.9 | 0.69 |
| Wire grass (*Poa compressa*) | 14.3 | 3.6 | 6.2 | 17.8 | 56.4 | 2.4 | 5.37 | 56.4 | 2.4 | 10.9 | 0.66 |
| Wire grass, early bloom | 5.2 | 6.2 | 12.7 | 19.1 | 52.7 | 4.0 | 10.2 | 52.7 | 4.0 | 4.5 | 0.83 |
| Foxtail pigeon grass (*Setaria glauca*), early flowering | 5.0 | 6.9 | 8.6 | 24 4 | 52.4 | 2.5 | 8.5 | 52.4 | 2.5 | 6.4 | 0.70 |

AVERAGE COMPOSITION, ETC., OF FEEDING STUFFS—*Continued.*

| | KIND OF FODDER. | Water. | Ash. | ORGANIC SUBSTANCES. | | | | DIGESTIBLE NUTRIENTS. | | | Nutritive ratio. | Value per 100 lbs. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Albuminoids. | Fibre. | Other Carbo-hydrates. | Fat. | Albuminoids. | Carbo-hydrates, including fibre. | Fat. | | |
| | | % | % | % | % | % | % | % | % | % | as 1: | $ |
| Dr. Collier's Analyses. | Barnyard grass (*Panicum crusgalli*) | 14.3 | 5.9 | 7.8 | 24.7 | 46.4 | 1.8 | 6.7 | 46.4 | 1.8 | 7.2 | 0.65 |
| | Bermuda grass (*Cynodon dactylon*) | 14.3 | 8.4 | 10.7 | 20.2 | 46.0 | 1.8 | 9.16 | 46.0 | 1.8 | 5.2 | 0.71 |
| | Quack grass (*Triticum repens*) | 14.3 | 7.8 | 11.4 | 16.6 | 48.2 | 3.0 | 9.8 | 48.2 | 3.0 | 5.2 | 0.76 |
| | Gama grass (*Tripsacum dactyloides*) | 14.3 | 5.3 | 8.6 | 22.7 | 48.2 | 2.0 | 7.4 | 48.2 | 2.0 | 6.8 | 0.65 |
| | Grama grass (*Bouteloua oligostachya*) | 14.3 | 6.7 | 8.6 | 19 4 | 49.5 | 2.7 | 7.3 | 49.5 | 2.7 | 7.1 | 0.69 |
| American Hay. | Timothy | 13.5 | 3.9 | 6.2 | 28.9 | 45.8 | 1.7 | .... | .... | .... | .... | .... |
| | Timothy and red top | 14.3 | 5.5 | 7.6 | 26.5 | 44.1 | 2.0 | .... | .... | .... | .... | .... |
| | Timothy and blue grass | 14.3 | 4.7 | 7.0 | 26.9 | 45.4 | 1.7 | .... | .... | .... | .... | .... |
| | Mixed grasses, including above two | 14.3 | 5.1 | 7.3 | 26.7 | 44.9 | 1 8 | .... | .... | .... | .... | .... |
| | Containing clover | 14.3 | 5.4 | 10.9 | 24.1 | 43.0 | 2.3 | .... | .... | .... | .... | .... |
| | Low meadow hay | 10.0 | 5.8 | 7.4 | 30.8 | 43.8 | 2.2 | .... | .... | .... | .... | .... |
| | Salt marsh hay | 10.7 | 7.6 | 6.1 | 31.9 | 41.3 | 2.4 | .... | .... | .... | .... | .... |
| | Italian rye grass | 14.3 | 7.8 | 11.2 | 22.9 | 40 6 | 3.2 | 7.1 | 41.5 | 1.4 | 6.3 | 0.74 |
| | English rye grass | 14.3 | 6.5 | 10.2 | 30.2 | 36.1 | 2.7 | 5.1 | 35.3 | 0.8 | 7.3 | 0.57 |
| | French rye grass | 14.3 | 9.9 | 11.2 | 29.4 | 32.6 | 2.7 | 5.6 | 33.1 | 0.8 | 6.3 | 0.57 |
| | Upland grasses, average | 14.3 | 5.8 | 9.5 | 28.7 | 39.1 | 2.6 | 5.3 | 40.9 | 1.1 | 8.2 | 0.64 |
| | Hungarian grass | 13.4 | 5.7 | 10.8 | 29.4 | 38.5 | 2.2 | 6.1 | 41.0 | 0.9 | 7.1 | 0.66 |
| | Hungarian grass, mature samples | 16.7 | 5.8 | 5.9 | 28.1 | 42.1 | 1.4 | .... | .... | .... | .... | .... |
| | Brown hay of clover | 14.0 | 8.2 | 16.7 | 25.4 | 33.3 | 2.4 | .... | .... | .... | .... | .... |
| | Brown hay of grasses | 14.3 | 6 3 | 8.6 | 22.4 | 45.5 | 2.9 | .... | .... | .... | .... | .... |
| | Brown hay of maize | 79.3 | 1.5 | 1.0 | 7.0 | 10.1 | 1.1 | .... | .... | .... | .... | .... |
| | Brown hay of esparsette | 52.5 | 3.3 | 9.8 | 15.4 | 16.7 | 2.3 | .... | .... | .... | .... | .... |
| | GREEN FODDER. | | | | | | | | | | | |
| | Grass, just before bloom | 75.0 | 2.1 | 3.0 | 6.0 | 13.1 | 0.8 | 2.0 | 13.0 | 0.4 | 7.0 | 0.22 |
| | Pasture grass | 80.0 | 2.0 | 3.5 | 4.0 | 9.7 | 0.8 | 2.5 | 9.9 | 0.4 | 4.4 | 0.21 |
| | Rich pasture grass | 78.2 | 2.2 | 4.5 | 4.0 | 10.1 | 1.0 | 3.4 | 10.9 | 0.6 | 3.6 | 0.27 |
| | Italian rye grass | 73.4 | 2.8 | 3.6 | 7.1 | 12.1 | 1.0 | 2.3 | 12.6 | 0.4 | 5.9 | 0.23 |
| | English rye grass | 70.0 | 2.0 | 3.6 | 10.6 | 12.8 | 1.0 | 1.8 | 12.2 | 0.4 | 7.2 | 0 20 |
| | Timothy grass | 70.0 | 2.2 | 3.4 | 8.0 | 16.3 | 1.1 | 2.1 | 16.0 | 0.5 | 8.2 | 0.28 |
| | Upland grasses, average | 70.0 | 2.1 | 3.4 | 10.1 | 13.4 | 1.0 | 1.9 | 14.2 | 0.5 | 8.1 | 0.23 |
| | Maize fodder | 84.0 | 1.0 | 1.4 | 4.7 | 8.4 | 0.50 | .... | .... | .... | .... | .... |
| | Green Maize, german | 83.0 | 1.0 | 1.8 | 4.4 | 9.3 | 0.5 | 1.0 | 8.4 | 0.2 | 8.9 | 0.13 |
| | Spurry, *Spergula arvensis* | 79.2 | 2.3 | 2.9 | 6.1 | 8.8 | 0.70 | .... | .... | .... | .... | .... |
| | White mustard | 87.4 | 2.0 | 3.3 | 3.8 | 3.5 | .... | .... | .... | .... | .... | .... |
| | Parsnip leaves | 83.1 | 2.6 | 1.8 | 2.2 | 9.9 | 0.4 | .... | .... | .... | .... | .... |
| | Sweet clover | 87.4 | 2.1 | 2.9 | 3.6 | 3.5 | 0.4 | .... | .... | .... | .... | .... |
| | Green leaves, of trees | 61.1 | 4.0 | 5.2 | 13.0 | 15.2 | 1.5 | .... | .... | .... | .... | .... |
| | Fodder rye | 76.0 | 1.6 | 3.3 | 7.9 | 10.4 | 0.8 | 1.9 | 11.0 | 0.4 | 6.3 | 0.20 |
| | Fodder oats | 81.0 | 1.4 | 2.3 | 6.5 | 8.3 | 0.5 | 1.3 | 8.9 | 0.2 | 7.2 | 0.15 |
| | Sorghum | 77.3 | 1.1 | 2.5 | 6.7 | 11.7 | 0.7 | 1.6 | 11.9 | 0.3 | 7.4 | 0.19 |
| | Hungarian, in blossom | 75.0 | 1.8 | 3.1 | 8.5 | 10.9 | 0.7 | 1.8 | 11.8 | 0.3 | 7.0 | 0.20 |
| | Pasture clover, young | 83.0 | 1.5 | 4.6 | 2.8 | 7.2 | 0.9 | 3.6 | 7.4 | 0.6 | 2.5 | 0.25 |
| | Red clover, before blossom | 83.0 | 1.5 | 3.3 | 4.5 | 7.0 | 0.7 | 2.3 | 7.4 | 0.5 | 3.8 | 0.19 |

AVERAGE COMPOSITION, ETC., OF FEEDING STUFFS—*Continued.*

| Kind of Fodder. | Water. | Ash. | Organic Substances. | | | | Digestible Nutrients. | | | Nutritive ratio. | Value per 100 lbs. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Albuminoids. | Fibre. | Other Carbo-hydrates. | Fat. | Albuminoids. | Carbo-hydrates, including fibre. | Fat. | | |
| | % | % | % | % | % | % | % | % | % | as 1: | $ |
| Red clover, in full blossom | 80.4 | 1.3 | 3.0 | 5.8 | 8.9 | 0.6 | 1.7 | 8.7 | 0.4 | 5.7 | 0.17 |
| White clover, in blossom | 80.5 | 2.0 | 3.5 | 6.0 | 7.2 | 0.8 | 2.2 | 7.9 | 0.5 | 4.2 | 0.19 |
| Swedish clover, at beginning of blossom | 85.0 | 1.5 | 3.3 | 4.5 | 5.1 | 0.6 | 2.1 | 5.8 | 0.4 | 3.2 | 0.17 |
| Esparsette | 80.0 | 1.5 | 3.2 | 6.5 | 8.2 | 0.6 | 2.1 | 8.0 | 0.3 | 4.1 | 0.18 |
| Trefoil | 81.5 | 1.6 | 2.7 | 6.2 | 7.3 | 0.7 | 1.5 | 7.5 | 0.3 | 5.5 | 0.15 |
| Hop clover | 80.0 | 1.5 | 3.5 | 6.0 | 8.2 | 0.8 | 2.2 | 8.7 | 0.5 | 4.6 | 0.18 |
| Seradella | 80.0 | 1.8 | 3.0 | 5.2 | 8.9 | 1.1 | 1.9 | 8.9 | 0.7 | 5.6 | 0.18 |
| Incarnate clover | 82.0 | 1.6 | 2.8 | 6.2 | 6.7 | 0.70 | .... | .... | .... | .... | .... |
| Medich, *Medicago lupulina* | 79.0 | 1.5 | 3.5 | 6.9 | 8.2 | 0.85 | .... | .... | .... | .... | .... |
| Lupine, medium | 85.0 | 0.7 | 3.1 | 5.1 | 5.7 | 0.4 | 2.0 | 6.7 | 0.2 | 3.6 | 0.16 |
| Lupine, very good | 85.0 | 0.7 | 4.2 | 4.5 | 5.2 | 0.4 | 3.1 | 6.5 | 0.2 | 2.3 | 0.20 |
| Field beans, at beginning of blossom | 87.3 | 1.0 | 2.8 | 3.5 | 5.1 | 0.3 | 2.0 | 5.2 | 0.2 | 2.8 | 0.14 |
| Fodder vetch, at beginning of blossom | 82.0 | 1.8 | 3.5 | 5.5 | 6.6 | 0.6 | 2.5 | 6.7 | 0.3 | 3.0 | 0.18 |
| Fodder peas, in blossom | 81.5 | 1.5 | 3.2 | 5.6 | 7.6 | 0.6 | 2.2 | 7.4 | 0.3 | 3.7 | 0.18 |
| Buckwheat, in blossom | 85.0 | 1.4 | 2.4 | 4.2 | 6.4 | 0.6 | 1.5 | 6.6 | 0.4 | 5.1 | 0.14 |
| Green rape | 87.0 | 1.6 | 2.9 | 4.2 | 3.7 | 0.6 | 2.0 | 4.8 | 0.4 | 2.9 | 0.15 |
| Fodder cabbage | 84.7 | 1.6 | 2.5 | 2.4 | 8.1 | 0.7 | 1.8 | 8.2 | 0.4 | 5.2 | 0.17 |
| White cabbage | 89.0 | 1.2 | 1.5 | 2.0 | 5.9 | 0.4 | 1.1 | 6.0 | 0.2 | 5.8 | 0.11 |
| Cabbage stems | 82.0 | 1.9 | 1.1 | 2.8 | 11.9 | 0.3 | 0.8 | 11.5 | 0.2 | 15.0 | 0.15 |
| Potato tops, October | 78.0 | 3.0 | 2.3 | 6.0 | 9.7 | 1.0 | 1.0 | 8.3 | 0.3 | 9.0 | 0.13 |
| Carrot leaves | 82.2 | 3.6 | 3.2 | 3.0 | 7.1 | 1.0 | 2.2 | 7.0 | 0.5 | 3.8 | 0.18 |
| Fodder beet leaves | 90.5 | 1.8 | 1.9 | 1.3 | 4.0 | 0.5 | 1.2 | 4.0 | 0.2 | 3.7 | 0.10 |
| Rutabaga leaves | 88.4 | 2.3 | 2.1 | 1.6 | 5.2 | 0.5 | 1.5 | 5.1 | 0.3 | 3.9 | 0.12 |
| Kohl-rabi leaves | 85.0 | 1.8 | 2.8 | 1.4 | 8.2 | 0.8 | 2.0 | 7.6 | 0.4 | 4.3 | 0.17 |
| Artichoke tops | 80.0 | 2.7 | 3.3 | 3.4 | 9.8 | 0.8 | 2.0 | 9.4 | 0.4 | 5.2 | 0.19 |
| Fermented hay from maize | 83.5 | 1.1 | 1.2 | 5.3 | 8.9 | 0.9 | 0.8 | 8.6 | 0.4 | 12.0 | 0.13 |
| Fermented hay from lupine | 79.9 | 2.9 | 3.1 | 6.8 | 6.5 | 0.8 | 2.4 | 7.0 | 0.3 | 3.2 | 0.15 |
| Fermented hay from beet leaves | 80.0 | 4.1 | 3.0 | 2.7 | 9.0 | 1.2 | 2.0 | 6.3 | 0.7 | 4.0 | 0.17 |
| Fermented hay from potato tops | 77.0 | 5.3 | 2.9 | 4.7 | 7.5 | 2.6 | 1.2 | 6.2 | 1.3 | 8.0 | 0.16 |
| Fermented hay from red clover | 79.2 | 2.1 | 4.2 | 5.9 | 6.4 | 2.2 | 2.8 | 7.2 | 1.7 | 4.1 | 0.26 |
| STRAW. | | | | | | | | | | | |
| Winter wheat straw | 14.3 | 4.6 | 3.0 | 40.0 | 36.9 | 1.2 | 0.8 | 35.6 | 0.4 | 45.8 | 0.37 |
| Winter spelt straw | 14.3 | 5.2 | 2.3 | 46.5 | 30.8 | 1.45 | 0.7 | 36.5 | 0.4 | 52.0 | 0.37 |
| Winter rye straw | 14.3 | 4.1 | 3.0 | 44.0 | 33.3 | 1.3 | 0.8 | 36.5 | 0.4 | 46.9 | 0.35 |
| Winter barley straw | 14.3 | 5.5 | 3.3 | 43.0 | 32.5 | 1.4 | 0.8 | 31.4 | 0.4 | 40.5 | 0.33 |
| Summer barley | 14.3 | 4.1 | 3.5 | 40.0 | 36.7 | 1.4 | 1.3 | 40.6 | 0.5 | 32.2 | 0.44 |
| Barley straw, with clover | 14.3 | 6.7 | 6.5 | 38.0 | 32.5 | 2.0 | 3.3 | 38.8 | 0.9 | 12.4 | 0.53 |
| Oat straw | 14.3 | 4.0 | 4.0 | 39.5 | 36.2 | 2.0 | 1.4 | 40.1 | 0.6 | 29.9 | 0.45 |
| Summer grain straws, medium | 14.3 | 4.1 | 3.8 | 39.7 | 36.4 | 1.7 | 1.4 | 40.4 | 0.7 | 31.0 | 0.45 |
| Summer grain straws, very good | 14.3 | 6.7 | 6.9 | 36.7 | 32.9 | 2.5 | 2.5 | 36.9 | 0.8 | 15.5 | 0.47 |
| Winter grain straws, medium | 14.3 | 4.8 | 3.0 | 42.0 | 34.9 | 1.3 | 0.8 | 36.0 | 0.4 | 46.3 | 0.37 |
| Winter grain straws, very good | 14.3 | 5.3 | 4.5 | 37.8 | 36.7 | 1.4 | 1.2 | 34.3 | 0.4 | 29.4 | 0.37 |
| Fodder vetch | 16.0 | 4.5 | 7.5 | 42.0 | 29.0 | 1.0 | 3.4 | 31.9 | 0.5 | 9.8 | 0.46 |
| Pea | 16.0 | 4.5 | 6.5 | 38.0 | 34.0 | 1.0 | 2.9 | 33.4 | 0.5 | 12.0 | 0.44 |
| Field bean | 16.0 | 4.6 | 10.2 | 34.0 | 34.2 | 1.0 | 5.0 | 35.2 | 0.5 | 7.3 | 0.55 |
| Straw of legumes, medium | 16.0 | 4.5 | 8.1 | 38.0 | 32.4 | 1.0 | 3.8 | 33.5 | 0.5 | 9.7 | 0.48 |

AVERAGE COMPOSITION, ETC., OF FEEDING STUFFS—*Continued.*

| KIND OF FODDER. | Water. | Ash. | ORGANIC SUBSTANCES. | | | | DIGESTIBLE NUTRIENTS. | | | Nutritive ratio. | Value per 100 lbs. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Albuminoids. | Fibre. | Other Carbo-hydrates. | Fat. | Albuminoids. | Carbo-hydrates, including fibre. | Fat. | | |
| | % | % | % | % | % | % | % | % | % | as 1: | $ |
| Straw of legumes, very good | 16.0 | 5.1 | 10.2 | 34.5 | 33.2 | 1.0 | 5.0 | 34.6 | 0.6 | 7.2 | 0.55 |
| Lentils | 16.0 | 6.5 | 14.0 | 33.6 | 27.9 | 2.0 | 6.9 | 30.8 | 1.2 | 4.7 | 0.68 |
| Lupine straw | 16.0 | 4.1 | 5.9 | 40.8 | 32.1 | 1.1 | 2.2 | 41.6 | 0.3 | 19.4 | 0.48 |
| Seed clover | 16.0 | 5.6 | 9.4 | 42.0 | 25.0 | 2.0 | 4.2 | 28.5 | 1.0 | 7.4 | 0.49 |
| Rape | 16.0 | 4.1 | 3.5 | 40.0 | 35.4 | 1.0 | 1.4 | 35.0 | 0.5 | 25.9 | 0.39 |
| Buckwheat straw | 12.1 | 5.2 | 4.1 | 44.3 | 32.9 | 1.4 | 1.4 | 36.0 | 0.4 | 26.4 | 0.40 |
| Corn stalks | 15.0 | 4.2 | 3.0 | 40.0 | 36.7 | 1.0 | 1.1 | 37.0 | 0.3 | 34.4 | 0.39 |
| CHAFF AND HULLS. | | | | | | | | | | | |
| Wheat | 14.3 | 9.2 | 4.3 | 36.0 | 34.6 | 1.4 | 1.4 | 32.8 | 0.4 | 24.1 | 0.37 |
| Rye | 14.3 | 7.5 | 3.6 | 43.5 | 29.9 | 1.2 | 1.1 | 34.9 | 0.4 | 32.6 | 0.37 |
| Oats | 14.3 | 10.0 | 4.0 | 34.0 | 36.2 | 1.5 | 1.6 | 36.6 | 0.6 | 23.8 | 0.39 |
| Barley | 14.3 | 13.0 | 3.0 | 30.0 | 38.2 | 1.5 | 1.2 | 35.0 | 0.6 | 30.4 | 0.38 |
| Vetch | 15.0 | 8.0 | 8.5 | 33.0 | 33.5 | 2.0 | 4.2 | 34.3 | 1.2 | 8.9 | 0.54 |
| Pea | 15.0 | 6.0 | 8.1 | 32.0 | 36.9 | 2.0 | 4.0 | 36.2 | 1.2 | 9.8 | 0.55 |
| Bean | 15.0 | 5.5 | 10.5 | 33.0 | 34.0 | 2.0 | 5.1 | 34.7 | 1.2 | 7.4 | 0.53 |
| Lupine | 14.3 | 3.5 | 4.5 | 37.0 | 39.0 | 1.7 | 1.7 | 44.2 | 0.5 | 26.7 | 0.49 |
| Flax | 11.2 | 7.2 | 2.7 | 45.2 | 32.6 | 1.1 | 0.7 | 36.8 | 0.4 | 53.8 | 0.38 |
| Rape | 14.0 | 8.5 | 4.0 | 40.6 | 31.3 | 1.6 | 2.0 | 33.4 | 0.7 | 17.2 | 0.41 |
| White clover | 11.5 | 7.9 | 18.3 | 22.4 | 36.8 | 3.1 | 10.7 | 34.8 | 1.5 | 3.6 | 0.84 |
| Corn cobs | 14.0 | 2.8 | 1.4 | 37.8 | 42.6 | 1.4 | 0.6 | 41.7 | 0.4 | 71.2 | 0.41 |
| ROOTS AND TUBERS. | | | | | | | | | | | |
| Potatoes | 75.0 | 0.9 | 2.1 | 1.1 | 20.7 | 0.2 | 2.1 | 21.8 | 0.2 | 10.6 | 0.29 |
| Artichokes | 80.0 | 1.0 | 2.0 | 1.3 | 15.5 | 0.2 | 2.0 | 16.8 | 0.2 | 8.7 | 0.24 |
| Fodder beets | 88.0 | 0.8 | 1.1 | 0.9 | 9.1 | 0.1 | 1.1 | 10.0 | 0.1 | 9.3 | 0.14 |
| Sugar beets | 81.5 | 0.7 | 1.0 | 1.3 | 15.4 | 0.1 | 1.0 | 16.7 | 0.1 | 17.0 | 0.19 |
| Rutabagas | 87.0 | 1.0 | 1.3 | 1.1 | 9.5 | 0.1 | 1.3 | 10.6 | 0.1 | 8.3 | 0.15 |
| Rutabagas, fermented | 84.6 | 2.8 | 1.4 | 2.3 | 8.8 | 0.1 | ... | ... | ... | ... | ... |
| Carrots | 85.0 | 0.9 | 1.4 | 1.7 | 10.8 | 0.2 | 1.4 | 12.5 | 0.2 | 9.3 | 0.18 |
| Giant carrots | 87.0 | 0.8 | 1.2 | 1.2 | 9.6 | 0.2 | 1.2 | 10.8 | 0.2 | 9.4 | 0.16 |
| Turnips | 92.0 | 0.7 | 1.1 | 0.8 | 5.3 | 0.1 | 1.1 | 6.1 | 0.1 | 5.8 | 0.11 |
| Parsnips | 88.3 | 0.7 | 1.6 | 1.0 | 10.2 | 0.2 | 1.6 | 11.2 | 0.2 | 7.3 | 0.18 |
| Sweet potato | 69.7 | 1.1 | 1.9 | 1.7 | 26.3 | 0.3 | 0.9 | 28.0 | 0.3 | 31.9 | 0.30 |
| Yam, American | 71.2 | 0.6 | 2.1 | 0.7 | 25.2 | 0.2 | 2.1 | 25.9 | 0.2 | 12.5 | 0.33 |
| GRAINS AND FRUITS. | | | | | | | | | | | |
| Wheat | 14.4 | 1.7 | 13.0 | 3.0 | 66.4 | 1.5 | 11.7 | 64.3 | 1.2 | 5.8 | 1.13 |
| Rye | 14.3 | 1.8 | 11.0 | 3.5 | 67.4 | 2.0 | 9.9 | 65.4 | 1.6 | 7.0 | 1.08 |
| Winter rye, American | 8.7 | 1.8 | 12.1 | 1.4 | 73.9 | 2.1 | 10.8 | 70.3 | 1.6 | 6.8 | 1.16 |
| Barley | 14.3 | 2.2 | 10.0 | 7.1 | 63.9 | 2.5 | 8.0 | 58.9 | 1.7 | 7.9 | 0.95 |
| Oats | 14.3 | 2.7 | 12.0 | 9.3 | 55.7 | 6.0 | 9.0 | 43.3 | 4.7 | 6.1 | 0.98 |
| Maize | 14.4 | 1.5 | 10.0 | 5.5 | 62.1 | 6.5 | 8.4 | 60.6 | 4.8 | 8.6 | 1.11 |
| Millet | 14.0 | 3.0 | 12.7 | 9.5 | 57.5 | 3.3 | 9.5 | 45.0 | 2.6 | 5.4 | 0.93 |
| Golden millet | 13.4 | 2.8 | 9.6 | 11.6 | 58.6 | 4.0 | 7.2 | 47.0 | 3.1 | 7.5 | 0.87 |
| Buckwheat | 14.0 | 1.8 | 9.0 | 15.0 | 58.7 | 1.5 | 6.8 | 47.0 | 1.2 | 7.4 | 0.77 |
| Rice, hulled | 14.0 | 0.5 | 7.7 | 2.2 | 75.2 | 0.4 | 6.9 | 72.7 | 0.3 | 10.7 | 0.96 |
| Peas | 14.3 | 2.4 | 22.4 | 6.4 | 52.5 | 2.0 | 20.2 | 54.4 | 1.7 | 2.9 | 1.44 |
| Field bean | 14.5 | 3.1 | 25.5 | 9.4 | 45.9 | 1.6 | 23.0 | 50.2 | 1.4 | 2.3 | 1.51 |
| Vetch | 14.3 | 2.7 | 27.5 | 6.7 | 45.8 | 3.0 | 24.8 | 48.2 | 2.5 | 2.2 | 1.63 |

AVERAGE COMPOSITION, ETC., OF FEEDING STUFFS—*Continued.*

| KIND OF FODDER. | Water. | Ash. | ORGANIC SUBSTANCES. Albuminoids. | ORGANIC SUBSTANCES. Fibre. | ORGANIC SUBSTANCES. Other Carbo-hydrates. | ORGANIC SUBSTANCES. Fat. | DIGESTIBLE NUTRIENTS. Albuminoids. | DIGESTIBLE NUTRIENTS. Carbo-hydrates, including fibre. | DIGESTIBLE NUTRIENTS. Fat. | Nutritive ratio. | Value per 100 lbs. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | % | % | % | % | % | % | % | % | % | as 1: | $ |
| Lentil | 14.5 | 3.0 | 23.8 | 6.9 | 49.2 | 2.6 | 21.4 | 51.2 | 2.2 | 2.6 | 1.49 |
| Lupine, yellow | 13.3 | 3.8 | 36.2 | 13.8 | 28.0 | 4.9 | 34.4 | 41.8 | 4.9 | 1.6 | 2.00 |
| Lupine, blue | 13.2 | 3.2 | 24.8 | 12.5 | 41.7 | 4.6 | 23.6 | 54 2 | 4.6 | 2.8 | 1.72 |
| Cow peas, American | 20.0 | 3.1 | 21.6 | 4.7 | 49.3 | 1.3 | 19.4 | 49.6 | 1.1 | 2.7 | 1.33 |
| Spurry | 8.7 | 2.4 | 18.0 | 5.7 | 53.7 | 11.5 | 16.2 | 54.6 | 9.7 | 4.8 | 1.61 |
| Serradella | 8.7 | 3.4 | 22.0 | 21.1 | 37.5 | 7.3 | 19.8 | 47.0 | 7.3 | 3.2 | 1.60 |
| Flax-seed | 12.3 | 3.4 | 20.5 | 7.2 | 19.6 | 37.0 | 17.2 | 18.9 | 35.2 | .... | 2.47 |
| Rape-seed | 11.8 | 3.9 | 19.4 | 10.3 | 12.1 | 42.5 | 15.5 | 10.2 | 40.4 | .... | 2.55 |
| Hemp-seed | 12.2 | 4.5 | 16.3 | 12.1 | 21.3 | 33.6 | 12.2 | 16.2 | 30.2 | .... | 2.01 |
| Poppy-seed | 14.7 | 5.3 | 17.5 | 6.1 | 15.4 | 41.0 | 17.2 | 15.3 | 39.0 | .... | 2.50 |
| Sunflower-seed | 8.0 | 3.0 | 13.0 | 28.5 | 23.9 | 23.6 | 10.4 | 24.6 | 21.2 | 7.2 | 1.59 |
| Cotton-seed | 7.7 | 7.8 | 22.8 | 16.0 | 15.4 | 30.3 | 17.1 | 14.7 | 27.3 | 4.6 | 2.08 |
| Palm-seed | 7.6 | 1.8 | 8.4 | 6.0 | 26.8 | 49.2 | 8.0 | 31.2 | 48.2 | 18.3 | 2 75 |
| Chinese oil bean | 6.9 | 4.6 | 38.3 | 5.3 | 26.2 | 18.7 | 34.5 | 28.3 | 18.1 | 2.1 | 2.56 |
| Acorns, fresh | 55.3 | 1.0 | 2.5 | 4.4 | 34.8 | 1.9 | 2.0 | 30.9 | 1.5 | 18.2 | 0.43 |
| Acorns, half dried | 37.7 | 1.6 | 3.5 | 7.8 | 46 6 | 2.8 | 2.8 | 41.9 | 2.2 | 17.0 | 0.59 |
| Acorns, shelled and dried | 17.0 | 2.0 | 5.1 | 4.5 | 67.4 | 4.0 | 4.1 | 59.7 | 3.2 | 16.5 | 0.85 |
| Chestnuts, fresh | 49.2 | 1.6 | 4.3 | 2.0 | 41.3 | 1.6 | 3.4 | 35.7 | 1.3 | 11.5 | 0.52 |
| Horse-chestnuts, with shell fresh | 49.2 | 1.2 | 6.4 | 2.9 | 38.9 | 1.4 | ... | .... | .... | .... | .... |
| Horse-chestnuts, with shell dry | 18.8 | 1.8 | 6.9 | 4.0 | 65.3 | 3.2 | .... | .... | .... | .... | .... |
| Apples and pears | 83.1 | 0.4 | 0.4 | 4.3 | 11.8 | .... | 0.3 | 12.9 | .... | 43.0 | 0.13 |
| Cow melons | 91.4 | 0.7 | 1.2 | 1.5 | 5.2 | .... | 0.9 | 5.6 | .... | 6.2 | 0.09 |
| Pumpkins | 89.1 | 1.0 | 0.6 | 2.7 | 6.5 | 0.1 | 0.4 | 7.1 | 0.1 | 18.4 | 0.08 |
| Squash, fresh American | 88.1 | 0.7 | 0.9 | 1.0 | 9.1 | 0.2 | 0.6 | 9.0 | 0.2 | 15.8 | 0.11 |
| Squash rind, American | 82.0 | 1.2 | 2.8 | 3.2 | 10.1 | .0.7 | 1.9 | 10.6 | 0.6 | 6.3 | 0.20 |
| Squash seeds and stringy parts, American | 74.1 | 1.4 | 5.3 | 4.3 | 8.6 | 6.3 | 3.7 | 10.3 | 5.6 | 6.4 | 0.49 |
| BY-PRODUCTS. | | | | | | | | | | | |
| Coarse wheat bran | 11.4 | 5.1 | 12.9 | 8.1 | 59.1 | 3.5 | 10.0 | 48.5 | 3.1 | 5.6 | 1.01 |
| Wheat middlings | 11.8 | 2.3 | 11.4 | 4.8 | 66.8 | 2.9 | 8.9 | 54.8 | 2.6 | 6.9 | 1.00 |
| St. Louis ship stuffs | 11.8 | 2.3 | 11.1 | 5.6 | 66.5 | 2.8 | 8.7 | 54.5 | 2.5 | 7.0 | 0.97 |
| Rye bran | 12.9 | 2.9 | 12.6 | 2.5 | 67.0 | 2.2 | 10.6 | 50.0 | 2.0 | 5.3 | 1.00 |
| Buckwheat bran | 14.0 | 3.4 | 17.1 | 14.7 | 46.4 | 4.4 | 13.5 | 44.0 | 3.9 | 4.1 | 1.15 |
| Pea-meal bran | 12.3 | 4.2 | 13.1 | 31.1 | 37.8 | 1.5 | 9.2 | 45.8 | 1.2 | 5.3 | 0.86 |
| Pea bran, hulls | 12.3 | 3.0 | 8.0 | 43.7 | 30.5 | 2.5 | 5.6 | 46.3 | 2.0 | 9.2 | 0.74 |
| Pea-meal | 11.4 | 3.5 | 23.7 | 4.5 | 54.5 | 3.5 | 20.9 | 55.4 | 2.8 | 3.0 | 1.53 |
| Millet bran | 9.5 | 7.5 | 6.5 | 57.6 | 14.4 | 4.5 | 4.5 | 38 8 | 2.7 | 10.1 | 0.66 |
| Barley bran | 12.0 | 4.1 | 14.8 | 19.4 | 45.6 | 4.1 | 11.5 | 43.2 | 3.6 | 4.5 | 1.04 |
| Poppy-seed cake | 11.5 | 11.1 | 31.9 | 11.5 | 25.8 | 8.2 | 26.8 | 25.4 | 7 4 | 1.7 | 1.73 |
| Hemp-seed cake | 9.9 | 7.8 | 29.8 | 24.7 | 23.3 | 6.5 | 20.9 | 17.4 | 5.2 | 1.5 | 1.30 |
| Walnut cake | 13.7 | 5.0 | 34.6 | 6.4 | 27 8 | 12.5 | 31.1 | 28.2 | 11.2 | 1.8 | 2.11 |
| Olive oil cake | 13.8 | 6.8 | 6.0 | 33.4 | 26.8 | 13.2 | 3.6 | 32.8 | 10.6 | 16.5 | 0.91 |
| Sunflower cake | 10.3 | 8.1 | 37.3 | 9.9 | 26.0 | 8.4 | 31.3 | 24.7 | 7.6 | 1.3 | 1.93 |
| Pumpkin-seed cake | 12.0 | 8.1 | 55.6 | 4.9 | 8.0 | 11.4 | 50.0 | 9.7 | 10.3 | 0.7 | 2.74 |
| Sugar-beet cake | 70.0 | 3.4 | 1.8 | 6.3 | 18.3 | 0.2 | 1.8 | 24.6 | 0.2 | 13.9 | 0.30 |
| Residue, centrifugal process | 82.0 | 1.2 | 1.0 | 3.6 | 12.1 | 0.1 | 1.0 | 15.7 | 0.1 | 16.0 | 0.19 |
| Clarifying refuse, fresh | 94.8 | 0.3 | 0.5 | 1.0 | 3.3 | 0.1 | 0.5 | 4.3 | 0.1 | 9.1 | 0.06 |
| Clarifying refuse, fermented | 92.0 | 0.5 | 0.8 | 1.8 | 4 8 | 0.1 | 0.8 | 6.4 | 0.1 | 8.3 | 0.10 |

AVERAGE COMPOSITION, ETC., OF FEEDING STUFFS—*Continued.*

| KIND OF FODDER. | Water. | Ash. | ORGANIC SUBSTANCES. | | | | DIGESTIBLE NUTRIENTS. | | | Nutritive ratio. | Value per 100 lbs. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Albuminoids. | Fibre. | Other Carbo-hydrates. | Fat. | Albuminoids. | Carbo-hydrates, including fibre. | Fat. | | |
| | % | % | % | % | % | % | % | % | % | as 1 : | $ |
| Clarifying refuse, pressed and fermented | 86.3 | 0.9 | 1.5 | 3.1 | 7.9 | 0.3 | 1.5 | 11.0 | 0.3 | 7.8 | 0.18 |
| Sugar-beet molasses | 17.2 | 10.3 | 8.0 | .... | 64.5 | .... | 8.0 | 64.5 | .... | 8.1 | 0.92 |
| Molasses slump | 92.0 | 1.6 | 1.8 | .... | 4.6 | .... | 1.8 | 4.6 | .... | 2.6 | 0.12 |
| Potato refuse in starch manufacturing | 86.0 | 0.4 | 0.8 | 2.0 | 11.7 | 0.1 | 0.8 | 13.7 | 0.1 | 17.4 | 0.16 |
| Rye refuse in starch manufac'ing | 70.0 | 0.8 | 6.1 | 2.7 | 18.9 | 1.5 | 5.2 | 18.1 | 1.2 | 4.1 | 0.44 |
| Wheat refuse in starch manuf'g | 74.0 | 0.6 | 4.4 | 3.4 | 15.4 | 2.2 | 3.7 | 15.1 | 1.8 | 5.3 | 0.37 |
| Corn bran | 12.0 | 2 3 | 8.0 | 2.5 | 61.2 | 4.0 | 6.2 | 55.0 | 3.6 | 10.3 | 0.92 |
| Corn sugar, or starch meal | 72.2 | 0.1 | 3.6 | 3.4 | 18.8 | 2.0 | 3.2 | 19.3 | 1.8 | 7.4 | 0.39 |
| Corn slump, or distillery refuse | 90.6 | 0.4 | 1.8 | 1.0 | 5.2 | 1.0 | 1.6 | 5.4 | 0.8 | 4.6 | 0.15 |
| Brewers' grains | 75.2 | 0.3 | 5.9 | 3.9 | 13.2 | 1.5 | 4.8 | 11.3 | 1.2 | 3.0 | 0.36 |
| Malt sprouts | 11.6 | 6.7 | 25.9 | 9.3 | 45.5 | 1.1 | 20.8 | 43.7 | 0.9 | 2.2 | 1.33 |
| Green malt, with sprouts | 47.5 | 1.7 | 6.5 | 4.3 | 38.5 | 1.5 | 5.2 | 36.9 | 1.2 | 7.7 | 0.60 |
| Ground malt, with sprouts | 7.5 | 2.3 | 4.4 | 8.7 | 69.8 | 2.3 | 7.5 | 67.2 | 1.8 | 9.4 | 1.00 |
| Wheat meal | 11.5 | 3.0 | 13.9 | 4.8 | 63.5 | 3.3 | 10.8 | 54.8 | 2.9 | 5.7 | 1.08 |
| Rice meal | 9.9 | 10.6 | 10.9 | 1.1 | 47.6 | 9.9 | 8.6 | 47.2 | 8.8 | 8.0 | 1.16 |
| Rice bran, hulls | 9.5 | 12.0 | 6.0 | 25.1 | 44.1 | 3.3 | 4.2 | 42.8 | 2.3 | 11.5 | 0.66 |
| Rape cake | 11.3 | 7.1 | 31.6 | 11.0 | 29.9 | 9.6 | 25.3 | 23.8 | 7.7 | 1.7 | 1.66 |
| Rape meal, extracted | 8.5 | 7.9 | 33.1 | 13.4 | 34.1 | 3.0 | 26.5 | 27.2 | 2.4 | 1.3 | 1.51 |
| Beech-nut cake | 16.1 | 5.2 | 18.2 | 23.9 | 28.3 | 8.3 | 13.5 | 22.2 | 6.6 | 2.8 | 1.08 |
| Beech nuts, shelled | 12.5 | 7.7 | 37.1 | 5.5 | 29.8 | 7.5 | 31.2 | 25.5 | 6.8 | 1.4 | 1.90 |
| Almond cake | 9.7 | 4.3 | 41.3 | 8.9 | 20.6 | 15.2 | 37.2 | 23.0 | 13.7 | 1.6 | 2.44 |
| Chinese oil-bean cake | 13.4 | 5.2 | 40.3 | 5.5 | 27.1 | 7.5 | 36.3 | 29.4 | 6.8 | 1.3 | 2.15 |
| Palm-nut cake | 10.5 | 4.2 | 16.9 | 17.4 | 41.0 | 10.0 | 16 1 | 55.4 | 9.5 | 4.9 | 1.61 |
| Palm-nut cake, American | 7.9 | 4.0 | 13.5 | 18.8 | 41.0 | 14.8 | 12.8 | 56.2 | 14.0 | 7.0 | 1.66 |
| Palm-nut cake, extracted | 10.5 | 4.0 | 18.5 | 20.2 | 43.5 | 3.3 | 17.6 | 60.4 | 3.1 | 3.9 | 1.44 |
| Cocoanut cake | 9.4 | 5.2 | 20.2 | 14.2 | 38.5 | 12.5 | 18.2 | 47.4 | 8.0 | 3.6 | 1.69 |
| Barley middlings | 12.3 | 6.2 | 11.6 | 14.3 | 52.9 | 3.6 | 9.6 | 47.0 | 3.2 | 6.0 | 0.93 |
| Oat bran | 9.7 | 3.7 | 7.1 | 19.3 | 57.9 | 2.3 | 5.6 | 49.8 | 2.0 | 9.7 | 0.77 |
| Linseed cake | 9.1 | 8.2 | 32.4 | 7.3 | 31.5 | 11.6 | 27.6 | 27.0 | 6.0 | 1.5 | 1.89 |
| Linseed meal, extracted | 9 7 | 7.3 | 33.2 | 8.8 | 38.7 | 2.3 | 27.8 | 33.9 | 2.1 | 1.4 | 1.61 |
| Cotton-seed meal, decorticated | 7.2 | 5.8 | 41.5 | 3.1 | 24.4 | 18.0 | 33.2 | 17.6 | 8.0 | 1.1 | 2.30 |
| Cotton-seedcake, undecorticated | 11.3 | 6.4 | 23.6 | 22.0 | 30.5 | 6.1 | 17.5 | 14.9 | 5.5 | 1.7 | 1.14 |
| SLAUGHTER-HOUSE WASTE. | | | | | | | | | | | |
| Dried blood | 7.2 | .... | 63.0 | .... | .... | 6.4 | 42.2 | .... | 5.7 | 0.3 | 2.08 |
| Meat scrap | 4.2 | .... | 47.3 | .... | .... | 2.1 | 45.0 | .... | 2.0 | 0.1 | 2.03 |
| Ground dried flesh | 8.3 | .... | 64.4 | .... | .... | 6.5 | 64.1 | .... | 6.0 | 0.2 | 3.04 |
| Fish scrap | 12.5 | .... | 49.6 | .... | .... | 9.5 | 44.6 | .... | 8.6 | 0.5 | 2.30 |
| Cows' milk | 87.5 | 0.7 | 3.2 | .... | 5.0 | 3.6 | 3.2 | 5.0 | 3.6 | 4.4 | 0.34 |
| Skimmed milk | 90.0 | 0.8 | 3.5 | .... | 5.0 | 0.7 | 3.5 | 5.0 | 0.7 | 1.9 | 0.23 |
| Buttermilk | 90.1 | 0.5 | 3.0 | .... | 5.4 | 1.0 | 3.0 | 5.4 | 1.0 | 2.6 | 0.22 |
| Condensed milk | 21.5 | 2.5 | 10.2 | ... | 52.9 | 12.9 | 10.2 | 52.9 | 12.9 | 8.3 | 1.48 |
| Whey | 92.6 | 0.7 | 1.0 | .... | 5.1 | 0.6 | 1.0 | 5.1 | 0.6 | 6.6 | 0.11 |
| Cream | 62.0 | 0.6 | 2.7 | .... | 2.9 | 31.8 | 2.7 | 2.9 | 31.8 | 30.5 | 1.54 |

THE FOLLOWING TABLES ARE AMERICAN ANALYSES, AND PRINCIPALLY TAKEN FROM REPORTS OF CONNECTICUT EXPERIMENT STATION, EXCEPT THE FIGURING OF THE DIGESTIBLE NUTRIENTS.

| HAY AND DRY COARSE FODDER. | Analyses No. | Water. | Ash. | ORGANIC SUBSTANCES. | | | | DIGESTIBLE NUTRIENTS. | | | Nutritive Ratio. | Value per 100 lbs. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Albuminoids. | Fibre. | Other Carbohydrates. | Fat. | Albuminoids. | Carbohydrates, includ'g Fibre. | Fat. | | |
| | | % | % | % | % | % | % | % | % | % | as 1: | $ |
| Clover hay.......... ... | 25 | 12.56 | 6.10 | 12.61 | 26.63 | 39.62 | 2.48 | 7.82 | 40.25 | 1.49 | 5.6 | 0.77 |
| Hay containing much clover................ | 8 | 13.94 | 5.50 | 10.41 | 25.97 | 41.59 | 2.59 | 6.66 | 34.87 | 1.34 | 5.7 | 0.58 |
| Timothy hay (*Phleum pratense*).. ..... .... | 40 | 11.07 | 4.06 | 6.02 | 30.89 | 45.82 | 2.16 | 3.67 | 41.25 | 1.03 | 12.7 | 0.62 |
| Red top (*Argrostis vulgaris*)..... ......... | 1 | 9.84 | 6.99 | 7.25 | 27.45 | 46.52 | 1.95 | 4.13 | 44.76 | 0.94 | 11.3 | 0 62 |
| Timothy and red top.... | 10 | 12.36 | 4.80 | 6.52 | 30.17 | 44.15 | 2.00 | 3.72 | 44.87 | 0.96 | 12.6 | 0.60 |
| Orchard grass hay (*Dactylis glomerata*)...... | 1 | 11.80 | 5.90 | 8.17 | 38.33 | 33.54 | 2.26 | 4.66 | 43.07 | 1.08 | 10.4 | 0.63 |
| Hungarian grass hay (*Setaria Germanica*). | 6 | 6.45 | 5 43 | 6.79 | 29.09 | 49.69 | 2.55 | 3.87 | 49 68 | 1.22 | 13.5 | 0.66 |
| Johnson's grass (*Sorghum halapense*) .... | . . | 14.30 | 6.92 | 11.80 | 21.47 | 44.77 | 2.43 | 6.70 | 41.00 | 1.20 | 6.0 | 0.71 |
| Japan clover (*Lespedeza striata*).......... ... | ... | 14.30 | 3.88 | 15.08 | 20.32 | 44.82 | 3.76 | 10.70 | 38.00 | 2.10 | 4.0 | 0.89 |
| Crab grass (*Panicum sanguinale*)....... . | ... | 14.30 | 10 81 | 9.78 | 27.50 | 36.59 | 2.42 | 6.26 | 41.90 | 1.20 | 7.1 | 0.70 |
| Barley hay (seed in milk) | 1 | 10.25 | 4.44 | 9.21 | 26.14 | 47.49 | 2.47 | 5.24 | 44.82 | 1.18 | 9.0 | 0.68 |
| Oat hay (seed in milk). | 2 | 9.15 | 6.48 | 8.90 | 28.07 | 44.79 | 2.74 | 5.07 | 43.85 | 1.31 | 9.2 | 0.68 |
| High meadow hay...... | 2 | 10.98 | 6.23 | 7.57 | 25.78 | 47.19 | 2.25 | 4.31 | 44.61 | 1.08 | 10.9 | 0.63 |
| Hay from mixed meadow grasses ............ .. | 9 | 15.48 | 4.71 | 6.24 | 31.09 | 40.43 | 2.05 | 3.55 | 43.09 | 0.98 | 12.8 | 0.58 |
| Low meadow hay....... | 10 | 10.50 | 5.80 | 7.70 | 30.20 | 43.60 | 2.20 | 4.38 | 44.55 | 1.06 | 10.7 | 0.62 |
| Salt marsh hay........ | 11 | 10.47 | 7.42 | 5.90 | 31.47 | 42.42 | 2.32 | 3.00 | 41.58 | 0.95 | 14.6 | 0.54 |
| Maize stover.... ....... | 5 | 19.56 | 5.79 | 5.89 | 25.61 | 41.56 | 1.57 | 2.41 | 34.48 | 0.47 | 14.7 | 0.43 |
| Buckhorn Fern (*Osmunda regalis*)...... | 1 | 14.56 | 6.09 | 10.24 | 21.60 | 45.10 | 2.41 | 5.22 | 31.82 | 0.99 | 6.5 | 0.55 |
| Maize fodder, field cured (very good)........... | 6 | 32.05 | 4.32 | 4.29 | 22.14 | 35.96 | 1 24 | 3.00 | 40.00 | 0.93 | 14.0 | 0.53 |
| Buckwheat straw. .. .. | 2 | 10.45 | 5.05 | 3.85 | 45.88 | 33.28 | 1.56 | 1.58 | 42.92 | 0.47 | 27.8 | 0.47 |
| Rice straw............. | 1 | 3.66 | 10.71 | 4.68 | 28.31 | 50.90 | 1.74 | 1.92 | 40.40 | 0.52 | 21.7 | 0.46 |
| Oat straw... .......... | 4 | 9 62 | 5.20 | 3.51 | 43.37 | 36.09 | 2 21 | 1.44 | 42.62 | 0.66 | 30.6 | 0 47 |
| Rye straw............. | 2 | 11.11 | 1.84 | 4.54 | 38.75 | 38.37 | 1.84 | 0.95 | 37.55 | 0.54 | 41.0 | 0.40 |
| Wheat straw........... | 1 | 6.50 | 6.96 | 4.98 | 38.08 | 41.99 | 1.49 | 0.85 | 37.70 | 0.54 | 45.8 | 0.39 |
| Cow pea vines.......... | 6 | 11.05 | 8.41 | 15.68 | 19.80 | 42.17 | 2.87 | 9.56 | 37.02 | 1.34 | 4.2 | 0 80 |
| GREEN FODDER. | | | | | | | | | | | | |
| Maize fodder........... | 48 | 80.98 | 1.13 | 1.62 | 5.23 | 10 62 | 0.41 | 1.19 | 10.87 | 0.31 | 9 9 | 0 16 |
| Maize fodder, ensilaged. | 53 | 80.47 | 1.35 | 1.51 | 5.77 | 10.21 | 0.70 | 1.10 | 10.99 | 0.53 | 11.1 | 0.16 |
| Sorghum . ............ | 5 | 76.08 | 0.91 | 1.16 | 6.65 | 14.87 | 0.33 | 1.01 | 15.52 | 0.28 | 16.0 | 0.19 |
| Sorghum, ensilaged..... | 5 | 75.83 | 1.04 | 0.75 | 6.28 | 15.82 | 0.28 | 0.46 | 16.03 | 0.24 | 36.0 | 0.17 |
| Rye fodder............ | 6 | 75.28 | 1.88 | 2.61 | 12.73 | 6.94 | 0.56 | 1.51 | 8.20 | 0.26 | 5.8 | 0.13 |
| Rye fodder, ensilaged... | 1 | 80.75 | 1.62 | 2.42 | 5.76 | 9.18 | 0.27 | 1.40 | 9.18 | 0.12 | 6.7 | 0.14 |
| Clover ................ | 1 | 73.33 | 2.16 | 4.09 | 8.12 | 11.61 | 0.69 | 2.70 | 12.78 | 0.44 | 5.0 | 0.25 |
| Clover, ensilaged....... | 3 | 76.27 | 2.50 | 3.34 | 6.66 | 10.21 | 1.02 | 2.20 | 10.98 | 0.65 | 5.7 | 0.22 |

| Green Fodder. | Analyses No. | Water. | Ash. | Organic Substances. | | | | Digestible Nutrients. | | | Nutritive Ratio. | Value per 100 lbs. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Albuminoids. | Fibre. | Other Carbohydrates. | Fat. | Albuminoids. | Carbohydrates, includ'g Fibre. | Fat. | | |
| | | % | % | % | % | % | % | % | % | % | as 1: | $ |
| Cow pea vines, green and succulent with pods... | 3 | 80.31 | 1.89 | 2.70 | 7.22 | 7.41 | 0.47 | 2.05 | 8.71 | 0.28 | 4.5 | 0.17 |
| Cow pea vine, ensilaged | 1 | 81.64 | 1.99 | 2.40 | 5.57 | 7.60 | 0.80 | 1.82 | 7.94 | 0.48 | 4.9 | 0.17 |
| Soy bean, entire crop... | 3 | 69.87 | 2.39 | 3.34 | 8.36 | 14.88 | 1.16 | 2.37 | 14.80 | 0.70 | 6.5 | 0.26 |
| Cabbage, ensilaged...... | 1 | 87.61 | 4.16 | 1.19 | 1 59 | 4.52 | 0.93 | 0.68 | 5.43 | 0.93 | 11.2 | 0.12 |
| Cactus (*Opuntia*)....... N. Y. Expt. Station. | ... | 88.00 | 2.73 | 0.82 | 1.80 | 6.35 | 0.30 | 0.62 | 6.30 | 0.20 | 1.11 | 0.09 |
| **Grain and other Seeds.** | | | | | | | | | | | | |
| Barley .... ... ........ | 9 | 10.92 | 2.38 | 12.39 | 2.57 | 69.88 | 1.86 | 9.64 | 60.77 | 1 86 | 6.7 | 1 04 |
| Rice ................... | 1 | 14.80 | 0.30 | 7.50 | 0.90 | 76.00 | 0.50 | 5.92 | 70.71 | 0.42 | 12.1 | 0.91 |
| Buckwheat............ | 8 | 12.60 | 2.00 | 10.00 | 8.70 | 64.50 | 2.25 | 7.70 | 49.21 | 1.84 | 6.9 | 0.85 |
| Oats ................... | 25 | 11 00 | 2.97 | 11.38 | 9.85 | 60.05 | 4.81 | 8.46 | 46.11 | 3.94 | 6.5 | 0 95 |
| Rye ................... | 6 | 11.60 | 1.90 | 10.60 | 1.60 | 72.60 | 1.70 | 8.37 | 63.16 | 1.09 | 7.8 | 1.98 |
| Wheat, winter... ...... | 242 | 10.52 | 0.86 | 11.73 | 1.77 | 72.01 | 2.11 | 9.26 | 62.70 | 1.79 | 7.2 | 1.07 |
| Wheat, spring .. ..... | 13 | 10.37 | 1.91 | 12.51 | 1.82 | 71.19 | 2.20 | 10.20 | 61.64 | 1.87 | 6.3 | 1.09 |
| Wheat, unclassified..... | 55 | 10.69 | 1.83 | 11.96 | 1.92 | 71.50 | 2.10 | 9.45 | 62.25 | 1.78 | 7.0 | 1.08 |
| Wheat, average of all analyses ..... ........ | 310 | 10.54 | 0.86 | 11.80 | 1.80 | 71.89 | 2.11 | 9.32 | 66.52 | 1.79 | 7.4 | 1.05 |
| Maize, dent......... .... | 78 | 10.10 | 1.55 | 10.34 | 2.29 | 70.59 | 5 13 | 8.16 | 65.64 | 4.36 | 9.3 | 1.13 |
| Maize, flint............. | 70 | 11.00 | 1.44 | 10.57 | 1.65 | 70 31 | 4.96 | 8.35 | 65.00 | 4 21 | 8.9 | 1.12 |
| Maize, sweet ...... .... | 26 | 8.82 | 1.92 | 11.62 | 2.80 | 66.70 | 8.14 | 9.18 | 62.56 | 6.92 | 8.6 | 1.26 |
| Maize, western corn. . | 3 | 19.10 | 1.20 | 8.30 | 1.75 | 66.00 | 3.70 | 5.17 | 60.06 | 3.14 | 11.1 | 0.85 |
| Maize, average of all varieties .............. | 190 | 10.52 | 1.55 | 10.58 | 2 08 | 69.81 | 5.46 | 8.36 | 64.81 | 4 74 | 9.3 | 1.15 |
| Sorghum seed...... .... | 9 | 12.52 | 1.80 | 8.88 | 1.88 | 71.27 | 3.65 | 6.84 | 53.06 | 2.99 | 8.5 | 0.90 |
| Cow pea..... .. .. .. ... | 5 | 15.00 | 3.20 | 20.77 | 4.06 | 55.75 | 1.43 | 18.48 | 54.53 | 1.07 | 3.1 | 1.34 |
| Doura, brown .. ....... | 3 | 11.00 | 1.60 | 10.30 | 1.50 | 69.90 | 4.20 | 7.93 | 51.98 | 3.44 | 7.5 | 0.96 |
| Soy bean (Chinese oil bean)............... ... | 3 | 8.59 | 4.37 | 36.22 | 4 24 | 28.66 | 17.92 | 31.14 | 27.48 | 15.59 | 2.0 | 2 20 |
| Broom corn seed (same as sorghum seed)..... | . | 12.76 | ... . | 9.12 | 2.30 | 70 57 | 3.71 | 7.10 | 56.80 | 3.00 | 9.0 | 0.95 |
| **Flour and Meal.** | | | | | | | | | | | | |
| House oat meal......... | .. | 8.00 | 2.00 | 14.70 | 0.90 | 67.50 | 7.00 | 12.7 | 54.00 | 5.60 | 5.3 | 1.28 |
| Barley meal ......... . | 3 | 15.10 | 0.50 | 11.80 | 0.10 | 70.90 | 1.70 | 9.08 | 61.68 | 1.70 | 7.1 | 1.02 |
| Buckwheat flour........ | 3 | 13.52 | 1.05 | 6.48 | 0.28 | 77.34 | 1.33 | 5.12 | 70.37 | 1 13 | 14.3 | 0.95 |
| Oat meal.............. | 6 | 7.85 | 2.00 | 14.66 | 0.86 | 67.57 | 7.06 | 11.29 | 50.15 | 5.79 | 5.6 | 1.19 |
| Rye flour.............. | 4 | 13.10 | 0.72 | 6.65 | 0.41 | 78.28 | 0.84 | 5.25 | 66.54 | 0.71 | 12.9 | 0.90 |
| Wheat flour, from winter wheat ............ ..... | 18 | 10.37 | 0.64 | 10.92 | 0.17 | 76.59 | 1.19 | 8.62 | 69.80 | 1.01 | 8.3 | 1.04 |
| Wheat flour, from spring wheat .. ............ | 16 | 14.45 | 0 68 | 11.63 | 0.22 | 75.00 | 1.11 | 9.19 | 68.38 | 0.94 | 7.6 | 1.05 |
| Maize meal............ | 49 | 15.19 | 1.48 | 9.20 | 1.89 | 68.39 | 3.85 | 7.27 | 63.40 | 3.29 | 9.8 | 1.03 |
| Hominy ....... ...... | 2 | 13.50 | 0.38 | 8.25 | 1.32 | 77.12 | 0.44 | 6.52 | 70.38 | 0.37 | 10.9 | 0.93 |
| **By Products.** | | | | | | | | | | | | |
| Apple pomace.. ....... | 5 | 67.49 | 0.52 | 1.37 | 4.19 | 15.04 | 1.39 | 1.23 | 15.04 | 1.25 | 14.6 | 0.24 |
| Brewers' grains, wet from brewery..... ........ | 15 | 75.00 | 1.01 | 5.57 | 3.87 | 12.86 | 1.68 | 4.06 | 9.73 | 1.41 | 3.2 | 0.32 |

| By Products. | Analyses No. | Water. | Ash. | Organic Substances. Albuminoids. | Fibre. | Other Carbohydrates. | Fat. | Digestible Nutrients. Albuminoids. | Carbohydrates, includ'g Fibre. | Fat. | Nutritive Ratio. | Value per 100 lbs. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | % | % | % | % | % | % | % | % | % | as 1: | $ |
| Brewers' grains, dried... | 3 | 8.19 | 3.58 | 19.89 | 11.01 | 51.75 | 5.56 | 14.52 | 37.41 | 4.77 | 3.3 | 1.20 |
| Brewers' grains, kiln-dried ... ............ | 1 | 2.57 | 3.97 | 20.30 | 11.79 | 54.89 | 6.40 | 14.81 | 39.73 | 5.37 | 3.5 | 1.23 |
| Brewers' grains, from silo.................. | 3 | 69.82 | 1.21 | 6 64 | 4.64 | 15.58 | 2.11 | 2.45 | 11.75 | 1.77 | 6.5 | 0.29 |
| Malt sprouts..... ..... | 3 | 10.28 | 5.67 | 22.95 | 10.72 | 48.60 | 1.79 | 18.82 | 52.95 | 0.88 | 2 3 | 1.33 |
| Cotton seed meal....... | 24 | 8.33 | 7.25 | 42.06 | 5.69 | 23.43 | 13.24 | 35.75 | 22.25 | 11.65 | 1.4 | 2.25 |
| Linseed cake........... | 4 | 10.00 | 5.97 | 33.77 | 8.52 | 36.68 | 5.04 | 29.04 | 33.09 | 4.53 | 1.5 | 1.75 |
| Linseed meal, old process | 9 | 9.20 | 5.87 | 31.53 | 9.26 | 36.34 | 7.78 | 25.85 | 26.52 | 7.08 | 1.6 | 1.66 |
| Linseed meal, new process .............. ... | 12 | 10.75 | 5.57 | 32.85 | 9.46 | 38.29 | 3.08 | 28.25 | 27.95 | 2.80 | 1.3 | 1.54 |
| Palm nut meal.......... | 3 | 8.29 | 3.74 | 14.39 | 21.40 | 38.88 | 13.30 | 13.67 | 45.09 | 12.63 | 6.1 | 1.62 |
| Rye bran........... .. | 5 | 11.48 | 3.68 | 15.39 | 3.56 | 63.92 | 2.47 | 12.00 | 48 98 | 1.43 | 4.4 | 0.89 |
| Wheat bran............ | 52 | 12.42 | 5.68 | 15.03 | 8.96 | 54.17 | 3.74 | 11.72 | 44.66 | 2.58 | 4 4 | 1.02 |
| Wheat middlings....... | 23 | 12.00 | 3.18 | 14.87 | 4.55 | 61.55 | 3.89 | 11.60 | 48.87 | 2.68 | 4.7 | 1.06 |
| Wheat shorts.. ....... | 8 | 12.74 | 4.25 | 13.83 | 7.45 | 57.59 | 4.14 | 10.79 | 44.80 | 2.85 | 4.7 | 0 99 |
| "Hominy Chops," "Hominy Feed," "Baltimore Meal," White Meal.... .... | 11 | 11.14 | 2.50 | 9.85 | 3.59 | 64.49 | 8.43 | 7.68 | 51.06 | 5.31 | 8.3 | 1.04 |
| Gluten meal........... | 8 | 9.15 | 0.78 | 29.88 | 1.46 | 52.62 | 6.11 | 23.30 | 50.92 | 3.85 | 2.5 | 1.63 |
| Maize cob.............. | 13 | 9.33 | 1.33 | 2.50 | 30.36 | 55.99 | 0.47 | 1.05 | 43.17 | 0.24 | 41.6 | 0.54 |
| Starch feed, refuse from manufacturing........ | 8 | 65.66 | 0.21 | 5.73 | 3.17 | 22.21 | 3.02 | 4.52 | 22.17 | 2.57 | 6.2 | 0.50 |
| Sugar feed, refuse from glucose manufacturing | 2 | 8.50 | 2.00 | 13.30 | 9.50 | 58.10 | 8.60 | 10.51 | 58.76 | 7.31 | 7.4 | 1.30 |
| Sorghum bagasse........ | 3 | 85.50 | 0.60 | 0.65 | 3.10 | 10.20 | ..... | 0.11 | 3.97 | ..... | ... | .... |
| Corn husks........ .... | ... | ...... | ...... | ...... | ...... | ...... | ..... | 1.80 | 40.00 | 0.40 | 37.0 | 0.45 |
| Rice flour ............ | 1 | 10.32 | 4.85 | 14.00 | 6.12 | 51.22 | 13.49 | 10.92 | 40.92 | 9.30 | 5.7 | 1.24 |
| Rice meal. ... ...... | 1 | 15.10 | 6 00 | 9.30 | 8.10 | 59.90 | 1.60 | 7.25 | 48.79 | 1.10 | 7.0 | 0.80 |
| Rice feed.... . .... .. | 1 | 10.33 | 9.62 | 11.43 | 9.93 | 47 20 | 11.49 | 8.91 | 39.42 | 7.93 | 6.5 | 1.08 |
| Rice middlings........ | ... | 10.00 | 10.60 | 10.70 | 11.10 | 47.70 | 9.90 | 8.45 | 50.28 | 8.41 | 8.3 | 1.18 |
| Rice bran ............. | 1 | 9.30 | 8.35 | 12.78 | 2.00 | 62.34 | 5.23 | 9.97 | 48.66 | 3.61 | 5.7 | 1.07 |
| Rice hulls............. | ... | 8.10 | 12.81 | 3.90 | 34.42 | 40.17 | 0.60 | 3.04 | 42.29 | 0.41 | 14.2 | 0.53 |
| Rice polish............ | ... | 11.21 | 2.80 | 12.93 | 2.41 | 62.96 | 7.59 | 9.31 | 48.13 | 5.92 | 6.6 | 1.09 |
| Dried sugar meal....... | ... | 8.50 | 2.00 | 13.30 | 9.50 | 58.10 | 8.60 | 10 20 | 54.50 | 5.40 | 5.4 | 1.16 |
| Buckwheat middlings... | ... | 16.30 | 5.50 | 30.30 | 4.02 | 36.29 | 7.55 | 23.60 | 29.30 | 5.20 | 1.8 | 1.41 |
| Oat Feed. ........ .... | 1 | 8.19 | 4.24 | 12.33 | 12.80 | 50.95 | 7.00 | 10.26 | 39.87 | 5.70 | 5.2 | 1.05 |
| **Compounds.** | | | | | | | | | | | | |
| Oats, 100 lbs.; Barley, "; Peas, 50 lbs.; Bran, " — ground together.... .................... | | | | | | | | 10.70 | 51.20 | 2.90 | 5.5 | |
| 600 lbs. Peas, 200 lbs. Oats, 50 lbs. Flaxseed, — ground together.... .................... | | | | | | | | 17.50 | 49.70 | 4.20 | 3.4 | |
| Corn, Oats, Wheat Bran, — equal weights ground...................... | | | | | | | | 9.10 | 50 80 | 4.20 | 6.7 | |

| Compounds. | Digestible Nutrients. Albuminoids. | Carbohydrates, includ'g Fibre. | Fat. | Nutritive Ratio. |
|---|---|---|---|---|
| | % | % | % | as 1: |
| 2 bu. Oats to 1 bu. Corn in the ear | 7.9 | 50.2 | 4 3 | 7.8 |
| 50 lbs. Corn, 100 lbs. Oats, 100 lbs. Peas, ground together | 14.3 | 51.2 | 3.5 | 4.2 |
| 500 lbs. Oats, 250 lbs. Corn, 50 lbs. Flaxseed, ground together | 9.3 | 47.1 | 6 6 | 6.7 |
| same mixed with an equal weight of bran | 9.7 | 47.7 | 4.8 | 6.1 |
| Corn, Oats and Barley in equal parts (ground) | 8.4 | 54.2 | 3 7 | 7.5 |
| 2 bu. Oats to 1 of Corn | 8.72 | 51.37 | 4.73 | 7.1 |
| 10 Oats, 5 Peas, 1 Flaxseed | 13. | 45.2 | 4.7 | 4.5 |
| 56 lbs. Corn, 14 lbs. Cob, 7 lbs. Husk (corn chop) | 6.2 | 54.2 | 3.6 | 10.1 |
| 32 lbs. Oats, 70 lbs. Corn and Cob (oat and corn chop) | 7 6 | 51.8 | 3.5 | 7.9 |
| ½ Oat and ½ Pea-straw | 2.15 | 86.7 | 0.55 | 4.0 |
| 64 lbs. Oats, 70 Corn and Cob (ground) | 7.9 | 50.3 | 4.3 | 7.6 |
| Corn and Oats (ground together in equal weights) | 8.7 | 51 8 | 4.7 | 7.2 |
| Corn and Rye Meal, equal parts. | 9.1 | 63.0 | 3.1 | 7.7 |
| Crab Grass, Shucks and Corn Fodder | 3.0 | 40.0 | 1.0 | 13.4 |
| Corn and Cow Pea, ensilage | 2.0 | 9.3 | 0.65 | 5.4 |
| Rye, Oat and Wheat Hay (equal parts) | 6.0 | 41. | 1.0 | 6.8 |
| Corn and Cob Meal | 6.8 | 56.6 | 3.9 | 9.7 |
| Bran and Middlings (equal parts) | 9.5 | 51.6 | 2.7 | 6.1 |
| Corn Fodder and Hungarian Hay | 4.0 | 40.5 | 0.6 | 10.4 |
| Oat and Barley Meal (equal parts) | 8.5 | 51.0 | 3.0 | 6.0 |
| Clover, Orchard and Rye Grass | 7.1 | 39.2 | 1.7 | 6 0 |
| Oats and Wheat, ground together, equal weights | 10.4 | 54.0 | 2 9 | 5.6 |

## Nitrogen and Ash Ingredients in 1,000 Lbs.

| Ash Analyses. | Dry Matter. | Nitrogen. | Ash. | Potash. | Lime. | Phosphoric Acid. | Value per Ton. |
|---|---|---|---|---|---|---|---|
| | | | | | | | $ |
| Winter Wheat Middlings. | 873. | 28.2 | 36.3 | 10.02 | 0.33 | 20.48 | 12.74 |
| Wheat Middlings | 867. | 25.4 | 40.3 | 12.19 | 0.96 | 19.70 | 11.99 |
| Winter Wheat Bran | 866. | 26.4 | 57.1 | 16.23 | 0.25 | 32.66 | 14.77 |
| Wheat Bran | 864. | 24.8 | 42.2 | 12.33 | 0.79 | 20.78 | 12.00 |
| Rye Bran | 877. | 25.3 | 32.2 | 10.20 | 0.86 | 15.78 | 11.13 |
| Corn Meal | 861. | 13.2 | 13.2 | 3.86 | 0.07 | 6.22 | 5.34 |
| Oat Feed | 902. | 22.5 | 36.6 | 6.60 | 1.10 | 11.07 | 9.18 |
| Buckhorn Fern (*Osmunda regalis*) | 855. | 16.4 | 58.6 | 13.68 | 5.05 | 1.46 | 6.52 |
| Asparagus | 62. | 3.7 | 5.9 | 3.02 | 0.26 | 1.31 | 1.62 |
| Cactus Plant (*Opuntia*) N. Y. Expt. Station. | 120. | 1.31 | 27.3 | 3.78 | 10.10 | 0.30 | 0.82 |

## COMMENTS ON TABLES OF FIRST EDITION.

In the last set of the foregoing tables it is easy to compare the value of every food given with average meadow hay—the value of which is figured at 64 cents for 100 lbs., and the value of each food figured on the same basis will show the comparison above or below meadow hay.

Dr. Wolff estimates the value of a food in Germany on the basis of 4⅓ cents for each pound of digestible albuminoids, and the same per pound for digestible fat, and .9 cent per pound for the digestible carbo-hydrates. These tables represent nearly all the important cattle foods, except a few grasses which have not been analyzed. A careful study of these tables will give the reader a pretty correct knowledge of the constituents in our cattle foods, of what is digestible and indigestible. The nutritive ratio, it will be seen, differs very much in some classes of foods, depending upon the condition. For example, the poorest meadow hay has only 1 of albuminoids to 10.6 of carbohydrates, whilst the best meadow hay has 1 of muscle-forming food to 5.1 of heat or fat-forming food. This, as will be seen by the "money-value," nearly doubles the feeding-value of meadow hay. Animals kept on the former would only be able to keep in store condition, without perceptible growth, whilst the latter would keep them growing steadily. It will be noted that the nutritive ratio in oat-straw is 1:29.9, and this is considered our best straw. Rye-straw is still poorer in digestible albuminoids, the ratio being 1:46.9. This very low nutritive ratio is occasioned by the fact that only 26 per cent. of the albuminoids in rye-straw is digestible, whilst an average of 48 per cent. of the fibre and carbo-hydrates is digestible. It is quite possible that Dr. Wolff has placed the digestibility of the albuminoids in rye and oat-straw quite too low. The samples experimented with may have been inferior. But those who have fed rye-straw know that neither horses, cattle nor sheep manifest any anxiety to eat it. Its fibre is exceedingly tough, making better paper than any other straw; and this is undoubtedly the best use to make of it, when there is a demand at paper-mills. Yet Pennsylvania farmers of the olden type, who were wont to have sleek, well-rounded team-horses, kept them largely upon the grain of rye, ground into meal and fed upon chopped rye-straw. It certainly would furnish an excellent divisor to separate the meal and carry it in a loose, porous condition into the stomach, giving the gastric juice an easy circulation and full effect in digestion. The feeders of large numbers of street-railroad horses, in New York City, for a similar reason, select ripe timothy hay, alleging that it keeps the animals in better health when fed largely upon grain.

Wheat-straw and barley-straw, contained in the tables, have a composition, chemically, the former very similar to that of rye-straw—but the fibre is less tough, and consequently a larger percentage of albuminoids and carbohydrates is digestible—whilst barley-straw is quite equal to oat-straw, and may be fed to good advantage in connection with grain.

In order that the reader may make an easy comparison between some of the most common kinds of food for cattle, we will give the chemical composition, digestibility, and money-value, according to the German standard, for 2,000 lbs.—or an American ton—of clover-hay, meadow-hay, corn-fodder, oat-straw, oil-cake, wheat-bran, corn-meal and oats. These foods are used more in the United States than any like number of others. They are also complementary to each other:

| | In 100 lbs. | Digestible. | In 2,000 lbs. | Money value. |
|---|---|---|---|---|
| **Clover Hay.** | | | | |
| Albuminoids | 15.3 | 10.7 | 214 lbs. | $ 9.24 |
| Carbo-hydrates | 35.8 | 37.6 | 752 " | 6.76 |
| Crude fibre | 22.2 | | | |
| Fat | 3.2 | 2.1 | 42 " | 1.82 |
| | | | 1008 " | 17.82 |
| **Average Meadow Hay.** | | | | |
| Albuminoids | 9.7 | 5.4 | 108 " | 4.68 |
| Carbo-hydrates | 41.6 | 41.0 | 820 " | 7.38 |
| Crude fibre | 21.9 | | | |
| Fat | 2.5 | 1.0 | 20 " | .87 |
| | | | 948 " | 12.93 |
| **Corn Fodder.** | | | | |
| Albuminoids | 4.4 | 3.2 | 66 " | 2.86 |
| Carbo-hydrates | 37.9 | 43.4 | 868 " | 7.81 |
| Crude fibre | 25.0 | | | |
| Fat | 1.3 | 1.0 | 20 " | .87 |
| | | | 954 " | 11.54 |
| **Oat Straw.** | | | | |
| Albuminoids | 4.0 | 1.4 | 28 " | 1.21 |
| Carbo-hydrates | 36.2 | 40.1 | 802 " | 7.21 |
| Crude fibre | 39.5 | | | |
| Fat | 2.0 | 0.7 | 14 " | .61 |
| | | | 844 " | 9.03 |
| **Linseed Oil Cake.** | | | | |
| Albuminoids | 28.3 | 23.77 | 475 " | 19.00 |
| Carbo-hydrates | 32.3 | 35.15 | 703 " | 6.32 |
| Fibre | 10.0 | | | |
| Fat | 10.0 | 9.0 | 180 " | 7.80 |
| | | | 1358 " | 33.12 |
| **Wheat Bran.** | | | | |
| Albuminoids | 15.0 | 12.6 | 252 " | 10.92 |
| Carbo-hydrates | 52.2 | 42.6 | 852 " | 7.67 |
| Fibre | 10.1 | | | |
| Fat | 3.2 | 2.6 | 52 " | 2.25 |
| | | | 1156 " | 20.84 |
| **Corn Meal.** | | | | |
| Albuminoids | 10.0 | 8.4 | 168 " | 7.28 |
| Carbo-hydrates | 62.1 | 60.6 | 1212 " | 10.90 |
| Crude fibre | 5.5 | | | |
| Fat | 6.5 | 4.8 | 96 " | 4.16 |
| | | | 1476 " | 22.34 |
| **Oats.** | | | | |
| Albuminoids | 12.0 | 9.0 | 180 " | 7.80 |
| Carbo-hydrates | 55.0 | 43.0 | 860 " | 7.74 |
| Crude fibre | 9.3 | | | |
| Fat | 6.5 | 4.7 | 94 " | 4.07 |
| | | | 1134 " | 19.61 |

These comparisons of value by the ton of these very dissimilar foods is very instructive. We find clover-hay worth $17.82 and oat-straw $9 per ton; but it cannot be inferred that oat-straw would be as cheap at that price as clover-hay to make an entire food for cattle, or other animals, because clover-hay is a well-balanced food for cattle, and oat-straw is only a partial food, containing so little albuminoids and fat that cattle would starve to death upon it if fed long enough. The muscles and nerves could not be nourished upon it; and yet a good article of oat-straw may be worth the price named, because of the digestible heat and fat-formers it contains. Now, put a ton of the best oat-straw with a ton of the best clover-hay, and you have a fairly-balanced food. It compares well with common meadow-hay. The digestible albuminoids, in clover 10.7, in straw 1.4, making the two added 12.1, and the average per cent. of the mixture is 6.05, whilst meadow-hay is only 5.04. The digestible carbo-hydrates in the mixture is about 39.0 to 41.0 in hay, and the fat is 1.4 to 1.0 in meadow-hay. The parallel is very close; and as the mixture has slightly more albuminoids and fat, it may be considered the better ration. These valuations of the different elements simply mean that each is worth the relative price named when fed in due proportion with the other elements. Oil-cake, for example, is as far from being a balanced ration as oat-straw, for it contains as much too large a proportion of albuminoids as straw too small. It has also oil in excess. Like straw, it must be fed with other foods. If 400 lbs. of oil-cake be mixed with a ton of oat-straw, the mixture will make a ration equal to meadow-hay.

## Waste Products.

The waste products, so called, from different manufactures are accumulating so rapidly, from the great increase of the several manufactures, that they assume a degree of importance in beef, mutton or wool-growing much greater than heretofore. These waste products are also becoming quite numerous, and the location of these manufacturing establishments widely distributed.

Corn-starch Feed.—Grape-sugar is now manufactured in very large quantities from the starch of Indian corn, and this leaves an immense quantity of refuse sugar or starch-meal, which must be utilized as food for animals. It thus becomes important to know its value, and how to combine it in the cattle ration. Some establishments run 2,000 bushels corn per day; and the whole amount manufactured does not probably fall much below ten millions of bushels per year. This gives a large amount of refuse—about 600,000 tons, including water, or about 200,000 tons of dry matter. If this were relieved of its water, it would bear transportation. Some manufacturers have adopted the plan of subjecting it to pressure to expel a large part of the water. The sample given in the analysis contained 72 per cent. of water; and it will be observed that the proportion of albuminoids is rather larger than in whole corn. The corn-sugar waste is what is left of corn after extracting all the starch that can be done by the present process used, which is converted into grape-sugar; but about ten per cent. of the starch remains in the waste, together with all the albuminoids not soluble in cold infusion. This food, if taken before too much fermentation has set in, is quite wholesome for cattle; but it should not be fed alone. We shall give rations including this food.

Brewers' Grains.—This waste product has been longer used, and is generally better known than corn-sugar meal; but it has also been greatly abused by allowing it to attain a high state of fermentation before feeding. This has been one cause of bad milk resulting from its use, and another that it has been fed almost without other food, it being but a partial food in itself. This waste is more nitrogenous than corn waste, and may thus be properly mixed with poor hay, or even straw, if fed fresh. One great fault in using it has been in not feeding sufficient hay with it. This is a waste from barley, and has a nutritive ratio of one to three; and, when properly combined in the ration, is good food for either milk or flesh. (See rations given in a future chapter.)

MALT SPROUTS.—This is a refuse that comes from malt in drying—the barley having sprouted, these fine filaments break off in handling, after drying. These sprouts are very nitrogenous, having a nutritive ratio of 2.2, and, being quite dry, may be kept any length of time, and transported in sacks. This waste may be used to good advantage with some food poor in albuminoids.

MEAT SCRAP.—This is produced in considerable quantities from some pork-packing establishments, being the residue of lard-making; and, when thoroughly dried, may be ground fine, and is sometimes used as a food for cattle, mixed with hay, roots and corn-meal. It is so extremely rich in albuminoids, that only a small proportion can be economically used, as it contains twice the proportion of nitrogen as cotton-seed cake; but it is not difficult of digestion in small quantity. Meat scrap from cattle and sheep, made almost wholly from the intestines, is also in the market in a sweet condition, and has been fed to good account. This will only be found in the Northern States bordering on the Atlantic, and, at present, is not very important.

FISH SCRAP.—In working up fish for oil, there is a very large quantity of scrap; and if the process is conducted in a cleanly way—as is the case at some of the works—the dry product, ground, has been proved to be entirely wholesome for cattle, mingled with other food, and it has been found to aid essentially in the fattening process. There have been numerous reports of the good effects of this scrap in fattening pigs. This fish scrap seems to be growing into favor as food; and we give its analysis in the foregoing table. We there give the analyses of these waste products, and also the most generally used of other foods. Feeders should familiarize themselves with the chemical qualities of these different foods. It will be understood that the money-value is merely comparative.

These analyses are principally taken from the Report of the Agricultural Experiment Station, at Middletown, Conn., many of them the work of the station, and others taken from Dr. Wolff, of Germany; and the money-value is calculated from the German formula—that is, the digestible albuminoids and fats are estimated at 4⅓ cents per pound, and the carbo-hydrates at $\frac{9}{10}$ cents per pound. This is a much higher estimate than the cost of these foods in most places in this country, especially west of New York State. But the table of values is intended to serve only the purpose of comparison, and they are no doubt approximately accurate in that respect.

A glance at the analyses of hay given will show how rapidly the quality of both timothy and clover deteriorates after fully heading out. They are in the best condition just before blossom. It will be seen that the nutritive ratio in timothy, just when headed out, is 1:10.4, and, when nearly ripe, 1:15.3; and clover, just before blossom, is 1:6.1, and when nearly ripe, is 1:10.3. This shows what cattle-feeders must do if they wish to retain the fattening quality of the grasses for winter feeding. They must cut at or before blossom for cattle-feeding. For city-market hay, it may be cut somewhat later, as horse-car companies in cities seek for a solid hay to mix with the grain, depending almost wholly on the grain for nutriment. If they fully understood this question of alimentation, they would likewise require the grass to be cut earlier, and then feed, not more hay, but less grain. Good, bright, early-cut straw would answer about as well with the ground feed; as the hay serves principally as a divisor for the grain, rendering the food in the stomach more porous, and more easily saturated with the gastric juice.

# CHAPTER VII.

## SOILING.

PREVIOUS to entering upon the discussion of the feeding any one class of stock, we think it fitting to give a short explanation of that mode of feeding now exciting great interest in all localities of dear land—soiling. The author does this with the more pleasure, as he was one of the early and earnest advocates of this mode of summer feeding on arable land worth $50 per acre. When he first wrote upon the subject of cutting green food in summer and feeding it to animals in stall or rack in the open yard, few were ready to listen; it was deemed a utopian scheme for performing useless labor. But a rapid change has been coming over cattle-feeders during the last twenty years upon the economy of soiling, caused mainly by the necessity for dairymen to provide green food for their cows during droughts or short pasture from other causes. In feeding an acre of good fodder corn, millet, clover, etc., they find the gain over pasture to be so great as to arrest their attention, and set them to thinking upon the propriety of using four acres of pasture when one acre soiled would furnish more cattle food. And besides, many occupants of small farms have not the space for pasturing any considerable number of stock, and turn to this method of feeding, which enables them to keep more than double the number of animals on a given number of acres. Josiah Quincy, who practiced the soiling system in Massachusetts as early as 1814, in speaking of the prevalent opinion of his time, as late as

1859, says: "A mistaken notion that a considerable extent of land is requisite to enable a farmer to keep many head of cattle, led to a most wasteful portion of it being retained for the sole purpose of pasturage; and thus, compared with its inherent productive power, was made useless."

Mr. Quincy was very desirous of showing the small farmer how he might compete with the farmer of two or more times his number of acres, by adopting this more economical system of feeding; and that same necessity exists now, twenty years later, but under much more encouraging circumstances. We can now enter upon the task of showing the benefits of this system in detail, with the assuring knowledge that a hundred are ready to listen where one gave a ready ear twenty years ago. It is not anticipated that soiling will obtain, except in a very partial way, for many years yet, on the great farms of the West; but on the smaller ones there, and on the medium-sized farms of the older States, soiling is likely to make much progress during the next ten to twenty years. It has a most important bearing on the meat production of the future, enabling the farmer upon high-priced Eastern lands to compete successfully with the cheap land and grain of the West in the production of beef and mutton. The improvements of the last few years, by which green food can cheaply be preserved for winter use, will also give the thorough soiling system an immense advantage over the out-door system of feeding in the West—giving the stock in the cold Eastern States the food of perpetual summer.

As we aim to adapt this instruction to a wide extent of country—many desiring to understand this system in all its phases—we shall discuss its several economic aspects, from the standpoint of twenty-five years' experience. We will take these up in their order, setting forth the advantage of the system, and then try to give full weight to all the objections that may be urged against it; for no subject is more than half discussed when we stop with the examination of one side. The advantages of the soiling system are:

### 1. Saving Land.

The capacity of a farm to carry stock must soon be regarded as its measure of value, and that even in a grain region, for grain is an assistance and not an obstacle to stock-keeping; and, on the other hand, stock-feeding is an assistance to grain-raising. France and Germany each keeps more stock and raises more wheat now than fifty years ago. These countries pasture very little, keeping their fields in crops, and these are fed to the stock. It is well-known to all farmers that an acre of good meadow grass, properly cured into hay, will furnish food for a cow or steer during the five or six months of winter; and on well-conducted stock farms, under the old system, it will be found that three to four acres are devoted to pasture one cow or steer through the warm season. Every stock-feeder also knows that it takes more food to keep an animal in cold than warm weather. This statement, open to proof before every farmer's eyes, shows the great waste incident to pasturing. This waste of food is caused—1. By walking over it; 2. By lying upon it; 3. By dunging and staling upon it; 4. By breathing upon it—all of these so affect the quality that animals will not eat the grass thus injured; 5. By frequent cropping, preventing its rapid growth, and thus reducing the amount grown upon an acre in a season. An examination of a pasture shows the effects mentioned by the tufts of old, uneaten grass, covering a large part of the ground. The only way to prevent some of these effects is to turn a large number of cattle for a few hours each day into a comparatively small pasture, and not allow them to remain over night. If there are cattle enough to eat off all the grass equally, and this plan is continued as often as the grass grows sufficiently to afford a good bite, much of the loss may be prevented. But under the best system of pasturage, it will require three acres of pasture to furnish as much food as one acre of good meadow. This, then, is equal to a loss of *two-thirds* of the land pastured, if we reckon only the absolute production. And if (as is usual) one-third of the farm is in grain and meadow, and two-thirds in pasture, then the loss on 66⅔ acres of pasture, on a hundred-acre farm, would amount to nearly 45 acres; or, in other words, the soiling system, on arable land, would amount to a saving of 45 acres in 100, or 55 acres under the soiling system would be equal to 100 under the pasturing system. But those who have made practical comparisons, both in this country and in Europe, estimate the gain in land greater than this. It has frequently been estimated that 50 acres, used under the soiling system, are equal to 125 acres under the pasturing system.

Hon. Josiah Quincy, who soiled his stock for 18 years, says: "One acre soiled from will produce at least as much as three acres pastured in the usual way; and there is no proposition more true than that any good farmer may maintain, upon 30 acres of good arable land, 20 head of cattle the year round;" and that he had "kept 20 head on 17 acres." I. D. Powell, of Winchester County, New Jersey, keeps 100 cows on 100 acres.

Let us test this by another mode of comparison. A full crop of red clover will weigh, green, 20,000 lbs. to the acre. This would feed, in its green state, 20 cows, of 800 to 1,000 lbs. weight, ten days, or one cow 200 days. This acre would furnish, in the second and third cuttings, two-thirds as much more, or in all, food for one cow through the year. We have raised clover that weighed 24,000 lbs. at a single cutting, per acre. Millet or Hungarian grass will yield about 16,000 to 20,000 lbs. per acre, and furnish food for one cow 200 days. A good crop of green corn will weigh from 40,000 lbs. to 60,000 lbs., and furnish food for a cow for 333 to 500 days. A neighbor of the author measured, accurately, one acre of field corn (grain in the milk) and fed to 104 cows (of an average estimated weight of 900 lbs.), and it gave full feed for four days, or feed for one cow 416 days. These cows were in milk, and yielded liberally on this ration.

It is not meant that green corn fodder furnishes a complete ration for a cow, but that if it were a complete food, the quantity would be sufficient for the time mentioned. The last experiment, feeding corn when the ear is in thick milk, furnishes a ration that would do very well for a month.

It will be seen that one acre in these crops represents about four acres under the ordinary system, or three acres of pasture and one acre of meadow. And there are many other crops producing as large an amount of cattle food. As the fences are dispensed with, the land they occupy on a 300-acre farm is at least five acres—and this, in good condition for soiling crops, would feed 10 cows through the pasturing season.

### 2. Saving Fences.

This is an item that should be carefully estimated, as it is one of the heaviest burdens of agriculture. Fences are needed only to restrain stock; and if stock is not pastured no fences are needed, except for yards, and perhaps a lane to lead the cattle to the wood lot for simple exercise. Take the fact of fencing 90 acres into four fields, for pasturing 30 cows or cattle. These fields would be 22½ acres, and would require 720 rods of fence. Now, if this fence cost one dollar per rod, and if we suppose it to last 20 years, then the decay will amount to 5 per cent. per year, and the labor of annual repair is generally estimated at 5 per cent.

The interest on original cost at 7 per cent. would be $50.40, and the 10 per cent. for decay and repair, $72; making $122.40 as the annual expense for fencing a pasture for 30 head of cattle. We shall see, under another head, that this is more than the cost of labor for soiling the 30 head of stock. Mr. David Williams carefully prepared the fence statistics of Walworth County, Wisconsin, and after deducting for waste lands in ponds and lakes, and one-half of the division fences, he makes the annual cost for the whole county about one dollar per acre. Mr. Prince, of Maine, goes into an elaborate calculation of the cost of fences in that State in 1860, and the result does not vary much from an annual cost of one dollar per acre. The late Ezra Cornell took a great interest in studying this question, and gave his views in an address before the State Agricultural Society of New York, in 1862; and he arrived at the conclusion that the average cost of fencing for every acre inclosed in that State is one dollar per annum. If, then, we take this as a fair estimate in the older States, every acre of the farm must be charged at this rate, or a farm of 300 acres, which usually keeps about 60 head of cattle, would pay a fence tax of $300 in labor and material. The smaller the farm and the smaller the lots, the greater the cost of fences per acre.

Mr. Quincy dispensed with 1,600 rods of fence on his farm when he adopted soiling. Mr. F. S. Peer says his farm required 1,000 rods of interior fence, and the interest on its cost paid for the labor of soiling his stock after adopting soiling.

### 3. Saving Food.

When the feeder has his animals and their food entirely under his control, he becomes culpable for any waste that may occur. Under the soiling system, food may be given in such quantity and condition as to be wholly eaten. All the waste of the pasture caused by treading, lying upon, fouling, etc., are prevented. A very important saving is also found in the use of all the green food that grows upon the land, such as plantain, foul grasses, thistles, daisies, and nearly everything denominated weeds, when cut in a succulent state, are eaten, and are wholesome. The fine flavor of the flesh of the antelope and wild game, comes from aromatic herbs and what we denominate weeds. Most, if not all of the troublesome wild grasses that infest our cultivated fields are wholesome food for cattle, if cut at the right time; and soiling does this and saves all. Young Canada thistles and other tender thistles, are eaten by cattle and sheep, and preferred by horses to grass. That pestiferous weed, the white daisy, makes excellent food if cut before blossom, and can probably be exterminated by frequent cutting. Soiling offers a complete remedy for weeds, as nearly all are killed by frequent cuttings. Judicious soiling will soon make clean farms, and the weeds will pay for their destruction.

Another source of saving food, in soiling cows or other cattle intended for beef, is that they are saved the exercise of many hours per day in foraging over large fields in search of food. This exercise is at the expenditure of food, and amounts to much more than is generally supposed. In a scanty pasture it requires constant exertion for 10 to 16 hours per day for cows or steers to get food to satisfy their wants. The food required to supply this force is saved when the animals get all the food they want without exercise. But it must be understood that the soiling system does not prevent such exercise as is necessary for the health of animals.

Youatt mentions in his "Complete Grazier," what all who have practiced the soiling system know, that cattle will eat many plants with avidity if given them in the barn, which they did not eat when growing in the field.

### 4. Saving Manure.

One important object of stock-keeping is the production of manure to keep up the fertility of the land. It is therefore of the first moment that the manure should be all saved. In pasture more than half of the value of the manure is lost. It is evaporated by the sun, runs into the streams, so that the result is fortunate if half remains to enrich the soil. Josiah Quincy found that his cows made, in soiling, one load of manure each per month, which he estimated worth $1.50 per load, or $9 per cow for the six soiling months. Prof. J. F. W. Johnston states that in Flanders the liquid and solid manure from a cow is valued at $20 per year. And at this rate, soiling for six months would save $5 per cow, if only half her manure were counted. Mr. Quincy says the saving in manure will pay all the labor of soiling. It is easy to preserve all the manure in the best manner under this system, and it can be applied just where and when needed. From personal experience of more than twenty years, the writer regards the saving in manure as worth at least $6 per cow over that of pasture, and he fully agrees with Mr. Quincy that it is a full compensation for all the labor, direct and indirect, in soiling.

### 5. Effect upon Health and Condition.

Almost the first question is, "But are your animals healthy?" This question is no doubt prompted by the supposition that strict confinement is necessary. Yet soiling may be practiced with such exercise for the animal as the feeder chooses. And as animals are soiled with the same food, or with as good as they would get in pasture, why should they not be healthy? Is it unhealthy for cows or steers to eat sweet clover in the cool stall? We have had cows soiled for fourteen consecutive years. We have raised many colts under this system, giving them a runway for exercise, and they were always quite as healthy and more thrifty than colts on pasture. Soiling furnishes an equal and plentiful diet, pasturing an unequal and often very scanty diet. In soiling the feeder has the condition of his animals entirely under his control, because he can supply such quantity of food as he chooses. The animal will make more progress on the same quantity and quality of food, because he gets it without unnecessary exercise. Exercise requires extra food to compensate for the waste of muscle. The true rule should be to let an animal, at certain hours of the day, take such exercise as it chooses, to promote health; not compel it to work sixteen hours to gain a living. The writer tested the comparative effect of soiling and pasturing on the same class of animals, by putting five two-year-old steers and heifers, weighing 4,500 lbs., into a good pasture, while five of the same age and condition, weighing 4,450 lbs., were soiled, with exercise in a small yard, and, at the end of four months, those in the pasture had gained 625 lbs., and the five soiled had gained 750 lbs., with nothing save green soiling food, making the two lots equal in kind of food. The pasture, although good and abundant when the experiment began, did not continue equally good throughout, on account of dry weather, whilst the soiling food was given in equal abundance to the end. A little grain would probably have added 200 lbs. more to those soiled, and no doubt also to those pastured. Grain is usually about as cheap as grass, and quite as cheap as hay, and might more generally be used with profit as an addition to these foods. In soiling it is easy to add grain when the grass or other green fodder becomes tough or scanty, and thus never allow an abatement in growth. In the feeding of "baby beef," mentioned in the next chapter, this grain ration was given with excellent effect. There can be no standing still, if steers are to gain two lbs. per day for the first 800 days. The German and

French beef-growers adopt largely a strict soiling system, and produce a higher average weight, at a given age, than any pasturing people has attained.

## 6. Effect of Soiling upon Milk.

Many persons, though satisfied of the good effects of soiling upon cattle fed for beef, fear that it will not operate well in the production of milk. But as the cow gets the same food in stall as she would in pasture, it is not easy to see why these fears should be entertained. The cow needs less exercise than almost any other domestic animal, and getting the fresh grass fed to her in stall, we might naturally expect an increased production of milk from a given quantity of food; and this has proved to be the case, according to the reports of both English and American feeders.

Curwen, of Cumberland, England, and Harley, of Glasgow, Scotland, established dairies on the soiling system (1805–10), and were very successful in supplying milk to towns. They both say the quantity of milk is much greater in proportion to the food consumed, than when the cows were pastured in the open fields. Mr. Harley estimates one acre of grass consumed by cows in stall as producing as much milk as five acres pastured (Harleian Dairy).

Mr. Quincy had no hesitation in saying that his cows yielded considerably more during the whole season when soiled than when pastured. Robert L. Pell, who kept a dairy on this system, gave strong testimony in favor of a larger yield by soiling.

But the most striking test of the two systems in the production of milk, is published by Dr. Rhode, of the Eldena Royal Academy of Agriculture, of Prussia. It was conducted through seven years of pasturing and then seven years of soiling. Mr. Hermann is the experimenter. The pasturing began in 1853, and ended in 1859—the soiling began in 1860 and ended in 1866. From 40 to 70 cows were pastured each year, and a separate account kept with each cow. The lowest average per cow is 1,385 quarts in 1855, when 70 cows were kept, and the highest 1,941 quarts in 1859, when 40 cows were pastured, and the greatest quantity given by one cow was 2,938 quarts. The average increased during the last four years from 1,400 to 1,941 quarts. The average per cow for the whole seven years of pasturing was 1,583 quarts.

In the soiling experiment 29 to 38 cows were kept, and the lowest average per cow 2,930 quarts, in 1862, and the highest average per cow 4,000 quarts, in 1866. The highest quantity given by any one cow was 5,110 quarts, in 1866. The average per cow for the whole seven years of soiling was 3,442 quarts. The yield of the same cow is compared for different years. Cow No. 4 gave, in 1860, 3,636 quarts; in 1863, 4,570 quarts; and in 1866, 4,960 quarts. Cow No. 24, in 1860, 3,293 quarts; in 1863, 4,483 quarts; in 1866, 4,800 quarts.

The first notable fact here is that the average for the whole seven years of soiling was more than double that of the seven years of pasturing. Many of these cows were the same during both of these experiments; and it will be observed that the same cow increased from year to year, which shows what high feeding will do, and also that soiling was conducive to the health of the cow during seven years. He fed in summer green clover and vetches, and later seradella (a leguminous forage plant), and in addition oil-cake and rye bran.

On the whole, this is a most encouraging experiment to the dairyman, showing him that he cannot pay too much attention to feeding, and that an increase of food and care will be constantly remunerated by the increase in the yield of milk. It shows him that he may expect much from the development of his cows, and that soiling is one of the best means to accomplish this object.

This testimony would seem to establish the fact that soiling is favorable to milk production, and the writer's experience has fully confirmed this view. He has often stated the gain to be from 20 to 30 per cent. over that of ordinary pasture. This may be accounted for, 1st, by the saving of exercise in not having to forage over the pasture all day for food, as the food required to support this exercise goes to the secretion of milk; and 2dly, because in soiling, the cow gets, uniformly, all the food she can digest; whilst in pasture a full supply of food is uncertain, and not usually obtained for more than brief periods. It is not contended that soiling will produce more milk than the best pasture, whilst that lasts—it is the whole season upon which this improved yield is calculated.

The dairyman is now likely to enter upon the system of continuous milk production, extending through the winter as well as the summer; and the new plan of preserving green fodder in silos naturally belongs to the soiling system. By this method he will use green food throughout the year, and keep his cows as cheaply in winter as in summer; for with warm stables, the fodder produced upon the same amount of land that kept them in summer will give them full rations in winter; and the same flow of milk may be kept up, requiring little or no grain-ration, according to the kind of green food preserved for winter use. It seems likely, with the successful preservation of green fodder, that the cost of keeping stock will be much less than under the old system, as the loss by drying is regarded, under favorable circumstances, as not less than 10 per cent., and under the ordinary practice much more than that. But for winter dairying, this green food will have the important quality of flavor. Grasses lose much of their aroma in drying. According to reports from France, where ensilage has been much used for the last ten years, the aroma of the green food is preserved in silos. This will give as fine-flavored butter in winter as in summer, and as large a quantity. It will also insure better health to the cows, preventing almost wholly impaction of the manifolds and kindred diseases caused by dry, innutritious fodder. The grasses and various green forage plants, well preserved for winter use, will render the raising of roots less important, as the sanitary effect of the roots will be found in the preserved grasses.

### 7. Effect on Meat Production.

The same reasons considered in milk production, apply with equal force to the growth of beef or mutton. Animals grown for their flesh require a different system of management from those whose value depends upon the muscular development. These latter need much exercise, as well as appropriate food for building up and perfecting the bony and muscular systems, whilst those used for human food need only such exercise as is necessary for health, a vigorous appetite, and growth. Absolute command over the supply of food is here necessary to insure constant progress, and, as we have seen, soiling gives us this most completely. For meat production we do not desire extra muscular development, and animals full-fed are not inclined to take excessive exercise. Calves full-fed, for rapid growth, are content to enjoy their food and take the rest required for quiet and rapid digestion. Under this system we have found it easy to continue the calf-flesh, as some feeders call it, keeping up that plump and rounded appearance of the animal for the whole time of feeding—twenty-four to thirty months—and to make a weight of 1,200 to 1,600 lbs. The purpose here is to produce the greatest weight of meat in the shortest time, or to grow the greatest weight of meat with a given amount of food. As we shall see, during the progress of these discussions, time is a most important factor in this result; and the time may be shortened materially with the opportunity the skillful feeder has to observe and supply the wants of each animal under the soiling system.

The English have adopted a system of beef-raising upon a partial pasturage—soiling and grain feeding combined—and the result is an average much greater than is produced with our system of pasturing. Moderate grain feeding, with soiling or pasturing, is usually a decided economy in growing meat; for grain is often a cheap food, and being given as an extra is applied wholly as food of production to the gain in weight. Cattle are able to assimilate more nutriment than can be gained from grass, limited to its powers of digestion. A small amount of grain will thus be assimilated, besides all the grass the steer can digest. For this reason a little grain is nearly always profitable to the beef-raiser.

Soiling offers the opportunity to push the growth of animals in warm weather, when food produces a far better result; and as the animals are constantly under the eye of the feeder, he can apportion the allowance to the wants of each. This system is, therefore, admirably adapted to the production of meat; and it offers the most feasible plan for the production of meat upon the small farms of the East. Under the present system of pasturage, the Eastern States are largely tributary to the West for the meat consumed each month. To partially compensate for this, Eastern farmers often buy Western steers in spring and fatten them on pasture during the warm season; but as it takes three to five acres to feed a steer through the summer, the profit is too small to be worthy of consideration. One acre prepared for soiling would feed the steer much better than four times this amount of pasture, and on this there might be a reasonable profit. The great need on Eastern farms is manure, and feeding cattle and sheep on the soiling system would produce a very large amount of manure to return to the land. This system of summer feeding, with green ensilage for winter feeding, would render the Eastern States wholly independent of meat produced beyond their borders. They could afford to buy Western grain for feeding under such a system; and this would enrich their farms each year and cause their much-needed grain crop to be greatly increased. This system of meat-production would soon settle the question of profitable farming upon all the arable small farms of the Eastern and Middle States. Much of the land in the Eastern States, now regarded as unprofitable to cultivate, would, under this system, soon produce as much meat per acre as the most favored Western lands, under their system. The abandoned "old homesteads" would again become the scene of a busy and profitable husbandry. France, largely following this system, has, of horses, cattle, sheep, goats, and swine, about five to every six arable acres; and, besides keeping this large proportion of stock, raises nearly as much wheat as the whole production of the United States in 1880.

## Objections to Soiling.

### LABOR.

The chief objection to this system has always been the labor required to carry it out. This extra labor consists, 1st, in raising soiling crops—producing them in regular rotation, so that there shall be no lack of green food for the animals at all times during the season—and, 2dly, in cutting these green crops and carting them to the feeding stable or yard, feeding the animals three or four times per day, cleaning the stable, if one is used, and all the necessary details belonging to the system. The objections as to its ill effects upon the health and thrift of the animal, or yield of milk, etc., we have already considered. Let us, then, examine carefully the question of labor. First, the preparation of the land to be used for soiling must be thorough, in order that full crops may be raised, and as large an amount of food produced to the acre as possible; for it will cost less labor to gather and cart 2,000 lbs. of green clover from 16 than from 30 to 40 rods, or the same amount of green corn from 5 or 6 rods than 15 rods. The real point in the preparation of the soil for a good crop belongs rather to the question of good farming than to soiling. The endeavor should be to raise large crops for their profit, under whatever system they may be used; and, if the land is in a proper condition for a good crop of corn, millet, oats, rye, clover, etc., then it will require no special preparation for such soiling crop; and a farmer should not consider a system that requires him to raise good crops as objectionable. The legitimate labor of soiling, in fitting and seeding an acre to rye, oats, peas, corn, millet, etc., when these crops are raised for that purpose, may be estimated at $4, but this is twice or thrice repaid by the extra value of the crop over an acre of pasture.

Secondly, the labor required to cut and haul the green crop to the animals, and feed it out, is, no doubt, greatly exaggerated in the minds of those who consider it theoretically. The cost per animal will necessarily depend somewhat upon their number—the labor of attending a small number must be greater in proportion than a large number; but that is the case under any mode of keeping. It costs more in proportion to fence a pasture for five animals than fifty. The smaller the lot, the larger proportion of fence per acre. All small farms labor under this disadvantage, and, in soiling, the labor will be more in proportion; but the large addition to the animals that may be kept by soiling will lead small farmers before large ones to adopt it.

An Experiment.—We can give, perhaps, the best idea of the labor required to soil a moderate number of animals in relating an experiment by the author during the season of 1862. This will also illustrate what may be done without much preparation, as the land set apart was mostly only in ordinary farm condition. The animals to be fed were 20 steers, 3 and 4 years old, 8 cows and 6 horses. These were regarded, in consuming capacity, as equal to 35 one-thousand-pound cows. And 100 acres of land, thought to be just sufficient to pasture these animals, were selected, and the whole product either fed to this stock as green food or stored by itself as hay. Ninety acres of this land were in ordinary meadow (some clear timothy, some timothy and June clover), five acres in excellent clover, two in oats, and three in fodder-corn. These animals were fed from May 20th to December 1st from this hundred acres, with a surplus of 65 tons of hay, which sold in barn for $972. An accurate account of the labor was kept—it requiring six hours' labor of one man, and two hours' of one horse, per day; costing in those cheap times, $75. The grass was cut by hitching a light wood mowing-machine behind a one-horse cart, driving the horse around the plat till sufficient was cut for a day's feed, raking and pitching it on the cart, and taking to the barn where the animals were fed. It required two cart-loads per day.

This experiment made a stronger impression, from the fact that good fat cattle were very low that year; and after deducting the cost of putting hay in barn, $97.50, and the labor of soiling, $75—making $172.50—a net gain was left of $799.50; whilst the 20 steers, of 1,100 lbs. average weight, brought only $34 per head, or $680, although fat—showing a gain on the experiment of $119 more than the whole value of the 20 steers, besides making 100 large loads of rich manure, worth $100 more than the droppings would have been on the field. The manure was regarded as a full compensation for the labor of soiling, and more than enough to pay for the extra labor of soiling over that of pasturing; for the labor of repairing fences was saved, and it is no small matter to keep the fences in repair on 100 acres of pasture land.

This experiment, taking common, and some of it thin meadow for cutting (except the ten acres mentioned as in clover, oats, and fodder-corn), was using smaller crops than is recommended for soiling, and, therefore, took more labor than would be required under the best circumstances. A smaller number would require more time proportionally under the same conditions; but a larger number, under just the right conditions, could be soiled at much less proportional cost.

### COST OF LABOR FOR ONE HUNDRED HEAD.

Let us see what one active man may do under favorable conditions. Let 100 head of cattle be arranged on both sides of a convenient feeding floor, with space to drive a wagon along the floor; and let the soiling crops be well prepared, and convenient to the barn. Now, let the man be provided with a team, mowing-machine, wagon, and hay loader. He goes into a field of green rye, standing thick on the ground, and 2 to 3 feet high, May 15th. Starting in with the mowing-machine, he cuts 100 rods, leaving the stubble 3 inches high. Now he hitches his hay-loader behind his wagon, and drives the wagon over the mown rye, the hay-loader picking it up and rolling it upon the hay-rack. Having loaded about one-third of it, or 35 hundred, he drives to the barn. This is one-third of a day's feed. He gathers up the other two loads and brings them to the barn, when the day's feed is provided. This has taken him less than four hours. If now the weather indicates a storm, he repeats this, and houses another day's feed; and sometimes two days' ahead, if the weather indicates a storm of more than one day's duration, for all external water should be avoided as far as possible. Nature has provided sufficient water in the sap of the plant, and any excess seems to be practically deleterious. Cows eating wet grass in barn will fall off in milk nearly as much as if out in the storm.

Mr. F. S. Peer, who has written a practical work on soiling, having practiced this system wholly for some eight years, recommends a stout self-rake reaper for cutting soiling crops, leaving the fodder in thick, heavy gavels, easily pitched from the gavel upon the wagon. It might also be pitched on with the loader, at the rate of a ton in five minutes. One advantage of cutting with a reaper would be its less liability to dry before hauling to stable.

It will be seen that our feeder, when the weather is propitious, has easily put in his day's supply for the hundred head in the forenoon; that the team is released for other work in the afternoon, and the feeder has time, not only for feeding, but for cleaning, littering, etc. The hay-loader will pick up the grass about as clean as it is usually pitched out of a windrow; then a horse-rake, passing over the ground, will gather up all the scatterings.

In cutting clover for feeding, the labor will be about the same, although it is somewhat easier to gather, and often produces a greater weight upon an acre; but it also contains a larger percentage of sap or water. As soon as the clover gets large enough to cut, it is well to mix rye and clover together for feeding, as clover contains a larger percentage of albuminoids than the rye, and, mingled together, they form a well-balanced ration. All the soiling crops, except, perhaps, fodder-corn, may be elevated upon the wagon by the hay-loader, and the labor will be about the same as that described with winter rye.

From this statement, it becomes evident a good man may perform all the hand-labor for soiling 100 head of cattle. How much more could he do than keep the fences in repair on the land required to pasture 100 head? Estimated in the ordinary way, the hand-labor would cost $1 per day, or 1 cent per head, per day; and if the horse-labor and other expenses be added, it will not exceed 2 cents per head, per day, on so large a stock.

In speaking of the ration above of rye, or corn, it is not intended to imply that a ration may properly be made up wholly of rye or corn fodder. These are good soiling foods, but neither forms a complete ration, and should, when practicable, be mixed with clover or some of the grasses. A mixture of grasses, such as is found in pasture or old meadows, afford such a variety as makes a complete ration.

Thus it will appear that the labor of soiling is compensated in three ways—first, in saving fences; secondly, in saving manure; and, thirdly, in the extra production of milk, meat, wool, or growth.

## Soiling Crops.

The success of this system must depend very much upon the skill exercised in the production of the proper soiling crops. It is not proposed to cut meagre green crops for feeding in stall or yard; for the labor—which we have just been considering—would be too great for any gain to be anticipated. It is expected that the land for soiling will be put in such fine condition as to bear excellent crops, and that these crops be located convenient to the place of feeding. A good crop of rye, clover, etc., will require only one rod or less per day for each animal, whilst a thin crop might require three rods for the same purpose. It is, therefore, most important that we should give careful attention to the best crops for cutting green. The crop that may be cut earliest in spring is—

Winter Rye.—This flourishes best on a sandy or gravelly soil, but will grow large crops on heavy clay loam, if well under-drained. It yields a large supply of green food on soil only moderately rich, as its roots spread out in a thick network over a considerable space, and furnish a large number of absorbents. It being an annual, it must be cut before the head forms, if proposed to cut more than once, and it will then spring up again at once for a second crop. Some German authorities say that it may be cut at short intervals during the first summer, and then mature a crop of seed the next season. Great care should be taken to cut it in its young and succulent state, so as to keep it in vigor. If the crop is good, and the land sufficiently moist, it may be cut every three or four weeks. But the difficulty is to get a sufficiently thick growth to pay well for cutting before the head is formed, so as to prevent a good second growth. And therefore it is mostly cut but once, and for this purpose it is left till headed out, but before blossom. It will then be 4 to 5½ feet high, and yield the largest crop. In this case, the land is used for a second soiling crop, usually corn or millet.

Rye should be sown early for soiling—say the latter part of August, or early in September, for the Middle and New England States, and for the Southern States it may be sown as late as November. It is better sown with a drill, at the rate of two bushels per acre. If it grows vigorously in fall, feed it off if the land is dry, or cut it high with a machine, so that it will not smother under snow. The proportion of dry organic matter in green rye is about 25 per cent., which is more than in clover, but its albuminoids are in less proportion than in clover or peas. And although we have found cattle to do well upon rye alone for a few weeks, yet it is better to give some more nitrogenous food with it, such as clover, oil-cake, wheat middlings, oat-meal, etc. Rye is ready to cut before clover; and small quantities of these other foods may be given with rye till clover is ready to be cut and fed with it. Rye and clover combined, make a most excellent ration for steers or cows. Medium clover is ready to cut, in latitude 38° to 41°, about the 10th to the 25th of May, and is but a short time behind rye. Rye is rich in carbo-hydrates, and clover in albuminoids, so that the one is the complement of the other. The rye crop is much benefited by harrowing once or twice in spring after the ground becomes sufficiently dry to drive upon it. The slanting-tooth harrow is used.

Red Clover (*Trifolium pratense*).—This must always be one of the most important crops for soiling, both on account of its early cutting, and its large amount of excellent green food grown upon an acre. It contains more water in the green state than rye; but its albuminoids and carbo-hydrates are in better proportion as a food for young and growing animals, and for the production of milk. On dry, rich soils very large crops may be raised, even as high as twelve tons of green food at the first cutting in early blossom, and often two more cuttings, amounting to eight or more tons—yielding even as high as twenty tons of green clover in a season, or over six tons of dry clover hay. This proportion of green to dry clover is calculated from experiments made by Prof. Voelcker on the College farm at Cirencester. This crop is cheaply raised, is subject to but few insect enemies, and not affected so much by drought as most other crops, owing to the fact that its long tap root reaches down deep, and draws up moisture and fertility from the subsoil. Its broad leaves also draw largely for nourishment upon the atmosphere.

Hon. Harris Lewis, a dairyman of much experience, says one acre of good clover will feed a dairy of 35 cows for 15 days; that 3 acres have furnished his herd of 38 cows with food for 35 days; but this was probably on partial pasture.

The author, many years since, in order to determine the feeding capacity of an acre of heavy clover, measured off 40 rods and fed to cows, and found it equal to feeding one cow 180 days. The two succeeding years the same experiment was repeated, and the ¼ of an acre was found equal to feeding one cow 168 and 165 days respectively, but these cows had a small bare pasture lot to run on a portion of the day. The cows yielded well in milk. We did not consider the pasture of much account.

ORCHARD GRASS (*Dactylis glomerata*) is an excellent soiling grass, and should be grown with clover, as they are both ready to cut at the same time. They both commence a fresh growth immediately after cutting. This grass attracted the favorable attention of Washington. He says: "Orchard grass, of all others, is, in my opinion, the best mixture with clover; it blooms precisely at the same time, *rises quickly again after cutting*, stands thick, yields well, and both cattle and horses are fond of it, green or in hay." This is a good description of its excellences, although in order to "stand thick" the soil must be made very fine and a large amount of seed sown. We have seen it growing luxuriantly on a heavy clay loam. With proper attention and manuring it may be cut at least three times in a season.

LUCERNE (*Medicago sativa*).—This plant also has, where the soil is adapted to it, a peculiar value for soiling. It belongs to the class of leguminous plants, and, like clover, takes a very deep root, penetrating even deeper than clover, the roots having been traced as much as thirteen feet beside a pit. Its nutritive qualities are about equal to clover, and it produces, in favorable situations, a much greater weight per acre. On rich, warm land it gives an early cutting, and four or five in a season. It is, perhaps, one of the oldest cultivated forage plants—was in common use among the Greeks and Romans. It was cultivated in New York nearly a century ago. Chancellor Livingston experimented with it in 1791, and reports some three years of his trial. He obtained over six tons of hay in five cuttings. The soil best adapted to it is a deep, rich loam, inclining to sandy, with a porous subsoil, or a well-drained clay loam. It is very sensitive to the interference of weeds, and, in

Europe, is usually hoed, as we do corn the first year, and top-dressed yearly, in the fall, with well-rotted manure. Its roots striking so deep into the soil prevents its suffering from drought, like shallow-rooted plants. When once well established it will yield bountiful crops for many years. It must have a peculiar value as a forage crop on the warm, rich, deep soils of the South and West. It is grown in some parts of the South, and quite generally in California, under the name of Alfalfa. This particular plant was brought from Peru, but is simply a variety of Lucerne.

As we are considering the crops best adapted to soiling, it will be well to consider them in about the order of their growth for cutting.

TIMOTHY and LARGE CLOVER come after lucerne and are ready, as a soiling crop, in June. These two make an excellent combination of green food. Timothy (*Phleum pratense*), deservedly stands at the head of grasses for the hay crop, and will often cut eight to ten tons of grass before blossoming; and at that period makes a nutritious food for the production of either beef, mutton or milk. It is also adapted to a wide range of soils. The only objection to it, as a soiling crop, is that it does not start quickly after cutting, yet it sometimes gives a heavy second crop in favorable seasons. It remains in vigor longer when cut early than late, and for this reason we have found it a valuable aid in soiling.

The large pea-vine clover does not differ materially in quality from common red clover, but is of larger growth, later in maturing, and is ready to cut at the same time as timothy; and being more nitrogenous, the two grasses are complementary to each other. A good crop of timothy and large clover will often reach twelve to sixteen tons of green food per acre, at the first cutting; and this is equal to furnishing food for a thousand-pound cow or steer for ten months, and the next cutting will usually furnish abundant food for the rest of the year.

Alsike Clover and Timothy.—These may also be grown together as a soiling crop. Alsike clover (*Trifolium Hybridum*) is an extremely hardy forage plant, will remain fixed in the soil and yield good crops for eight or ten years. It branches very much, throws out many stalks from one root, thus requiring only thin seeding; the roots strike very deep into the sub-soil. The period of bloom is much longer than in red clover, and it is in good condition to cut with timothy. By beginning to cut it when the first blossoms appear, it remains in condition for soiling some three or four weeks—an important point in some seasons. It may be doubtful if so large crops are raised of alsike as of red clover, but the greater permanence of the root renders it an important plant for soiling. Some say it will not yield a second crop, but as it bears cropping well in pasture, and is deemed a valuable plant for pasturage, it is not easy to see why, if cut early, it will not grow again after cutting. But one large crop of alsike and timothy will be quite satisfactory, as it would feed twelve cattle for one month per acre. Only one half the seed used for red clover is required for alsike. It is sown with timothy either spring or fall.

For Southern soiling, Desmodium, Japan clover, Mexican clover, Satin grass and Gama grass, mentioned on pages 149–52, will be found profitable. These may all grow large crops and will bear several cuttings.

Green Oats.—In regular order, oats will mature sufficiently to cut after timothy. If the soil is rich and warm, oats will come forward rapidly and make a good cutting in the latter part of June. If oats are cut before the head is formed, they will make a second growth, starting quickly and growing more rapidly the second than the first time. In this respect the oat plant is governed by the same rule as winter rye. The oat crop is best put in with a drill, three bushels of seed to the acre for soiling, but to be matured as grain, two to two and a half bushels of seed is better. Two harrowings with the slanting-toothed harrow should be given to stimulate the growth of the oats and cause them to tiller freely. Oats will then grow very thick, and the heading will be somewhat delayed so that, at a foot high, they may be cut for soiling and another crop grown rapidly. But it is best, generally, to cut only one crop and then the grain should be in milk, as at that point it contains the largest amount of digestible nutriment, but if there is a considerable quantity to be used, cutting may be begun when fairly headed out.

PEAS and OATS may also be combined in the same soiling crop, and they will be ready to cut at the same time. This combination of green food is of the very best—the pea and the oat being both rich in albuminoids—it furnishes a most excellent fattening food, as well as one for the production of milk. They both grow well together and largely increase the amount of nutriment. For seed, mix two bushels of peas to forty quarts of oats, and then drill in four bushels of the mixture to the acre. This will give a good stand, and soon cover the ground and keep down the weeds. This combined crop is ready to cut as soon as the pea is in blossom, but is best when the seed is in milk. We have had a yield of fourteen tons of this combined green food to the acre, and no better food is grown. This united crop may be put in early, as frost does not injure either peas or oats.

COMMON MILLET (*Panicum Milliacium*).—On a dry, rich, light, well-pulverized soil, millet will furnish an abundant yield of green food of the best quality. But, being a fine seed, it is not adapted to heavy soils, which do not easily pulverize, especially not without thorough underdrainage. Heavy clay loam, if rich and finely pulverized, will raise the heaviest crops; but this quality of soil is difficult to pulverize sufficiently. A very great weight of green food may be produced from millet. It will grow four to five feet high, and, if thick on the ground, will yield fifteen to eighteen tons per acre. In this green state it has a nutritive ratio of one to seven, whilst timothy grass is one to eight, which shows well for quality. If sown broadcast, 32 to 40 quarts of seed may be used; if planted with a drill, 16 to 20 quarts, but it should be put in not more than half to an inch deep. May be sown from first of May to first of July. Should be cut before or in early blossom.

HUNGARIAN GRASS (*Setaria Germanica*) belongs to the millet family, and its quality as a green food is nearly or quite as good. It has a still finer seed. It does not grow quite so tall, but grows a heavy crop on good land, which requires to be of the same quality as for millet.

Sixteen to twenty quarts of seeds give a good stand. It should be cut for soiling (if only a single crop) before or while blossoming, but two crops may be cut if the first is taken before the head is formed. It grows again very quickly, yet it is doubtful if two crops would be as profitable as one full crop. For seed Hungarian grass carries a shorter, more erect, spike-like panicle, and yields less grain than—

ITALIAN MILLET (*Setaria Italica*), which grows four feet high, and has an abundance of foliage, with a long and numerously-branched panicle, yielding a large amount of seed. This is said in Europe to produce three to five times as much grain as wheat to the acre. Its head is of a yellowish color, whilst the Hungarian is darker, the seeds also darker.

The millets grown in this country are considerably mixed, almost all kinds being found in every field. The Italian is often called "Golden Millet."

When the land is appropriate the millets cannot be safely left out of the list of soiling crops.

VETCH (*Vicia Sativa*).—There is both a winter and a spring variety of vetch, but the winter is thought the best. It may be sown with winter rye, or, if the spring variety, with oats. We have had no experience with the vetch, but know that it is grown between Toronto and Montreal, in Canada, and see no reason why it may not be grown in a similar climate on the American side. It is a valuable soiling crop in England and Europe. Its food value is very similar to the pea. It is highly esteemed as food for work horses during summer. It may be cut several times in a season, and furnishes a large amount of food.

FODDER CORN.—This, although given near the last, is not least. Corn is adapted to the soils of all the States, and produces, under favorable circumstances, enormous yields of green fodder. The author has grown 28 tons to the acre; but M. Goffart, of France, grows from 30 to 50 tons, as he has stated in his work upon "Ensilage." His statements seem quite reliable, as he weighed whole fields when brought to silo. There is no doubt that it produces a larger weight of green food than any other crop raised in the United States except, perhaps, sorghum, and this renders its study, as a soiling crop, of the highest importance. Its nutritive ratio is about one to nine; so it is not so nutritious as grass or millet; yet, being digestible, and furnishing such an abundant quantity, it is a most desirable crop, as it can be fed in combination with clover, oats and peas, and other more nitrogenous food. The largest crops may be grown with the large Western or Southern varieties of field corn; and next to these, mammoth sweet corn and Stowell's evergreen sweet corn. The quality of the sweet varieties is better than the field varieties. The greatest amount of desirable nutriment is obtained by planting in drills 32 inches apart, so that the corn can be thoroughly cultivated. The sweet corn will then grow ears upon a large proportion of the stalks, and these ears, in the soft state, greatly improve the quality of the food for both fattening and milk production. When thus grown, cattle fatten rapidly upon it, and cows yield milk abundantly. Corn is so easily grown, and produces so largely, that dairymen make it the principal green food to sustain their herds upon short pasture. Judicious feeders, when they have no other green food but fodder corn, are in the habit of feeding wheat bran and middlings with the corn fodder, so as to make it a well-balanced food.

SORGHUM.—This is very much of the nature of Indian corn, but contains a slightly larger percentage of albuminoids; and, on soils suited to it, as large crops may be grown as of corn. It requires a finer tilth than corn, and more careful attention in the beginning of its growth. It needs to be grown very thick in the drill to prevent the stalks from having a hard, flinty rind. It contains much sugar, which is very digestible and fattening, rendering it also appetizing to the cattle. It grows very tall, and thus yields a great weight, often 30 or more tons per acre. Its curing for winter fodder should not be attempted, as it contains so large a proportion of juice as to render this almost impracticable.

### HOW TO USE THE GREEN CROP.

Our farmers are quite too much inclined to confine animals to a single food whilst it lasts, and then take another and feed that in the same way. Under the soiling system, as every other system of feeding, the first study should be to give as much variety in the ration as convenience will allow. Winter rye makes a wholesome soiling crop, but it is much better to feed it with clover when that can be done. The two make a better-balanced ration, and the over-succulent clover is modified by the less succulent rye. When the only green crop is clover in its most succulent state, we have often run the clover through a cutter and then mixed it with one-quarter to one-third of its bulk of cut straw, let it lie in mass for a few hours and the straw absorbs the extra moisture, when the whole will be eaten greedily, the straw preventing all danger of bloat. We have been a little surprised to find that cows will yield the same milk upon a mixture of one-fourth straw with the clover as when fed on clover alone. The test, however, was not made so accurately as to determine whether they made the milk on a quarter less clover; they may have eaten nearly as much clover and the straw extra. But with a great deal of experience in thus mixing in straw, we concluded that it was a profitable way to use straw, as we found on examining the drippings that the straw was well digested. When the clover begins to blossom, its succulence is so much reduced that it is quite safe to feed it alone. When the system of soiling is conducted on a large scale, the use of the feed-cutter will be found very profitable in mingling all the fine and coarse parts of the fodder together, especially if the green crop is fed a little too mature, so as to become slightly tough. The animals relish such tough green food much better after being cut.

Fodder corn should also be fed with second-crop clover when the two are ready at the same time. If fodder corn and clover are run through a cutter together, even when the corn-stalks are large, every part will be eaten clean. A very heavy crop of corn is largely benefited by being cut into quarter-inch lengths, and if no other green crop, such as clover, millet, or vetches, etc., is to be had, then mix one-fourth cut clover hay with it, or two quarts of bran, or one pound of linseed-meal, or cotton-seed-meal, per bushel of cut corn. This will render the corn a profitable ration.

Sorghum, when used as a soiling crop, is even more benefited by being passed through the cutter and reduced to very short lengths. This, also, should be mixed with other green food, such as clover, millet, orchard grass, lucerne, etc., or some dry food as above described.

The feeder will often be able to feed three or four different green foods at the same time, or he can feed two one day and change to two others next day, and he can be guided in the selections by the chemical qualities of each, and the tables we gave in the last chapter will enable him to determine the proper combination. He need never fear of giving too great a variety.

## Soiling Horses.

This class of stock is thought by many to be quite unadapted to the soiling system, especially colts, as they require exercise to develop the muscular power; soiling is thought to require too close confinement. This arises from a misconception of the flexibility of this system. Soiling does not, necessarily, require the confinement of animals any more than pasturing. It is true that pasturing furnishes larger fields to range in; but nearly every farm can devote a lane running to the wood lot as space to exercise in. This lane is necessary for the convenience of the farm, and generally furnishes a road to the different parts of the tillable land and meadow. This will furnish abundant room for colts to make trials of speed, and afford all the exercise required to develop muscle. This runway is easily fenced so substantially as wholly to prevent the colts from jumping, and thus becoming troublesome. We have raised a dozen colts in this way, and found them to develop in every respect as well as those pastured. That colts may be as little confined as possible, racks may be arranged under a shed, into which the soiling food may be placed, and the colts have access to it at all times. We found this food to work well with brood mares and their foals. Having the food of the mares wholly under control, their production of milk will be more uniform, and the growth of the foals much better, than on pasture. The dam requires full feeding upon appropriate food, and this may always be given in soiling, as any defect in the succulence and nutrition of the grasses or other soiling food may be supplemented with middlings, oil-meal and oats. The foals are also constantly under the eye of the feeder, easily become accustomed to handling, and may be taught to take other food at a younger age. Early familiarity with the attendant and docility are not only favorable to the foal's progress in development, but to its easy management at the training age. The vigorous, steady and healthy growth of colts is most essential to their future value as serviceable animals, and, therefore, to the profit of the breeder. Soiling offers the most complete control over the food and management of the colts, and, therefore, under this system they may be grown with much more uniform success, and, on land worth fifty or more dollars per acre, much cheaper than by pasturing. As we have shown in another chapter, the foal responds more quickly to the use of cow's milk than any other food after weaning, and this may be skimmed milk, after teaching it first to drink new milk. The colt being under attention in soiling, this extra food may be given with very little labor. From considerable experience we regard the soiling system as well adapted to the raising of horses in all stages, from the suckling colt to the mature horse.

### Soiling Cattle.

We have treated incidentally of this subject in previous pages, but will here speak of the appropriate arrangement of cattle in soiling economically.

1st. Those who believe that steers should have full liberty and freedom of exercise at all times through the summer may arrange a double rack, with a feeding trough or manger for grain on each side, under the center of an open shed, high enough to drive a wagon under and deliver the soiling food into the rack. This rack will accommodate a row of cattle on each side, and may be constructed in several ways, but the following is as good as any: Construct a platform 4 feet 8 inches wide and 18 inches high, of 1½-inch plank, and let the two outside planks be 16 inches wide, and these planks form the bottoms of the feeding troughs or mangers. Nail a plank 10 inches wide on each edge of these outside planks, and you have a manger 8½ inches deep. Between these two mangers will be a rack, consisting of sticks, round or 1½ inches square and 4 feet long. Set these up 4 inches apart, 2 feet wide at bottom, flaring 4 feet at top. These rack sticks may be fastened to the manger at the bottom and between two strips of board at the top to form an upper rim, tying across from side to side every six feet. The green fodder is thrown into this rack, and the cattle eat from either side. The grain, or ground-feed ration, if any is given, will be placed in the mangers. The greatest objection to this mode of feeding is that the master animals may annoy the timid ones. The steers may be tied, but this will add somewhat to the labor; or it might be arranged with gates to shut in each animal, but most farmers would prefer to have them loose. The rack should be long enough to give 2½ feet to each animal. A careful feeder may devise methods to give the timid animals their share. Pure water should be provided near this feeding rack, where the cattle may drink at pleasure.

2dly. Those who have had most experience think a well-ventilated stable, with the cattle tied so as to be easy, having freedom of action (the tie shown in figure 10, page 98, or the same somewhat modified and described on a future page, is among the best), will give the best result in feeding, as here every animal gets its rations perfectly undisturbed, and the ration may be varied to suit the particular requirements of the animal. With the tie here mentioned, no greater space is required than with stanchions—say 3 feet 2 to 6 inches for large cattle, the tie permitting them to lick themselves and change positions at will. They should be arranged upon both sides of a feeding-floor, with heads turned to the floor. This affords the greatest facility for feeding, as both rows of cattle may be fed at the same time from a wagon driven along the floor. Animals that are reared in this way will take their places regularly, and are easily fastened. This feeding-floor should be ten feet wide in the clear of the mangers, so that a wagon with a hay-rack on may be conveniently driven through it. In this case the cattle may be let out from 10 A. M. to 3 P. M. for exercise and water, if water is not provided where they stand in the stable. A farm that carries on a regular system of stock feeding will have convenient buildings for that purpose, especially in those States where cattle are fed in barns. A well-constructed stable is also cooler than the open air, and troubled less with flies.

Under this system the skillful feeder has the condition and thrift of his cattle wholly under his control, and his profit will consist in giving all the food they can properly digest. He may take full advantage of the element of time, securing the largest growth in the shortest time, which always produces the greatest profit.

## Soiling Cows.

In feeding cows will be found one of the most important uses of the soiling system. To produce milk profitably, cows must be full fed constantly whilst in milk, and this system furnishes the surest means to that end. It is also most important that cows should be kept comfortable—that they should have a cool stable in summer and a warm one in winter. If cows are fed in stable in hot weather, then it should be at least as cool as in the open air, and this requires that the walls of the stable should be non-conductors. A thin wooden wall—that is, a frame, merely boarded—will make a hot stable, the heat of the cows' bodies assisting in raising the temperature. If made of wood, the wall should be double, and the space filled with sawdust, tanbark, or corn-cobs, laid in straight and compact, and then, being well ventilated, it will be cool. A concrete wall, such as has been described in the chapter on stock barns, will make a very cool stable in summer and a warm one in winter, as it is a very poor conductor of heat and cold. The cows should be arranged the same as described for the fattening cattle, with heads turned to the feeding-floor. If wholly soiled, the cows should be fed four times—at 6 and 9 A. M. and 3 and 6 P. M., giving air and exercise between 10 A. M. and 3 P. M. It is particularly important to look after the condition and yield of each cow, and, being fed in stable, where each cow eats unmolested, it is easily done. This affords such control over the food of each cow that her capacity for milk production can be tested, and, after a thorough trial, can be passed upon and selected to keep or be discarded.

We have had many years' experience in soiling cows, and find that healthy, vigorous cows of 900 lbs. will eat 100 lbs. of succulent clover or grass, the same of green oats, green rye, or peas, 85 lbs. of millet or Hungarian grass in blossom, and, there being more water in green fodder-corn, they will eat 100 to 125 lbs. of this. These rations are the average for a herd of cows of 900 lbs. weight. The loads of green food were weighed upon the scales for many weeks, to find the average amount of such food required. But some cows eat considerably more than others, and the feeder must have judgment to determine the wants of each. Milk is made from the daily food, and one cow, yielding much more than another of the same weight, requires more food to balance the account. It is very easy in soiling to add a small grain ration, and this is especially necessary if green corn is fed, for this food is not rich enough in albuminoids to feed alone for any considerable length of time. It should be fed with some nitrogenous grain or feed, such as wheat-bran, oats, oil-meal, or pea-meal, clover, peas, or millet. But it is easy, when soiling is undertaken systematically, to grow a variety of crops, so that corn need seldom be fed alone. When cows are properly soiled, they yield a much more uniform quantity of milk through the whole season, and thus produce a larger aggregate yield.

It is better to have pure running water within reach of the cow as she stands in stable, or, at least, in a trough in the manger, which may be opened for her twice or more per day.

We regard it as important also to place cows upon a self-cleaning iron platform, because, standing so much in stable, it is very difficult to keep them clean in any other way. This self-cleaning stable was illustrated and described on pages 97 to 101. It is not expensive, and is so durable that it will save its cost in labor many times over. Cows may be soiled in rack, under a shed, as described for feeding cattle, and milked in the yard, as many dairymen still do; but the stable is preferable, for the reasons given above.

## Soiling Sheep.

Some will regard soiling sheep as quite impracticable, thinking that these animals cannot bear the necessary confinement. A single small field will not do for sheep to run on, as for cattle; and, hence, they think sheep cannot be soiled. But this opinion is not well founded. They may be soiled as safely as any other stock. It is only necessary that they be kept in small flocks, and changed frequently to fresh ground. This can be done by using a portable hurdle fence. The fields first cut over for soiling may be used to hurdle sheep upon. Let the sheep be kept in flocks of fifty to one hundred. Surround a plat, ten rods square, with a movable hurdle fence, and on this plat may be placed fifty to one hundred sheep, to be fed in racks on each side of the field. These racks may be made very light, and thus be easily moved. The sheep are fed on this plat one week, and then removed to the plat adjoining. By having extra hurdle fence for three sides of the field, this may be placed so as to surround a new field on one side, and the sheep then let into the adjoining plat. This gives at least one rod of fresh ground to each sheep per week; and the droppings will make a slight top-dressing of manure, and, with one bushel of plaster sown over this, to prevent evaporation of its volatile elements, will be found to increase the next cutting. This may be carried on across the field; and by feeding the sheep all the green food they can eat, they will not injure the growth of the second cutting. The greatest difficulty in this plan is in furnishing water to the sheep. If this is obviated by having springs or a stream of water in the field thus used, everything will work well. We have tried this plan, and found no practical difficulty—the sheep doing excellently well, and remaining healthy.

The reader will see how many advantages may attend this mode of feeding sheep. The different classes of sheep may thus be separated, and each put under the course of feeding desired to accomplish the special purpose aimed at. Those intended for market, may be fed specially to that end; and, having the absolute control of the ration, they may be pushed as rapidly as the feeder chooses. A small grain ration may be given with the green food, combining it so as to produce the most rapid fattening. This plan also keeps the sheep constantly under the eye of the shepherd, and their condition is much more under his control than when in pasture.

In soiling sheep, the grasses must be cut in a more tender and succulent condition than for cattle or horses. Meadow grasses should be cut when from 6 to 10 inches high, before fairly heading out, and clover the same. If clover is allowed to come into blossom, the sheep will only eat the heads, leaves, and small branches, rejecting the body of the stalks. The only way to induce them to eat clover in blossom is to cut it all into one-half inch lengths in a straw cutter, and then feed in troughs. In this form sheep will eat it clean.

Soiling offers the best plan for raising lambs for market, as the dam may be fed in the best way to produce a large yield of milk, and the lambs furnished with such additional food as will push them the fastest for an early market, at which the best prices are obtained. We regard soiling as specially adapted to sheep-feeding where lambs and mutton are principally depended upon.

As to the matter of health, the English practice of folding sheep upon turnips whilst they eat them out of the ground, confines them longer on the same space than this proposed plan of soiling; and, therefore, it need not be feared that their health will suffer under such confinement with the weekly change.

In the hottest part of the season there should be some shelter to screen them from the sun. A simple canvas awning will answer every purpose, and is easily put up and removed. This will completely modify the sun's rays, and add much to their comfort. This plan of feeding reduces the labor of delivering the food to the sheep, since the soiling crops are near. From our experiments in soiling sheep, we became strongly impressed with its importance, especially on small farms and near good markets for mutton.

## SOILING EXTERMINATES WEEDS.

We wish to emphasize this point, as it is of great practical importance. In many parts of the country noxious weeds almost render the land valueless for cultivated crops, as the weeds occupy so much of the soil that there is only room left to raise a crop adequate to pay the labor. In a proper system of soiling, the land is not suffered to mature weeds. The annuals are generally killed by the first cutting, and if not, always by the second. The perennials are cut before the seed forms, thus preventing any seed ripening to grow new plants; and as all the successive crops are cut green, no seed can mature. The soil may have several crops of weed seeds in it; but whenever they come to the surface and grow, the first cutting kills them. Canada thistles, being cut before seeding, are soon killed; and if seed exists in the soil, the new crop that grows after plowing will also be killed before seeding; and a few years will exterminate them. As all the various weeds will be eaten when cut in the green, succulent state, it may be said that the weeds will pay for their own extermination.

Fields that are infested with the worst weeds may be selected to cultivate a few years in soiling crops, and thus rendered clean. Under the strict soiling system no plant could grow, the seed of which was not sown, after the land once became clean. The white daisy and plantain are even worse, if possible, than Canada thistles, but frequent plowings and cutting before seeding will end these also. Soiling may be considered the only feasible system of ridding our fields of weeds, and this alone would, in some localities, render it profitable.

## HOW TO INTRODUCE SOILING.

A good system is not appropriate for all farms. A farm turned up at an angle of 45 degrees, covered with rocks, or a newly-cleared one, covered with stumps, is not adapted to soiling. There is much land that can only be profitably pastured. It is only comparatively level, arable land that permits the introduction of soiling; and on cheap, level western prairie, where labor is more valuable than land, soiling will not pay till land rises to a value of fifty dollars per acre. This system may, however, be partially used even in hilly Vermont. Many farms have some very rough fields, which can only be pastured; but a large part of the farm being arable and fertile, crops may very profitably be grown for partial feeding when pastures are short. These farms, with one-half in hill pastures, having the other half in rich, alluvial soil, may double the stock kept, by using one-fourth of the tillable land for soiling crops. The increase in stock will so increase the manure as to double the winter fodder, and thus carry them through the year. In this way many farms, having a portion of soiling land, may carry a larger stock than other farms, all arable, on which stock is only pastured. But we do not advise a sudden change from pasturing to soiling, even on the farm best adapted to it. It requires preparation to change from one system to the other, and this preparation should be carefully considered and fully made. The want of such preparation has usually caused great disappointment; and we therefore advise that only a small addition should be made to the stock at first, leaving the pasture nearly the same, but providing clover and a small allowance of the most important soiling crops, thus giving the stock what they can eat besides the pasture, and then reducing the pasture year by year, as the new system is better understood. Dairymen will find soiling to grow rapidly in their confidence, if they will provide this green food for their cows at evening and morning in the stable, allowing them to run in the pasture through the day. This will keep the pasture in good condition; and giving the cows full feed, they will give an increased yield of milk through the season. They will soon see how much they can reduce the pasture, and how well adapted their fields are for producing green crops. Dairymen are better prepared than other stock-feeders to introduce this system, from the practice they have had in raising and feeding fodder-corn in times of short pasture. The change may be so gradual as not to interfere with the general business of the farm, and whether the system be partial or full soiling, there will be no disappointment.

## Winter Soiling—Ensilage.

France, Germany, and some other portions of Europe, have practiced summer-soiling for more than a century. But, although they were able to supply their cattle and other stock with green, succulent food during the warm season, yet they were obliged to cure grass and other green food to be given during the winter season. This seriously checked the growth of their animals and also added to the expense of keeping them. It is not at all surprising that great effort should be made to overcome this obstacle to steady growth. They could raise any desired amount of green food, and if any plan could be invented for keeping it in its succulent condition, soiling could be continued throughout the year. Some parties, who desired to preserve the refuse beet-pulp of the beet-sugar works for future feeding, hit upon the plan of pitting it like potatoes, and found that it could be preserved in this way for many months. It became evident that the only condition necessary was to exclude the air, to prevent fermentation. That principle had long become familiar in the preservation of perishable fruits in hermetically-sealed cans. The only thing to be devised was an economical plan of excluding the air. The pit answered for beet-pulp, and next green corn was pitted, and found to come out with only a moderate amount of fermentation. Long trenches were dug in dry earth, five feet wide at the bottom, seven feet at the top, five feet deep, and as long as was required for storage of the green corn. The green corn was at first placed lengthwise and flat in the trench, trodden in thoroughly, carried up above the surface of the ground three or four feet, and straw placed over the top; then the earth thrown out of the trench was packed upon this green corn, and, as it settled, more earth was thrown on to prevent cracking so as to admit the air.

These rough pits were found to preserve the fodder with most of its original succulence, and although more fermentation had occurred than was desirable, yet cattle ate it greedily, compared with what they did hay. This mode was continued for several years in Germany, and was adopted by many in France. It soon became evident that the more solidly it was packed into the pit the better it was preserved. The next step in improvement consisted in running the fodder through a straw-cutter, and cutting it into short lengths of half an inch or less. In this state it packed much more solidly, and was thus rendered less penetrable by air, and much more could be stored in the same space. When put up in this way, and much care taken to preserve a solid crust of earth over it, the fodder came out in much better condition, frequently only undergoing saccharine fermentation. Even this rough way of preserving the green food was considered a great improvement over drying. But a most important advance upon this system has been made by Mons. A. Goffart, of France. He desired something more certain and uniform in its operations than the covering of earth. He built two parallel walls, air-tight, and as far apart as was convenient—from 10 to 15 feet, and 8 to 12 feet deep. The ensilage is packed between these walls and trodden in closely to the top. Wishing to get rid of the earth, which was liable to get mixed with the feed, he hit upon a cover of planks, placed across the silo, fitting to the wall, but moving down as the body of the green ensilage settled. To keep this plank cover pressing on the top, he weighted the planks with about 500 pounds to the square yard. His movable weight-cover, which gave *continuous pressure* upon the green ensilage, and thus excluded the air, was the last improvement that he regards as insuring the uniform success of this mode of preserving green fodder. M. Goffart has tested this system so thoroughly, not only as to its success in preserving the quality of the green food, but as to the effect of the ensilage upon the health and growth of hundreds of cattle, and so many other most intelligent French farmers have verified his results, that we are forced to regard the practicability of the system as established—that all the soiling crops that we have described may be preserved in silo, at just the point in their growth when they are most succulent and nutritious—and that these green foods may be produced upon all stock farms in the settled portions of the country, in such abundance, that all our stock may be fed upon the most succulent grasses throughout the winter. There may be many details in the system yet to be perfected and improved, but all the important facts are well established, and their probable effects may be considered.

1st. This discovery continues the soiling system throughout the year. A continuous succession of green food may be presented to our cattle and other stock during their whole lives. This will offer facilities for producing a much more uniform growth in all our stock. It simplifies our feeding operations, and when fully put in practice will supersede all efforts to render hay and other coarse fodder more digestible by cooking. The succulence of ensilage is greater than we can ever hope to produce by cooking. Its digestibility must be very similar to grass eaten in pasture, provided it is preserved at a proper stage of its growth.

2dly. This system will enable farmers to carry more stock with less grain, and thus save much labor in cultivation of grain crops intended as food for stock. The good book says "all flesh is grass;" and feeders often find that cattle take on flesh as rapidly on fresh pasture-grasses as under grain-feeding. Grain makes the flesh of cattle more solid than that from grass; and grain will always be an important addition in meat and milk production, but the proportion of it profitably used will be much less in winter-feeding on mixed ensilage than on hay.

3dly. Winter-feeding upon ensilage will require less labor than the old system. The labor of cutting crops green and storing in silo will be less than that now bestowed on cutting, curing and storing in the barn. And, whereas a very large percentage of hay is badly damaged by storms and over-ripening, green fodder may always be cut and properly stored in the silo during the worst seasons. It is found that all the succulence and moisture are required to preserve the green food in the best condition. It is ready to feed directly from the silo without any preparation, it having been cut into short lengths when stored. This system insures the best preparation of the food, requiring the least labor in its mastication, because, in order to preserve it best, it must be cut into half-inch lengths, so as to pack most solidly and exclude air.

4thly. The silos in which to store green food will cost less than barns to store hay, as it is compressed so solidly as to occupy much less space. A cubic foot of ensilage weighs about 45 pounds, or about 12 tons of ensilage would only occupy the space of one ton of hay; but as the ensilage will contain much more water, two and a half tons of this will only equal one ton of hay in dry food; yet the ensilage will still occupy only one-fourth of the space accorded to dry food.

5thly. This system will be applicable to the whole country—may be as successful in Maine as in Virginia. Perhaps it will be more prized in the colder States, as the season of winter-feeding is there much longer and more trying to the constitution of the animals.

In the colder Northern States cattle make excellent progress on good pasture, but much of this is lost during the long, cold winter, when they are confined to hay and coarse fodder. Grain is there often thought too expensive for feeding growing cattle, but with ensilage, these cattle, in warm stables, will make a summer growth all the year round. This system put in active operation, would have a remarkable influence on the production of meat, milk and wool, in the Middle and New England States. These States could then fully supply the home demand for meat. Our exports of animal products amounted, for the year 1881, to nearly $175,000,000. These exports are constantly increasing, and as we improve our processes of preserving meats, and our system of transportation of live animals and dressed carcasses (the latter is likely to be the principal mode of transportation in the future), the demand is likely to grow in proportion to our facilities. We believe the most profitable part of our farming for the next fifty years will be in the production of meat, milk and wool. An increase in animal products means an improvement in our system of farming—an increase in the value of our landed property. Grain-raising, without stock, means a constantly deteriorating soil, and an inevitable impoverishment of our resources. This system of ensilage may be made the means of carrying a large proportion of stock in grain-raising States, as every acre properly treated under this system will represent, for cattle-feeding, three acres under the old system. The increase of manure will give a larger yield of grain on two-thirds the number of acres. The system of soiling, with the addition of ensilage for winter-feeding, is rounded out into full proportions, and gives a hundred-acre farmer as great a capacity for keeping stock as the three-hundred-acre farmer heretofore.

## SILOS.

We have above spoken of the recent improvements of this system of ensilage, and some have regarded it as a recent discovery, but it had been practiced by the Austro-Hungarian farmers, in their rude way, more than 50 years before the French had turned their attention to it. The Hungarians pitted their green fodder in the earth. According to some of the early Roman agricultural writers, grain and fodder were pitted by the farmers of Italy at an early period of history. The principle involved in the ensilage system is, therefore, far from being new. The Hungarian and German silo was simply a pit dug in a dry place in the earth, 8 to 10 feet wide at the top, 6 to 8 feet at the bottom, 6 to 8 feet deep, and as long as suited the convenience of the makers.

The green fodder, rye, rape, vetch, clover, seradella, or grass, etc., was laid in the pit, crosswise, trodden firmly, and pitted three or four feet above the surface of the ground, like the cone of a potato heap. This top was covered with straw, leaves or brush, and the earth thrown from the pit was banked upon and over the top to the depth of 18 to 24 inches. This covering of earth was compacted so firmly as to exclude the air, furnished a heavy cover which settled with the fodder in the pit; but in settling it was liable to crack and let in the air, so that frequent attention was required to fill these cracks and compress the earth. So the improvements made by Goffart were the natural growth from the primitive method. We mention these facts rather to strengthen the impression of merit in the system, for, having been in practical use for a thousand or more years, the question of economic value in the preserved fodder must be considered as settled.

The present form of silo is a very great improvement upon the earth silo, and the ensilage must be correspondingly improved. When the air-tight wall silo with its constant pressure cover is operated expertly, the green food should not pass beyond the saccharine stage of fermentation, and when taken from the silo and exposed to the air, the alcoholic fermentation soon begins. In this state the ensilage (preserved fodder) is in its best condition for feeding and its food value is probably equal to what it was at the time of packing in the silo—that is, its changes have improved its digestibility as much as fermentation has reduced its weight of dry substance. Some have figured a considerable increase in food value, but this would be equivalent to the production of *something* from *nothing*, except so far as an increase in digestibility might occur from the chemical action of fermentation.

## Plan of Silo.

That our readers may get a clear idea of the plan of building silos, in convenient form, of concrete or other durable material, we give the outline of a ground plan for a triple silo—the inside of each being 16 feet wide by 32 feet long and 16 feet deep.

We give plan for triple silo because many farms require storage of this capacity (about 185 tons for each silo, or 555 tons), and if less storage is needed two may be built, or one, if that is all that is needed. If more capacity than one is required and less than two of this size, then it would be better to build two side by side 25 feet long, rather than to build one 50 feet long. The latter would take 23 feet more in length of wall; besides, the two silos side by side would be more convenient, the doors being near together. The roof on this ground plan would span the silos lengthwise, and another silo could be added at any time, requiring only one side, or long wall, and two end walls, and the roof can be extended over the new silo. This plan, then, permits one to be built as a trial silo, and others to be added at any time without any change of plan. This form of silo may be placed with the door end near the driveway into the basement stable. A track laid from the silo door to and along the center of the feeding-floor of the stable, on which a car can be run to the silo and the ensilage delivered to the animals on either side of the floor. This car may hold one feed for the whole stock, and be moved on the track by one man.

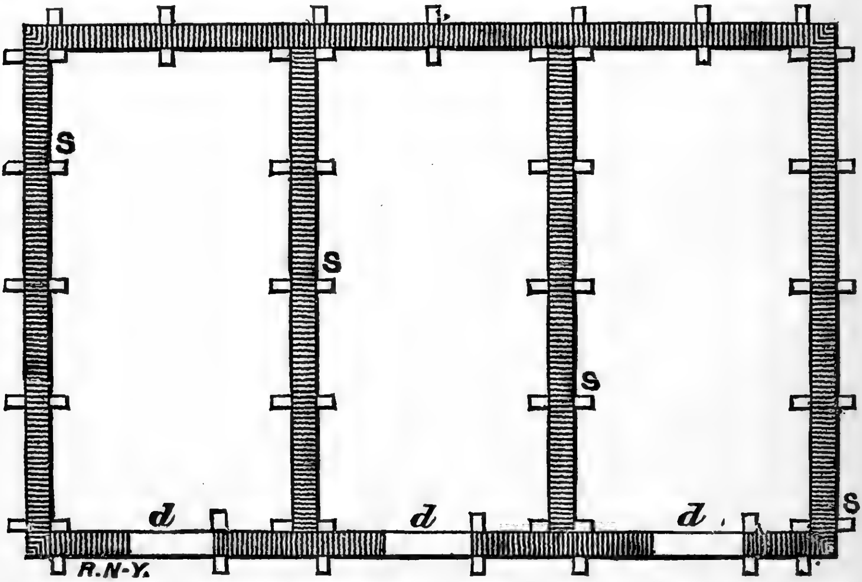



*Fig.* 16.—TRIPLE SILO.

These silos are intended to be built of concrete, and the plan shows how the walls are constructed. *S S S S* represent the standards—3 × 6-inch scantling—placed inside the proposed walls, edges to the wall, making them stiffer in holding the plank boxing. These standards are placed mostly in pairs (one on each side of the wall) and three inches further apart than the wall is to be thick, and reaching some inches above the top of the intended wall—17 feet long for a wall 16 feet high. The pairs of standards are placed about 8 feet apart. The boxing planks (represented by the lines inside of the standard) may most conveniently be 1½ inches thick, 14 inches wide and 16 feet long, except those on the outside of the end walls, which must be 17½ feet long. The walls, being 16 feet high, should be 16 inches thick, if made of concrete. Concrete walls are stronger than the same thickness of stone wall, laid by a mason. The doors are represented by the letters *d d d*. The boxing plank extend across these doors.

## Building the Silo.

For convenience of filling, the silo may be sunk half its depth or more in the earth, where the situation permits this to be done with good and easy drainage. But if the soil is springy, or if the silo is to be sunk in slate or shale rock which permits the water to pass freely through it, so as to produce a pressure of water on the bottom, it is difficult to make the bottom water-tight without cutting a free drain 12 inches from the outside of the wall and some inches below the bottom, so as to conduct the water around and off. It is better not to go deeper in any case than can be easily drained. It is also most convenient not to have the bottom of the silo below the level of the feeding floor of the basement stable, unless the ensilage is to be taken out at the top, run into the upper floor of the barn and dumped through upon the feeding floor of the basement where the stock is kept. If two to four feet are excavated, this earth can be used to bank up on the back end of the silos for an elevated drive-way for setting the cutter or for delivering the green fodder. The excavation should be at least 18 inches beyond the proposed wall for convenience of working. Having got the bottom leveled, set the standards 19 inches apart (this will give a space between the boxing planks of 16 inches), care being taken that the edge of the inside standard next the boxing be straight. To hold the standards firmly in place, nail a lath across the under ends; this will prevent them from spreading, leaving the lath under the wall and offering no obstruction to the removal of the standards after the wall is built. Now a bracket should be nailed across the top and the pair of standards set accurately plumb on the inside edge and solidly stay-lathed in that position. It is well to stay-lath across the top of the silo from standard to standard besides bracing from the outside; for it is of the utmost importance that the standards should not move, as that will throw the wall out of plumb. When the standards are all set about the proposed walls, and the boxing planks are all placed, we are ready for

### Preparing the Concrete.

The first tier on the bottom of the wall should be made wholly with water-lime concrete, as follows: Mix well one part of Akron or Rosendale cement with three parts of fine sand, while dry. You may now mix in also three or four parts of clean gravel; now mix into thin mortar and place a layer of this mortar, two or three inches thick, in the bottom of the wall-box, and if you have cobble or rough stones, or any irregular stones picked from the field, bed these in the mortar, taking care not to let them come quite out to the boxing plank. Use all the stone you can get in, taking care to have a layer of mortar between them; tamp it all down solid so as to have no spaces in the wall. Fill the boxing to the top, using a layer of mortar and a layer of stone alternately.

For the next layer of wall, and all above, if you desire to use some quick-lime, which is cheaper, then mix as follows: One part of cement with six of fine sand, while dry. Mix in four parts of gravel as before. Have a vat of quick-lime, well slaked under water, standing near, and use this thin milk of lime to wet up and mix into mortar the water-lime, sand and gravel. Make a calculation so as to get about one part of dry quick-lime to eight of sand used.

Being mixed up into thin mortar, it will not be difficult to get the milk of quick-lime mixed thoroughly through the mass of mortar. The quick-lime should be slaked under water several days before using. This quick-lime will improve the walls and when hard will be water-proof. This will give, if stones are also used, about one part of water-lime to 12 or 14 of sand, gravel and stone, and one of quick-lime to about 15 of other materials. This wall will be cheaper than one built wholly with water-lime.

But if the silo is sunk in the earth, it is better to use only water-lime to 12 inches above the ground, although we have seen such mixed-lime wall stand well below ground; yet the quick-lime does not assist in standing moisture. If built wholly of water-lime, the instructions for the first layer should be followed in all the other layers. The boxing planks, after the first layer has become hard, are raised just 12 inches, leaving a lap of 2 inches on the wall below. The mortar is then put in the wall-box and stone bedded in as before, and the tiers are carried up in this way to the top. The standards may be kept from spreading in the middle by having a movable clamp hooked across some feet above the boxing.

Plates $8 \times 10$ inches are placed on the top of the silo walls, and when the boxes are leveled for the top layers of the walls, three-quarter-inch bolts, 21 inches long, with screw or nut on the upper end and a square bend on the lower end, are used. Place three of these in each long wall, one in the center of the wall and one near each end, 12 inches from the end wall. Let the bolt go 12 inches into the wall. To hold these bolts while filling around them, bore a hole in a narrow strip of board and tack this board across the top of the box just where the bolt is to be placed, the upper end of the bolt being put through the hole in the board, standing perpendicularly and 8¾ inches above the box, so as to take the plate. These bolts will be in line, so that holes may easily be bored in the plates to receive them ; or, instead of one plate 8 × 10 inches, it is better to place two 8 × 8 plates side by side, and both just reach across the wall. In this case the bolts in the wall come between the two sticks. In this case the two plates are bolted together at each end and in the middle.

These plates are framed for short posts 4 or 5 feet long, upon which 6 × 6-inch plates are placed for the roof to rest upon. This space between the top of the wall and the roof is usually occupied by swinging doors, which are closed after the silo is filled, but it may all be boarded up except such doors as are wanted for filling the silo; and when it is desired to get as much as possible into the silo, temporary boarding is carried above the wall even with the inside and the ensilage is piled above the wall two or three feet before the weighted cover is put on, and the compressed ensilage only sinks a very little below the top of the wall.

The inside of the walls of the silo is given an even coat of cement, thoroughly troweled down. The bottom is also cemented so as to make the whole air and water-tight. And should it be desired to give a sandstone color to the outside wall, this can be done by mixing one-fiftieth part of oxide of iron with the cement and plaster the outside. The doors should be double, one hung inside and the other outside. The inside door should be hung so as to shut even with the inside wall, be in two parts, and swing out. Felting should be placed on the jams, so that the inside doors will shut air-tight. The outside door should be made in three parts, fastened together with hinges, the upper part only 10 inches wide, and should be fitted to the outside jams of the door so as to be screwed fast, one section at a time, beginning with the lower section. The space between the two doors should be filled with sawdust, packed in, and the upper section is so narrow that the sawdust can be packed closely to the top, and thus make the doorway air-tight. The concrete wall should be built for 10 cents per cubic foot, and the silo need not cost over $1.50 per ton capacity.

## Progress of Ensilage in United States.

Having considered the rise and progress of this system in Europe, let us see what progress it is making in this country. Mr. Francis Morris, of Maryland, some six years ago began pitting green corn in the German fashion, and feeding upon ensilage for a short time in winter some 300 head of cattle. His was green corn ensilage only, and his report was very favorable to its economy. He has continued this practice up to the present, and still gives favorable reports. Perhaps Mr. O. B. Potter, of Sing Sing, N. Y., was the first in this country to build a masonry silo, and he began to preserve corn ensilage about 1877, using a covering of earth to compress the ensilage. His ensilage progressed farther in fermentation than is generally approved, but still was found, as he reports, a very economical food for stock. He has since wisely used clover to ensilage with corn, so as to furnish a better-balanced ration than corn alone, and after some two years' trial gives a favorable report. His earth covering does not so effectually exclude the air as the weighed plank covering.

In 1879 Dr. J. M. Bailey, of Billerica, Mass., built the first double silo of concrete masonry, and stored about 125 tons of corn ensilage, which, although somewhat belated in storing, gave him much satisfaction in feeding. His report stimulated inquiry and experiment in the new process.

At the beginning of 1880 this process was much discussed by the agricultural press, and the result was the building of some fifty or more silos in different parts of the country, most of them substantial, and many of them in the most durable form. This was most remarkable progress for a new system to make in a single season. Probably 8,000 tons of corn ensilage were preserved. The reports from these various experiments were made to the agricultural papers during the next six months, nearly all of them favorable, many of them very enthusiastic, as to its economy and value. Some very extravagant estimates were made as to the tons of corn raised upon an acre, but these estimates were soon reduced to solid fact by the measurement of the compressed contents of the crops in the silos. Forty-six pounds were found to be the weight of a cubic foot of ensilage after compression under 500 pounds to the square yard, and the contents of the silo were easily measured, and thus the yield per acre determined. The yields noted ranged from 20 to 33 tons of green corn per acre. Thirty tons may be considered an excellent yield of green corn. This is equal to about five tons of water-free food, which is nearly five times the average yield of dry food per acre of our ordinary meadows. But it must be noted that the dry food of corn ensilage is not as valuable per weight as that from meadow grasses.

An Ensilage Congress was held in New York in January, 1882, attended by a body of very intelligent men, and reports were made from something like 100 different experiments, and these reports were almost wholly favorable. It is true the experiments were few of them carried out with as much accuracy as is desirable, but the general tenor of them was strong evidence of the probable success of the system. The Commissioner of Agriculture also took the testimony of about one hundred persons who had built and filled silos and fed the ensilage to the close of 1882, and published it in a pamphlet of 71 pages; and in this the reports were nearly all favorable to the economy of the system. The Commissioner says: "There is hardly a doubt expressed on this point—certainly not a dissenting opinion."

It must be admitted that the success of the silos built up to the present time, in the ensilage of green corn, has been very remarkable, and has given this new system a respectable standing in American agriculture; but the final verdict upon the system can only be given when it shall be applied practically to the preservation of our meadow grasses, and thus prove itself worthy of being considered a system in stock feeding.

## Cost of Ensilage.

Mr. August Goffart states that he is able to take the corn growing in a field, cut it, haul it to the silo, run it through the cutter, pack and cover it in th silo, for one franc per ton—a little less than 20 cents. This cannot be done in this country, because our labor wages are more than double those in France. What, then, is the whole cost of producing and ensilaging one ton of corn? Whitman & Burrell estimate it at 80 cents per ton. Mr. Avery estimates the cost of harvesting, hauling, running through a cutter, packing in a silo and covering at $200 for 300 tons, or 66 cents per ton. Dr. Tanner, of Orange County, N. Y., estimates the cost of harvesting and putting in the silo complete 150 tons at 75 cents per ton. Mr. Chaffee, of the same county, who put up ensilage for 30 cows, estimates the whole cost of raising corn and storing in the silo at $2 per ton, and this he considers very cheap feed. The whole cost of raising corn and putting it in the silo has been estimated by some half dozen others at from $1 to $2 per ton. If we take the latter figure as approximating to the real cost, and if we estimate three tons of properly-kept corn ensilage as equal in feeding value to one ton of good hay, then we find it as cheap as hay at $6 per ton in the barn.

But the great advantage to the small farmer in corn ensilage is, that he may produce as much cattle food upon one acre of corn as upon four to six acres in meadow; yet the drawback to this view is, that the meadow produces a complete cattle food, whilst corn is not a complete food, but must be fed with other nitrogenous food to obtain its full value.

The conclusion, then, must be that all the grasses, including corn, supplemented by the clovers and other leguminous plants, must go into the silo together, and these furnish complete rations for the production of meat, milk and wool. The labor bestowed per ton in ensilaging the grasses and grains, in the more succulent state, will be even less than for corn, because the former can be more easily cut by the mowing-machine and handled by the horse-rake and hay-loader, or even with the fork.

It is also quite probable that the grasses, in the fit condition for ensilaging, may be put in the silo with less labor than they can be cured and put in the barn.

The larger digestibility of succulent grass over that of cured hay will certainly be an ample remuneration for this new method of preserving it. It is quite true, however, that by some small German experiments it appears that grass, after carefully drying, is as digestible as in the succulent condition; but when these experimenters seek to generalize from these few and exceptional cases, founding upon them a general axiom that green food loses none of its digestibility by drying, let us oppose to this the great general fact that cattle grow and fatten rapidly and profitably upon the succulent grasses, but cannot be profitably fattened upon the dried grasses or hay. Our meadows are usually stocked with nearly the same combination of grasses as our pastures, but who would assert that a full ration of the best hay would produce as much milk or lay on as much flesh as the best pasture? Such facts, open to the general observation of all intelligent feeders, are not to be upset by a German experiment upon two sheep!

## Ensilage as a Complete Ration.

Conceding that the system of ensilage, which we have described, will preserve the grasses in a comparatively fresh state, how shall this process be applied to general stock-feeding, making a complete system by which animals may be grown, yield milk, and be fattened?

Ensilage, as generally discussed in this country, has been used to signify preserved green corn. This single food is quite inadequate to the complex wants of the animal system. It is deficient in albuminoids to nourish the muscular system, and deficient in the phosphates to build the bones. Yet it is a very valuable ingredient in the ration of animals because of the large weight grown upon an acre, and because it is relished by all our farm animals. Some of the grasses and clovers are rich in the elements in which corn is deficient. To make a complete ensilage ration only requires a proper combination of green grasses and clovers with green corn. Corn having the least proportion of albuminoids, can seldom be used for more than half of the ration. In the table on next page we give some of the most important of the green foods for ensilaging, and give only the water and digestible nutrients in each.

There are many other grasses not mentioned in this table, that may also be used; in fact, all grasses, in their succulent state, make the very best ensilage, and all succulent leguminous plants, may be ensilaged with profit; but this table contains all the plants that will usually be chosen for ensilage. The two German plants, esparsette and seradella, have not been grown much in this country, but, from the few trials, bid fair to be valuable ensilage plants. From this list a proper ration can be combined for growing young animals, for fattening animals, for producing milk, and growing wool. No one can doubt that these green foods, properly combined, contain every element in the right proportion for all purposes of stock feeding. Where these grasses are found in perfection in pasture the feeder relies upon them to produce the highest results.

| Fodder Plants. | Water. | Digestible Nutrients. Albuminoids. | Carbo-hydrates. | Fat. | Nutritive ratio. | Value per 100 pounds. |
|---|---|---|---|---|---|---|
| Maize fermented in silo; average of 11 analyses | 82.0 | 1.00 | 10.19 | 0.54 | 11.4 | 0.16 |
| Red clover ensilage | 79.2 | 2.30 | 8.10 | 0.60 | 4.1 | 0.28 |
| Alsike clover | 82.0 | 2.46 | 8.21 | 0.49 | 3 9 | 0.20 |
| Winter vetch | 82.0 | 2.50 | 6.70 | 0.45 | 3 1 | 0.19 |
| Lucern | 75.3 | 3.50 | 9.10 | 0.40 | 2.9 | 0.25 |
| Green rape. | 87.0 | 2.00 | 4.80 | 0.40 | 2.9 | 0.15 |
| Sorghum | 77.3 | 1.60 | 11.90 | 0.30 | 7.4 | 0.19 |
| Orchard grass | 74.0 | 1.90 | 12.47 | 0.40 | 7.0 | 0.24 |
| Fodder peas | 81.0 | 2.48 | 7.8 | 0.40 | 3.5 | 0.19 |
| Cow peas | 76.0 | 2.6 | 9.4 | 0.24 | 3.8 | 0.24 |
| Esparsette | 80.0 | 2.1 | 8.0 | 0.30 | 4.1 | 0.18 |
| Seradella | 80.0 | 1.9 | 8.9 | 0.7 | 5.6 | 0.18 |
| Carrot leaves | 82.2 | 2.2 | 7.0 | 0.5 | 3.8 | 0.18 |
| Fodder beet leaves | 90.5 | 1.2 | 4.0 | 0.2 | 3.7 | 0.10 |
| Rutabaga leaves | 88.4 | 1.5 | 5.1 | 0.3 | 3.9 | 0.12 |
| Fodder oats | 81.0 | 1.3 | 8.9 | 0.23 | 7.2 | 0.17 |
| Timothy grass | 70.0 | 2.10 | 16.0 | 0.50 | 8.2 | 0 28 |
| Hungarian grass in bloom | 72.0 | 2.64 | 13.2 | 0.40 | 5.2 | 0.24 |
| Fodder rye in head | 76.0 | 1.90 | 12.0 | 0.40 | 6.8 | 0.21 |
| Upland grass, average | 70.0 | 1.90 | 14.2 | 0.50 | 8.1 | 0.23 |

If we examine the table, we find that 100 pounds of green corn would give only one pound of digestible albuminoids. If this were fed to a cow that yielded 30 pounds of milk, it would be insufficient to furnish the caseine and albumen in the milk alone, without yielding anything to supply the waste of the cow's body. The German experimenters think they have shown the necessity of supplying two and a half pounds of digestible albuminoids per day to a cow of 1,000 pounds weight, in milk. This would require 250 pounds of corn ensilage as a daily ration—an impossible ration. But if we take from the table 65 pounds of clover ensilage and 60 pounds of corn ensilage, it will give a complete daily ration for a cow of 1,000 pounds weight, in milk—2.58 pounds albuminoids; 11.37 pounds carbo-hydrates; 1.4

pound fat. This is a large excess of fat, which will more than make up the deficiency of carbo-hydrates. We know from experiment that this ration will produce a large flow of milk, having fed it in just this proportion early in September, from green corn and second-crop clover, both in excellent condition ; but being fed fresh, it contained more water than that given in the table, as that had lost water in the silo. Yet it contained liberal nourishment to produce a full flow of milk. We have fed this combination in several different years, and always with complete satisfaction.

Let us examine red clover as an ensilage crop. As will be seen by the table, red clover is the most nitrogenous of the leguminous grasses there given, except lucerne or alfalfa, and this latter has not been cultivated to any considerable extent except in California. A full crop of green clover weighs more than most farmers suppose. The author has fed many acres of red clover for soiling, and carefully weighed the product of an acre in different seasons. Ten tons have been found only a good crop in a favorable season, and sometimes 12 tons have been weighed from an acre at the first cutting. Twenty tons may be taken from an acre at three cuttings in the most favorable seasons. Lawes' and Gilbert's experiments with different fertilizers for clover, produced from fourteen to eighteen gross tons of green clover upon an acre at one cutting, the latter yield being equal to a little over 20 American tons. And as a ton of clover is worth about two tons of fodder-corn, it will be seen that the clover crop may be quite as profitable for ensilage as corn. It can be cut and ensilaged at a less price per ton than corn can be grown and ensilaged. If, then, we estimate the specially raised clover crop, in two cuttings, to produce 15 tons per acre, this would give a ration of 65 pounds per day for 461 days, and it would take half an acre of good corn to produce the 62 pounds of corn per day—

this is equivalent to keeping a 1,000-pound cow on a full ration of clover and corn 308 days from the product of one acre. This would be the full milking season of ten months, and ought to produce an average of 6,000 pounds of milk. In this case the acre produces everything the cow consumes, and this is certainly a cheap production of milk.

The same proportional ration may be combined of alsike clover, orchard grass, Hungarian grass, or winter vetch and corn, when these shall all be put in the silo. Fodder rye and clover, 50 pounds of each, will furnish a complete ration. One hundred and twenty-five pounds of peas and oats ensilaged together, will give a complete ration. So, likewise, will 100 pounds of timothy and Hungarian grass, or 125 pounds of sorghum and orchard grass. The reader will see that an almost endless combination may be made from this table, giving the requisite ingredients for a complete ration.

If, then, it is conceded, and the proofs are beyond dispute, that these green foods may be preserved in silo in a fit condition for the production of milk, meat and wool, the farmer may feed stock without the use of grain, and thus make his farm self-supporting. In this way the system of ensilage may enable the stock farmer to continue succulent food to his animals throughout the year.

## Ensilage Crops.

The same crops are as appropriate for ensilage as for soiling. But as the crops raised for the silo should be sufficient for the purpose intended, and cannot be assisted by partial pasture, great care should be given to their cultivation, and a sufficient amount of land devoted to them to produce the amount required. A rational calculation for this purpose should be made, based upon 45 lbs. as the weight of each cubic foot which the silo contains. This will render it easy to estimate the number of tons of green crop required to fill the silo. But what shall be the estimate of the expected weight of corn per acre, of rye, clover, millet, etc.? It is well to strive for a large yield by the best management of the land and seed; but it is necessary to make a liberal allowance of land for ensilage crops to meet unexpectedly-short yields. In a large proportion of silos yet built they have proved too large for the crop intended to fill them. This comes from overestimating the probable crop from ordinary cultivation. They have expected to obtain the largest crop with the ordinary amount of manure and labor. It is quite commendable to strive for the largest crops by the best means, but a considerable allowance should be made for an adverse season, and another considerable allowance made for the liability to overestimate crops. The silo makes no loose estimate of a green crop put into it, but weighs it accurately according to the compression. Corn requires about 100 lbs. pressure to the square foot to give a weight of 45 lbs. to the cubic foot of ensilage. The ordinary grasses will pack somewhat solider and give 48 lbs. to the cubic foot after compression under that weight.

The best method of raising corn for ensilage is to plant 36 to 42 inches apart and cultivate it as for a regular field crop. Corn is a rank feeder, and the land should be wel prepared, strongly manured, and that thoroughly worked into the soil. The land, if old, should be worked fine at least 8 inches deep.

Two hundred and fifty pounds of green stalks per rod is a fair yield of corn, or 20 tons per acre; but it is possible to double this yield, yet this figure is seldom reached, and any ordinary caculation, based upon this yield for filling a silo, will come to grievous disappointment. When a party has fairly reached this figure he will have a basis for it.

WINTER RYE, standing thick and 5 to 6 feet high, will often reach 12 to 16 tons green to the acre, but it is not safe to estimate over 10 tons for a carefully-raised crop in filling silo. A good crop of clover, as we have before stated, should reach 10 to 12 tons green, and in favorable seasons, the two subsequent cuttings should reach 8 to 10 tons more. But it must be remembered that this means a thick stand of full-height clover.

MILLET, on land suited to it, should reach 10 or more tons per acre, at blossoming.

PEASE and OATS, in blossom, reach about the same figure as millet. But pease may properly be left, in cutting for ensilage, till the berry, in the earliest pods, is in the dough state. Some part of the head of the oats will also have formed the seed, at this point. But the crop must not be left any longer, for it will deteriorate for ensilage rapidly beyond this point, and if there is any probability of being delayed the crop had better be cut when the pea is in blossom.

TIMOTHY and LATE CLOVER, when in perfection, will make a most valuable ensilage crop—both on account of the large amount of nutriment on an acre, and because it comes at a favorable time for laying in a supply of green food for feeding on short pasture. On land adapted to timothy it often stands five feet high and so thick as to yield 24,000 to 28,000 pounds on an acre as a single crop. The Woburn experiments report a crop of timothy, cut in blossom, that yielded 40,000 pounds on an acre. This is the largest crop ever reported. Professor Way found timothy the most nutritive of all the grasses he subjected to analysis. The danger with timothy is in cutting it too early or too late. The bulb on the lower joint requires to mature before cutting or the root is likely to die. The most appropriate time for cutting timothy is when the first dry spot appears above the lower joint. This indicates the maturity of the bulb, and it occurs while in blossom—

that on the lower part of the spike slightly turned brown, but the upper part still purple. It should now be cut immediately, as it deteriorates in quality very rapidly. The combined crop of timothy and large and late clover may be cultivated to produce from 12 to 14 tons upon an acre, and each ton worth about two tons of fodder-corn. So that this crop should be considered quite as profitable as the corn crop for ensilage, and when the labor is taken into account, much more profitable, as on favorable soil it may give 5 to 10 consecutive crops without any labor except an occasional top-dressing. This crop, allowing 60 lbs. per head per day, would feed a cow through the year. The ensilagist must, however, learn to raise the crop before he estimates more than 60 per cent. of these figures.

SORGHUM CANE is likely to prove a valuable ensilaging crop. Some of the larger varieties yield very large crops, will produce as much as the largest corn; on suitable land 25 tons would be a moderate yield. Should cane be raised largely for sugar, the tops and leaves will make excellent ensilage, amounting from 4 to 8 tons per acre, according to the size of the variety. Containing so much sugar will increase its tendency to fermentation, and the silo will require a well-weighted cover. This crop will have one advantage which may be of considerable service—it may be cut twice in a season. If the season is favorable it may be cut when four or five feet high, and it will spring up again with great rapidity and mature a second crop. We have, for two years, pursued this plan for summer soiling to advantage.

### STORING SEVERAL ENSILAGE CROPS TOGETHER.

If second crop clover is ensilaged with corn, the clover fills the spaces between the coarser pieces of corn, makes a solider mass than corn alone, and more effectually excludes the air, so that it is an advantage in the preservation of the ensilage; and besides, it will furnish the more nitrogenous addition to the ration which corn requires. If corn, millet and clover are ready at the same time, they may be all ensilaged together to the great advantage of the resulting preserved fodder. This combination would give a complete ration for milk without the addition of grain.

When winter rye is ensilaged in June, it may most profitably be mingled with the first cutting of clover. This will furnish an admirable ration for milk through August and September, when pasture is short. These different crops may all be mixed in the cutter together without requiring any extra labor, and all be delivered by the carrier in the silo together. This will give a variety in the ration, and enable the thrifty dairyman to feed his stock without purchased food.

Summer soiling is likely, in the future, to be so closely connected with the system of ensilage that the soiling ration will come from the silo in summer as well as winter. It will be found so much less labor to cut and store the green food all at one time, instead of cutting one day's feed at a time; and, besides, if cut and stored in silo, it can be done when the crop is at its very best, instead of beginning before it is quite ready and continuing to cut it some time beyond its best condition. It will probably lessen the labor of soiling 40 per cent. This will also increase the yield of the crop, and in case of clover or other crop having more than one cutting, give more time for the growth of the second crop.

But the ensilage system must be expanded beyond the very narrow one of green-corn preservation, and include every green-fodder crop—this makes every complete farm independent of the productions of every other farm in carrying on its stock operations. It will often be profitable, when short of ensilage crops, to make up the deficiency by cutting and ensilaging the common meadow grasses when in blossom. These will make the most nutritious ensilage.

The system of milk production, as heretofore carried on, cannot be remunerative without grain-feeding during some portion of the year, whilst under the general system of ensilage, grain-feeding will not be necessary for the profitable production of meat, milk or wool. This being true, it does not follow that grain may not be fed at a profit, but this new system may render every farm independent of grain if it chooses to rely upon its own resources.

## Cutting Crop and Filling Silo.

The best machine for cutting corn and all ensilage crops, except, perhaps, clover and the ordinary grasses, is a strong, self-rake reaper, laying it off in compact gavels, which may be bound into bundles or loaded without binding. Corn may be lifted from the gavel upon the wagon without gathering up stones or sticks to injure the cutter. The reaper will cut an acre of heavy corn as quick as 20 men with ordinary hand corn-cutters. If the corn must be cut by hand, then a stout corn-cradle in the hands of a skillful man will do the best execution. Three teams, with two men to help load in field, will haul corn, from a short distance, as fast as it can be run through the cutter. And there has been no way yet devised better than to have the corn lifted from the wagon by hand upon a table behind the cutter, and have it passed through the cutter as fast as it is delivered upon the table. With an extra wagon the teams will not be delayed at the cutter.

The cutter must be placed so that the cut corn or grass will fall directly into the silo, or be run from the cutter into the silo by a carrier. Carriers are very easily arranged by belts and canvas so as to elevate it 8 to 12 feet as fast as it can be cut.

In hauling winter rye, millet, peas, oats, etc., these may be lifted upon the wagon with a strong gavel-fork, without danger of gathering stone, sticks, etc., and these crops can be handled very rapidly—each team should bring to the silo 20 tons per day with sufficient help in loading.

It will often be advisable, when a large crop of rye is cut in June and no clover to cut with it, that early miscellaneous meadow grasses should be cut so as to mix 25 per cent. of these with the rye in the silo to improve the ensilage.

It is much the cheapest and best to mix the different qualities in the same silo than to mix the ensilage from different silos.

Great care should be taken to spread the ensilage in the silo even and tread as even as may be whilst filling, and the filling should go on continuously every day till finished, and the weighted cover should be put on at once. A foot of clean straw put over the top of the ensilage will assist in preserving it. The straw will spoil and leave the ensilage under it sweet.

# CHAPTER VIII.

## CATTLE-FEEDING.

THE business of cattle-raising in the United States has grown to very great proportions within the last fifteen years—so great as to astonish the European cattle-growers. The typical American is prone to reduce every business to its simplest elements; and he naturally prefers a system of cattle-feeding in which, instead of the expenditure of labor in raising cattle food, building warm barns and feeding the cattle in them with all the modern appliances of science and machinery, the cattle shall feed themselves all the year on the natural grasses of our Western plains. Cattle are thus produced by millions over large districts of our domain; and, from the most favored belts, steers have come to market with a well-matured weight of 1,400 to 1,800 pounds. Skillful ranch operators have made and are making fortunes under this simple patriarchial system of beef production. But this system is merely temporary, a few years, more or less, and the native grasses are eaten out, and beef-growing returns to the civilized system, involving labor directed by skill. Besides, the home and foreign markets require all the good beef we can produce under the best system.

We shall therefore confine our attention to the regular system where so much depends upon skill in its manipulation. We have previously shown that there is no mystery in the growth of animals—that every pound weight put on represents so much food. We wish to impress upon the mind of every stock-feeder this primary law of equivalence—that every pound of growth must be the result of food expended. There is no game of chance in cattle-feeding, by which you may sometimes get something for nothing—every favorable result must be balanced by an expenditure of food and care. It is here all even-handed justice—so much for so much—but never so much for nothing.

Farmers, during the last decade, have given much greater attention to the economical question of stock-raising, not only as a source of present profit, but as a means of perpetual fertility to the soil.

We have long regarded it as the height of unwisdom to export the heavy raw material (grain) instead of the concentrated product, meat; and have been pleased to note a decided change in the general opinion and practice among farmers in this matter. The grain and the animals should be raised upon the same farm, but only the animals sold. There is more profit in the sale of the concentrated product than the raw material.

We shall hope to show how grain-raising and stock-growing may be profitably blended together.

A thorough discussion of cattle-feeding requires that we take up first—

### How to Feed the Young Calf.

As we have seen, fresh milk is the best food for the young calf, and the natural method of taking it is for the calf to draw it from the udder of its dam. But there are many considerations that come in to prevent this natural method among the 500,000 dairymen of the United States. This natural method is only practicable among the breeders of pure-blooded and high-priced stock, grown primarily for beef; and if such breeder of high blood is located in a dairying district, where milk is valuable, it is quite unnecessary that he should feed new milk longer than one or two months. After that period, the calf may be fed upon the skim-milk, and linseed or flax-seed gruel, with an excellent chance of growing a prize animal. In thirty to sixty days the calf will have made an excellent start and be ready for the modified diet. And if the calf is to be taught to drink, it is better to do this when six to ten days old. It will learn easier at that age than later, and the cow will give more milk through the season than if the calf is permitted to suck longer. The milk being fed warm from the mother, the calf will make a growth not perceptibly different from one that sucks. This blooded calf should have the free run of a dry yard, with a little hay or grass to eat, that it may early develop its first stomach and chew its cud. A small field of grass in summer is still better. When the time comes for feeding skim-milk, the ration may be made about as nutritious as the new milk by adding to it flax-seed gruel, made by boiling a pint of flax-seed and a pint of oil-meal in ten to twelve quarts of water, or flax-seed alone in six times its bulk of water. Mix this one to three parts with skim-milk and feed blood-warm. Let the calf have its fill twice per day, at regular times, until six months old. During this time teach it to eat a few oats, and in case of a tendency to scour, give, for a meal or two, in the milk, a quart of coarse wheat flour, sometimes called by farmers canel. It will be perceived that the oil of the flax-seed will make good the loss of the cream in the milk—in fact it is a ration as rich as milk itself; and we have seen calves raised upon it quite the equal of calves running with the dam. We have also used flax-seed and pea-meal to make the gruel to mix with the skim-milk, and it has proved an excellent combination.

Dairying under the improved system introduced in the factory, has become profitable; and the discovery has been made, that butter and cheese of excellent quality may be made beyond the so-called dairy belt; that good grass will make good milk, and, when well manufactured, good butter and cheese, West as well as East. Dairy products have become too valuable to permit calves intended for the dairy or for beef to be raised upon whole milk; they must be grown upon the refuse of the dairy—either skim-milk or whey—with other and cheaper food to be added.

### Skim-milk Ration for Calf.

The dairyman may feed whole milk a single week, and then substitute skim-milk, with a little flax-seed jelly mixed in as above described; or, if flax-seed is difficult to procure, add two tablespoonfuls of oil-meal per day, dissolved in hot water. This oil-meal may be doubled in a week, gradually increasing to one pound per day; but this will be sufficient up to sixty days old. When the calf is sixty days old, add one pound of oats or oatmeal or wheat middlings. Continue this for sixty days. Twenty pounds of skim-milk per day will be sufficient for the first ninety days, but no injury will occur from a larger ration as the calf grows older. For the next ninety days, if milk is short, feed only ten pounds of skim-milk, and increase the oats or middlings to two pounds per day. We have advised the linseed oil-meal because it is excellent for the health of the calf, and, as we saw by the analysis, has ten per cent. of oil and a large percentage of muscle-forming food, and phosphate of lime to build the bones and extend the frame. It has most excellent qualities as a food for raising calves, and can always be had for this purpose at from one and a half to two cents per pound—generally at the former figure in the West, and the latter in the East. New process linseed-meal is now gradually taking the place of the old style oil-meal, the difference being that the oil is reduced to two and a half per cent.; but oil-meal may be dispensed with, and oat-meal or middlings used in its stead, with skim-milk. In fact, if you have plenty of skim-milk, an excellent calf may be raised on this alone. But it often occurs that more calves are to be raised than the skim-milk will feed. Skim-milk is much more valuable as food than is generally supposed. It contains all the qualities of the milk, except the cream. The casein, the most valuable food constituent of the milk, and the milk sugar or whey, are still in it. If you feed only skim-milk to a healthy calf, it will require, on an average, from fifteen to twenty pounds of milk to make one pound of live weight during the first ninety days, if the calf is given all it wants; and a good eater will gain two and a half pounds per day. We have often had calves seventy days old fed with one-half pound of flax-seed and one and a half pounds of oat-meal each, with twenty pounds of skim-milk per day, that have gained in weight thirty to thirty-seven pounds in ten days—an average of over three and one-fourth pounds each, per day. The flax-seed and oat-meal are boiled, and then mixed with the milk. The average weight of these calves, when dropped, was about sixty pounds; their average weight at seventy days was two hundred and thirty pounds—they had consequently gained 2.42 pounds per day. They were fed new milk for one week, then half new and half skim-milk for another week, then upon skim-milk and four ounces of boiled flax-seed each, per day; at thirty-four days old flax-seed increased to one-half pound and one-half pound oat-meal added; the latter was increased to one pound in a few weeks, and afterwards another half pound added. These calves were small, but excellent eaters, and made an extra gain. But we have generally succeeded with the ration first given in making an average growth of two pounds per day, for the first ninety days. We expect thrifty calves to reach three hundred pounds at three months. We have calves at this writing forty to fifty days old, that are gaining two pounds per day upon a ration compounded in the same proportion. For the second three months the calves may have good pasture, with what milk can be spared—say ten pounds—with one quart of oats and one pound of wheat middlings. This will keep them growing steadily and vigorously, which is the only way to make them profitable. Good feeders, on the ration we have given, will reach an average of five hundred pounds at six months; and we do not think it worth the cost to attempt raising a mincing eater. A good appetite and good digestion are essential in growing a profitable calf.

Flax-seed as a small part of the ration for the calf cannot be too highly recommended. It is a natural antidote to scouring, or a feverish condition of the stomach and intestines. Its large proportion of oil renders it so appropriate to mingle with other food deficient in oil, that it will well repay any feeder to keep a few bushels on hand. It is also excellent to mix in the food of older animals, the details of which will be given in subsequent pages.

There are many examples we might mention as an encouragement to pursue this system of full feeding upon refuse milk and other food.

Hon. George Geddes mentions a calf, at Syracuse, N. Y., only 240 days old, that dressed 655 pounds, and must have had a live weight of 875 pounds, though not weighed alive.

Mr. C. S. Marvin, of Oxford Depot, Orange Co., N. Y., had a calf dropped in October, 1864, afterwards called Uncle Abe, that weighed at birth 134 pounds; at 90 days, 385 pounds; at 6 months old, 670 pounds; at 1 year, 1,036 pounds. But this calf had the milk of his dam, and, after he was some two weeks old, a quart of meal, increased gradually up to two quarts. This steer continued to grow rapidly, and, at 18 months, weighed 1,354 pounds, and, at 2 years, 1,616 pounds; at 30 months, 1,830 pounds; at 3 years, 2,070 pounds; and, at 4 years and 5 months, 2,530 pounds. This is a case where new milk did its best during the first year, and we give it to illustrate the best feeding with whole milk. But, to show that new milk may, without injury, be omitted, we give a stronger case with skim-milk and oil-meal: Mr. William Wallace, of Grant Park, Kankakee Co., Ill., had a pair of twin grade Short-horn bull calves, dropped April 2, 1870, and named Ellsworth Twins. Their only food the first summer was sour skim-milk, oil-meal and grass. They weighed together, at 6 months, 1,340 pounds; at 1 year old, 1,960 pounds; at 2 years, 3,305 pounds; at 3 years old, 4,500 pounds. They were weighed at various intermediate times, and made a regular and steady growth. These steers were fed upon grass, hay, oats and corn, in the open air. Their increase was somewhat less the second 6 months than it should have been, which we attribute to the want of proper shelter. It will be seen that they gained only half as much the second as the first six warm months. But they made a greater average weight at 2 years than Uncle Abe, with all the new milk he could take for the first ten months. It is to be regretted that their food of all kinds was not weighed, so as to teach us a most important lesson as to cost of producing such weight under the system of full feeding; but we know that it cost less than to have made the same growth in a longer time.

Let us give another illustration of large growths made upon refuse milk, reported, on good authority, in the *Country Gentleman.* A grade Short-horn calf, dropped March 1, 1876, was purchased, at four weeks old, by C. H. Farnum, of Concord, N. H., and weighed 160 pounds. He intended it as a mate to one of his own, weighing 205 pounds, proposing to raise them for working oxen. Their feed was exclusively skim-milk—all they would take. But it was soon apparent that the lightest calf was outgrowing the other, and he abandoned the idea of using them for oxen. He slaughtered the one originally the heaviest, at eight and one-half months old, and it dressed 522 pounds. Its live weight is not known, but must have been at least 800 pounds—its girth was five feet two inches. His mate was much better to appearance, and it was determined to keep it, on experiment, till a year old. This calf was fed, during the last three months, on skim-milk, shorts and hay. At the end of the year its girth was six feet five inches, and the calf so fat as to cover his hips from sight. He was purchased by a butcher, at ten cents per pound dressed weight. His live weight was 1,200 pounds, and his dressed weight 902 pounds, meat 748 pounds, hide and tallow 154 pounds. Price paid $90.20.

This last calf weighed, at twenty-eight days old, 160 pounds. It gained in 337 days, or the balance of its first year, 1,040 pounds, an average of 3.08 pounds per day, which is, so far as we know, the largest gain on record, for so long a period, whatever the food.

Here are two cases of two calves, each making an unusual weight, especially the last one, without any new milk. It is doubtful if any case can be found of greater weight than 1,200 pounds, at one year, fed upon new milk in any quantity. In fact the cases are so numerous of great growth upon skim-milk, that it cannot longer be claimed that whole milk is necessary to raise even the best calves. It is thus evident that the dairyman may raise his calves for beef or for the dairy without interfering with his profits in butter. And the expert butter-maker can realize more money from the cream than the whole milk will bring in cheese, and, besides, raise fine calves upon the skim-milk. We have raised many fine calves upon half the skim-milk of the dam, supplemented with other food; but it is quite an easy matter for a skillful feeder to raise one calf to each cow devoted to butter making, with the aid of a small amount of grain.

## Cost of Calf at One Year.

As the author's object is to induce farmers to raise better animals, and thus, not only add to their profits, but equally to their pleasure and satisfaction, we will estimate the cost of growing a good calf for the first twelve months. In the Western States the 240 pounds of oats required for the first six months would cost about one cent per pound, and, if bran were used, about half that; the 182 pounds of oil-meal, about one and one-half cents, or $2.73—whole cost of grain, $5.13. The 2,700 pounds of skim-milk may be called worth one-fourth cent per pound, or $6.75; and if we call the hay or grass for the second three months worth one dollar, we have $12.88 as the entire cost, allowing a fair price for everything eaten by the calf; and, with the ration in the case we have described, the calf should have a live weight of 500 to 600 pounds at six months. This calf would be worth twenty-five dollars—certainly a fair margin of profit. But let us continue the estimate to the end of the year. The second six months the calf will require ten pounds of hay per day—1,820 pounds, costing, at forty cents per 100 pounds, $7.28; three pounds of oats and corn, ground together, and two pounds of bran, per day, 910 pounds, at three-fourths of a cent (the price in ordinary times), $6.83—amounting, for second six months, to $14.11, and for the year to $26.99. This calf, at a year, will weigh 800 to 1,000 pounds, and be worth forty to sixty dollars, depending on price of beef. We have estimated an average top price of cost for the food of such a calf in the West, and from ten to twenty per cent. must be added to represent the cost in the East. Deduct one-third of this food, and you have the cost of a common animal—not worth the cost of its keep.

Here, as everywhere in feeding animals, is illustrated the fact, that from the extra food comes all the profit.

There are many other foods that may be used to feed the calf the second six months, to be determined by the price of the particular food in the different localities. Linseed-meal (extracted by the new process), is one of the best foods to grow the young animal. This can usually be bought for twenty to twenty-five dollars per ton, and, when corn is cheap, the best grain ration would be two pounds linseed-meal and three pounds of corn-meal per day added to the hay ration, or hay and straw ration. The linseed-meal has a nutritive ratio of 1: 1.4, and corn-meal 1: 8.5, and the mixture would have a nutritive ratio of 1: 5.6, or a well balanced ration. The linseed-meal is rich in the constituents of bone and muscle, and the corn in the elements that generate heat and lay on fat.

Rye and barley-meal, millet and buckwheat-meal, pea and oat-meal, are all excellent food for calves the first winter.

### Whey Ration for the Calf.

Although an easy matter to raise a fine calf upon milk deprived only of its cream—this single element being easily supplied—the successful use of milk deprived of both cream and casein, or cheese, leaving only whey or milk sugar, requires much more skill and a knowledge of the composition of different foods. Sugar is an important element of food, but only one—and no animal can subsist upon sugar alone. Whey, however, is not pure milk sugar, but contains a little soluble albumen, a trace of casein or cheese, a little soluble phosphate of lime—but still mostly mere sugar of milk. This milk sugar in whey is in a very soluble and digestible condition, and has a feeding value well worth saving. We have usually considered whey, theoretically, as containing only the sugar of milk; but Prof. Voelcker gives 18 analyses of whey, taken from as many different cheese makers' vats, and if these samples are no better than the general average of the whey from our cheese factories, then whey has a greater feeding value than its milk sugar would indicate. The following is the average of his 18 analyses :

| | | Calculated dry. |
|---|---|---|
| Water | 93.02 | ..... |
| Butter (pure fat) | .33 | 4.80 |
| *Albuminous compounds | .97 | 14.00 |
| Milk sugar and lactic acid | 4.98 | 70.18 |
| Mineral matter (ash) | .70 | 11.02 |
| Total | 100.00 | 100.00 |
| *Containing nitrogen | .146 | 3.75 |

This shows a greater waste than has been supposed of the nitrogenous matter in the whey. The ash also is remarkably large—nearly as much as in whole milk—but common salt, probably, forms half of this ash, and this comes from the salt used in cheese making. But the albuminous matter forms nearly one per cent., and will be a great assistance in feeding beyond that of nearly pure milk sugar. Yet, to make whey a suitable food to grow the young animal vigorously, we must supplement the oil taken away in the cream—the nitrogenous food, the phosphate of lime, magnesia, sulphur, soda, etc., taken away in the casein, or cheese, and when we have combined these in proper proportion with the whey, we have restored it nearly to its normal condition of milk, and it then forms an appropriate food to grow calves. This requires a little thought on the part of the feeder; but every farmer ought to be willing to give thought and care to his business. Probably the best single food to be added to whey is oil-meal. By recurring to the table of analyses given on page 140, it will be seen that oil-meal has 28 per cent. of muscle-forming food—just what whey is deficient in—and also 10 per cent. of oil (another deficiency in whey); and it has nearly 5 per cent. of ash; and this ash is made up of phosphate of lime, magnesia, potash, soda, etc.—just what is needed to build the bones and frame of the calf. Now, if one-quarter of a pound of oil-meal or cake (which is less likely to be adulterated), dissolved in hot whey, is added to each gallon of whey, it will make it good food for a calf ten days to two weeks old. When the calf is three to four weeks old, add a quarter pound, or an equal amount of wheat bran, ground oats or barley, to each gallon of whey. This oil-meal, bran or oats, will make the whey about equal to milk. The oil-meal and oat-meal should be scalded in whey or water. This extra food given with the whey is not very expensive, costing only from $4 to $5.50, according to location, to feed a calf for six months, if we suppose the calf to take four gallons per day; and we have known many calves thus fed that weighed 500 lbs. at six months old; but an average of 400 to 450 lbs. can be depended on with good care and this ration; and such calves are worth about $20 per head at that age. If raised upon whey alone, they are not worth enough to pay the labor expended. The proper use of whey in feeding young animals is a matter of much importance. It is estimated that there are made in the United States 300,000,000 lbs. of cheese. This would represent in the whey, according to Voelcker's analyses, 188,000,000 lbs. of dry food, reckoning one gallon of whey to each pound of cheese. And if we suppose each calf to take during the season 600 gallons of whey, the 300,000,000 gallons would feed 500,000 calves. And if these calves were fed according to our formula, they would average a weight of 400 lbs.; and if we estimate them as worth only $14 per head, and the extra food as costing $5 per head, it would leave a credit to the whey of $9 per head, or a sum total made from whey of $4,500,000. We regard this as less than the actual result would be if the whey were fed as indicated; and here seems to be an important field for improvement. It is not necessary to follow the exact plan here proposed in order to utilize the whey. If oil-meal or oil-cake cannot easily be obtained, wheat bran, oat-meal, barley-meal, or oats and peas ground together, may be substituted ; a small portion of corn-meal may be mixed; but it is not proper to be fed alone with whey, as corn has too large a proportion of starch and too small a proportion of muscle-forming elements to make up for the deficiencies in the whey. Another important point is, that the whey should not be allowed to get very sour before feeding, but should be fed as nearly sweet as possible.

The new process linseed-meal also makes a good addition to whey for feeding calves. This has only one-fourth as much oil as the old style, but the per cent. of albuminous matter is larger. A better ration to feed the young calf than the one first above given, would be one-fourth pound of linseed-meal and one-fourth pound of flax-seed, boiled together and added to two gallons of whey. This would replace more of the oil and cost but slightly more. Whey is not so badly balanced as a food for young animals of some age as is generally supposed, but it contains too much water in proportion to its dry matter—93 per cent. water to 7 per cent. dry substance. And, for this reason, there is a large benefit in mixing other food with it to reduce the proportion of water. After the calves reach an age of 60 to 90 days, wheat middlings may be mixed with the whey alone, at the rate of one-half pound to the gallon. The food then will be 87 per cent. water to 13 per cent. dry substance, comparing favorably with milk, beets, mangel, and some of the more watery green foods, such as green rape, beans in blossom, cabbage, carrot-tops, etc. To this, requiring the calf to take so much water for so little food, is, no doubt, due much of the injurious effects of feeding whey alone, and, as we have seen, it is easy to obviate this by mixing dry food with it.

Large experiments have been conducted by Mr. I. H.

Wanzer, of Elgin Creamery, Illinois, in feeding this whey ration to a large number of calves. He used oil-meal, oats and bran with whey after the calf was four weeks old. He raised 120 calves in 1876 on this diet, and sold them at an average of about $21 per head, at seven months old. The farmer cannot properly object that it requires grain under this mode of feeding, because he raises his grain with a view to realizing so much money from it, and the money will come more surely by feeding it to calves than selling in market. It is not good farming to sell grain, when more money can be made from feeding it to animals and selling the animals. It is time American farmers had changed their system of raising so largely of grain to sell in market, and adopted the better English system of raising all the coarse grain required in the rotation, and buying all they can economically use in addition, to feed out on the farm, that the land may be kept good if not improved.

### Hay Tea Ration for Calves.

This old expedient to rear calves without milk had an excellent basis, as do most common practices. The soluble nutritive constituents of the hay are extracted by boiling, and this extract contains all the food elements required to grow the animal, besides being as digestible as milk. If the hay is cut early, when it has most soluble matter, and is of good quality, the tea will grow good calves; but this extract frequently has too small a proportion of albuminous and fatty matter. Yet if the hay tea is boiled down so as not to contain too much water for the dry substance, calves will usually thrive upon it. We tried an experiment by feeding 2 gallons of hay tea, in which ¼ lb. of flax-seed and ¼ lb. of wheat middlings had been boiled, to each of 5 calves 30 days old. This experiment was continued 60 days, with a gradual increase, during the last 30 days, of the middlings to 1 lb. per day. These calves did remarkably well, gaining an average of a little over 2 pounds per head per day.

Having mentioned this experiment to a farmer, who sold his milk for city consumption, yet desired to raise a half dozen calves, he tried the same formula and reported a gain per day for 60 days of 2¼ lbs. per head. In our experiment we boiled hay cut ⅝ of an inch long, and 3 lbs. for each calf, half an hour, and then the short hay was raised upon a wire-cloth sieve over the kettle and drained, whilst the flax-seed and middlings were put into the kettle and boiled to a jelly. The plan might be carried out on a large scale at little cost per calf.

## WHAT AGE FOR BEEF?

This is a vital question at the entrance of the discussion of the cattle-growing business. The attention of the American farmer has been strongly called to the profitable age for beef by the great increase in our exports of live cattle during the last few years. The appreciation of English consumers of our best cattle offers every inducement for perseverance in improving our methods and cheapening our results to the greatest extent. The greater the value we can concentrate into an animal of 1,600 lbs., within the shortest time, or into a ton of dead meat, the greater will be our profit. The consumption of meat by the people of Great Britain and of Europe is much less per capita than in the United States, and a large increase is reasonably to be expected when the best quality of meat shall be offered them. The uneasiness of English farmers, excited when our exports of dead meats first commenced, has, happily, been quieted by a reasonable consideration of the fact that their home demand for meat is much greater than they can supply. There is room for their own and all we can send. We have only to study how to produce the best quality at the least cost; and we may in this learn a valuable lesson from the practice of the best English breeders and feeders. Their lands are so expensive, and cattle food so dear, that they have long been obliged to look at the question of cost in feeding very closely, and have been able to produce results that we may most profitably imitate.

In a previous chapter we have strenuously insisted upon the speediest growth consistent with health, showing that *early maturity* offered the only safe system of profitable beef production; and as these pages are written to teach more by example than precept, we shall often try to illustrate the principles taught, not only by our own practice, but by that of the best feeders in this and other countries. In those countries where the first study is to furnish food for the greatest number of animals, that abundant manure may be returned to the soil, we may expect to find little matters studied that quite escape the attention of feeders in a country like ours, where space and food are so abundant. But we are also now strongly admonished that the generous production of a new soil cannot last forever, without also studying, as all other countries do, how to compensate the soil for the crops taken from it.

The tendency of the best English feeders has been, for many years, towards the early maturity of cattle for market. They are fast exploding the old idea that four-year-old beef must necessarily be better than younger beef. They first compromised on three years old, fearing that cutting off one year would reduce the quality; but that proving entirely satisfactory to butchers and customers, they continued to shorten the time down to 30 months, with very little falling off in weight, and no deterioration in quality. It was at once discovered that shortening the market age added a large percentage to the profit, and the best feeders have at length succeeded in maturing the steer at 24 months, reaching about the same price they had obtained at 36 months; and now Mr. Henry Evershed writes an article for the *Royal Agricultural Journal,* giving the experience of various eminent farmers in raising

## "BABY BEEF."

This beef is from steers and heifers brought to market at from eleven to twenty months old. The points made in this article of Mr. Evershed's are so important, and have such a material bearing upon the true course to be followed in beef raising in some parts of the United States, that we shall make sufficient extracts to show the mode of doing it and the results. Mr. Stanford, of Charlton Court, is stated as having lately sold the following high-grade Short-horns at the following ages and prices:

| | Price (Gold). | Return per month from birth. |
|---|---|---|
| One eleven-months-old steer | $ 74.00 | $6.73 |
| One thirteen-months-old steer | 101.64 | 7.82 |
| Three fourteen-months-old heifers, average | 92.40 | 6.60 |
| Three fifteen-months-old heifers, average | 101.64 | 6.77 |
| One sixteen-months-old steer | 127 00 | 7.94 |
| Five sixteen-months-old steers, average | 102.30 | 6.39 |
| One eighteen-months-old steer | 115.50 | 6.42 |
| One eighteen and one-half-months-old steer | 129.36 | 7.00 |
| Two eighteen and one-half-months-old steers, average | 122 10 | 6.60 |

It does not appear what the individual weights of these "baby-beef" animals were, but the price, net weight, is given at an equivalent of sixteen to eighteen cents per pound, probably according to our New York custom, counting only the four quarters.

Mr. Evershed remarks:

"The above figures show that tolerably-bred Short-horns will return seven shillings a week from birth on this system, at from thirteen to eighteen months old. Those Short-horns which afford the least return were bought in the market, and those which gave the highest were by Mr. Stanford's pedigree bull, out of his well-bred, but not pedigree cows.

The best feeders of common country-bred cattle in Sussex and Surrey inform me, that they consider a fair average weight for animals, well fed from birth, 100 Smithfield stone at one hundred weeks, giving a return of one stone (eight pounds dressed weight) per week, or six shillings ($1.32) per week."

He mentions one killed by Mr. Page, that dressed 132 stone at one hundred weeks. This would be equivalent to 1,760 pounds live weight. Some of the sixteen-months steers dressed, in the quarters, 600 pounds, having 120 pounds of rough fat, and a very small proportion of offal. This is not equal in weight to several given, pages 238–40. He represents that the best feeders are able to reach an average of $1.43 per week at sixteen to twenty months, from a Short-horn cross on common cows. This would give $122 per head at twenty months old—a figure that American feeders would like to reach. There is nothing to hinder them reaching the weights at that age, but they may seldom reach those prices. Yet it may truthfully be said that we can raise these steers or heifers at quite as good a profit as that of the English feeder—the cost of our animals being no higher in proportion to the price received than those raised in England.

That we may see how the English feeder's account stands, let us copy his statement of the cost of a "baby bullock" seventy-one weeks old, or one year and nineteen weeks, reducing the figures to our gold currency:

| | |
|---|---|
| Purchase of calf | $8.88 |
| Four weeks' new milk, six quarts daily, at 2d. per quart | 6.16 |
| Eight weeks' skimmed milk, six quarts daily, at ½d. per quart, and two pounds of meal, at 1¼d. per pound | 5.63 |
| Seventeen weeks, in June, July, August, and September, on a daily diet of two pounds of linseed cake, two pounds bean meal, mangel, hay, grass, clover, etc | 17.57 |
| Twenty-six weeks to end of March, five pounds of cake and meal daily, three-fourths bushel of roots, hay and straw for fodder | 30.27 |
| Sixteen weeks to harvest, eight pounds of cake and meal daily, mangel, grass, clover—total $1.59 per week | 25.44 |
| Attendance, seventy-one weeks, at eleven cents | 7.81 |
| Insurance, interest, and rent of shed | 5.54 |
| Total | $107.35 |

This estimate shows the young bullock, born in the spring and sold at harvest time the next year, costs $1.51 per week, and should be worth, according to Mr. Stanford's average, $108.02. The value of the manure is estimated at twenty per cent. of the cost of the food ($85.12) or $17.02. The account stands thus:

| | | |
|---|---|---|
| *Dr.*—A bullock 71 weeks old | | $107.35 |
| Profit | | 17.69 |
| Total | | $125.04 |
| *Cr.*—A bullock sold at 71 weeks old | $108.02 | |
| Value of manure | 17.02 | |
| Total | $125.04 | |

This is an instructive exhibit of the most profitable form of English stock feeding. The English farmer is obliged to take his profit in the manure account, which the American farmer too seldom takes the trouble to estimate. It is to be considered, also, that this English farmer is merely a tenant, and estimates the value of the manure to the tenant, to be applied to the land of his landlord. A study of this fact would be of the greatest value to the American farmer who holds the fee simple of his land, but is less desirous of improving it than the temporary holder of an English farm. The sooner our farmers shall study this manure problem, connected with cattle feeding, the better it will be for their permanent prosperity. It will also be noted that the food is charged at figures as much higher than our current rates as the price of beef is higher there than here. Cake is the principal food that the English farmer buys; and, therefore, when he turns his own crops into meat and realizes full prices for them, besides saving the manure for his land and laying the foundation for more crops, he properly thinks himself on the prosperous road.

We must here contrast the cost of keep of such young bullock in this country, that we may get a proper comparison of the situation here and there. On page 241 an estimate is made for first-rate keep for such young animal during the first 12 months in the Western States, and the cost found to be $12.88 for the first 6 months, and $14.11 for the second 6 months; making 12 months cost $26.99, with an addition of 20 per cent. for the Eastern States, making the cost in the latter $32.38; whilst the food alone cost $56.18 to the English farmer. Perhaps many readers will desire to see in detail the cost of a "baby bullock" of 71 weeks in this country, calculated on the same plan of feeding as given in Mr. Evershed's formula. We will calculate this for the West, which will require an addition of 10 to 20 per cent. to the grain ration to adapt it to the Eastern States. That it may have more than a temporary value, it will be estimated on average prices for a series of years, and not on the present high figures for grain.

| | |
|---|---|
| Purchase of calf | $ 5.00 |
| 4 weeks' new milk, 14 lbs. daily, at 1c. | 3.92 |
| 10 weeks' skim-milk, 16 lbs. daily, at ¼c.; 2 lbs. oats or finished middlings, at ⅞c. | 4.02 |
| 16 weeks, to about 1st of November, on a daily diet of 10 lbs. skim-milk, 2 lbs. oil-cake, at 1½c.; 2½ lbs. oats or middlings, and grass or clover | 10.00 |
| 22 weeks, to the end of first year—10 lbs. hay, 2 lbs. oil-cake, 2 lbs. oats, 2 lbs. corn-meal | 17.32 |
| 19 weeks, to end of feeding 71 weeks—grass, 30c. per week; 3 lbs. cake, 5 lbs. corn-meal, daily | 16.67 |
| Attendance, 71 weeks | 8.00 |
| Insurance | 1.00 |
| Total | $65.93 |

Our estimate shows the cost of such a young bullock to be 92 cents per week. It will dress about 600 lbs. in the quarters, weighing, on foot, about 1,200 lbs., and will bring on an average, in our market 6½ cents on foot—or, say $75. If we count the value of the manure as 20 per cent. of cost of food—say $10—the account will stand thus:

| | | |
|---|---|---|
| *Dr.*—A bullock, 71 weeks old | | $65.93 |
| Profit | | 19.07 |
| Total | | $85.00 |
| *Cr.*—A bullock, sold at 71 weeks | $75.00 | |
| Value of manure | 10.00 | |
| Total | $85.00 | |

This tabulation of the cost of our "baby bullock" shows that the profits are easier on our side than theirs, although their market price is 30 to 50 per cent. higher than ours. There is no doubt that the American farmer has a larger margin of profit, even in our depressed market, than the English farmer in his. We know that we can produce as good weight and quality at the same age as the most skillful British farmer, and at a cost 40 per cent. less. Unfortunately the proportion of skillful feeders in this country is much less than in England, and therein is where we should make every effort to improve. If 50 per cent. of all the young beef animals were raised on a similar plan to the formula given, we should be able to double our exports of live cattle and beef. Unfortunately the surplus of such high quality is not large, and consequently much of a poorer quality takes its place, and thus injures our market abroad. Our foreign market for the best beef will grow as fast as the quality of our animals improves.

## Quality of Young Beef.

Mr. Evershed gives some important testimony on this point. He speaks of a somewhat general opinion, that very young beef cannot be of the best quality, and says:

"Beef is affected by the mode of feeding, and it is not the fact that young beef is necessarily poor. Mr. Post, the butcher of Ship street, Brighton, who supplies a superior class of customers, writes of some young bullocks of Charlton Court, purchased in January, 1874, at 19½ months old, and weighing 100 stone, 94 stone, 92 stone and 90 stone: 'These bullocks, when slaughtered, were most complete bodies of beef; and the meat gave every satisfaction to the consumer, being very tender, and of delicious flavor.' Mr. Post says of another lot: 'I bought of Mr. W. Stanford, at Steyning Market, on March 9th, five very superior Short-horn steers, under 20 months old, with calves' teeth. Their meat is of most excellent quality. The heaviest weighed 111 stone. The flesh on the ribs, where quartered from the loin, measured five inches thick.' And, further, says: 'I have during the last three years killed a large number of the young bullocks fed by Mr. Stanford;" and, after expressing a favorable opinion of their general quality, speaks of a particular one as 'full of fat, with large, thick flesh, finely grained, and of very superior flavor.' Mr. Duke, of Steyning, writes of some bullocks, under 20 months old: 'They were all remarkably ripe, handsome carcasses of beef, giving me and my customers great satisfaction, as they have always done. They carried an average of 12½ stone (100 lbs.) of fat.' Mr. Glazebrook, of Steyning, writes: 'Some of the buyers at the sale considered I had given a guinea a bullock more than 6s. per stone; but, from the experience I have had of Mr. Stanford's young beasts, I had confidence.'"

These details give strong evidence of the high quality of this young beef, and show that there need be no fear of a failure for want of ripeness and flavor in the flesh of these young animals when the feeding proceeds upon right principles.

There are many considerations in favor of this system. First. The less cost per hundred pounds of beef made at 20 months or under than over that period. Second. The reduction of risk in shortening the market age. Third. The quicker returns from investment, and, therefore, the greater profit. We are fully persuaded that profitable feeding must establish a market age in this country not above 24 months, and the best feeding will frequently reduce this to 20 months.

## The Economy of Young Beef.

We have just been discussing the quality of young beef. It is now important to show the reader the fundamental law of growth as proved by the gain which cattle make at different periods or ages. We have had no means of determining this question in a great practical way till the institution of the Chicago Fat-Stock shows. Some great lesson was necessary to be taught, in a practical way, which should show farmers, by ocular demonstration, the true system of feeding. They can see the bearing of facts presented tangibly before them in the exhibition of the best specimens of cattle of various ages, and this is an illustration which carries conviction. The author had taught, for years, that all profit lay in full feeding and early maturity; but no statement could be so forcible as an array of cattle of all ages, from one year to six, with the exact age and weight of each stated. Seeing is believing.

The show held in 1878 was remarkable as the first one; but the four exhibitions that have followed since, have each improved upon its predecessor, and all have given the classification of age, weight, measurement, and gain per day. In this respect our show teaches a much more practical lesson than the great Smithfield Show of England. Sir J. B. Lawes has complained of his countrymen's want of exactness in estimating the weight of animals instead of actually weighing them. It is a very important point that we take a more practical view of the matter, and bring every animal to the scales. We adopt the commercial standard—substitute fact for hypothesis. And when we apply a demonstrated improvement in feeding to our 38,000,000 of cattle, the result must reach great proportions.

We here present tables grouping the animals according to age, within certain limits—and if we take their average age, weight, and gain per day, the law of growth will be most evident. Some of these tables show less difference in growth according to age than others. We have arranged them arbitrarily according to age, ignoring the question of breed. The table for the show of 1881, in the group of 631 days old, shows but a mere fraction of greater gain than in the group of 903 days old. This was occasioned by associating three Devon steers with three Short-horn or grade Short-horns. The Devons gain, respectively, 1.36, 1.15, 1.38 per day, whilst the grade Short-horns gain 2.17, 2.05, 2.01—the average gain of the six being 1.69 per day. And in the group of 903 days are two remarkable grade steers that gain respectively 2.21 and 2.11, which brings up the average gain of the group of eight to 1.58 per day. Still it is easy to see the effect of age upon the gain per day. It will be seen that the appropriate comparison is of the same breed with itself at different ages, and better still, the same animals at different ages.

It will be seen in all the tables that the average gain per day constantly decreases as the animals grow older and heavier. In the fifth group of steers of the show in 1879 the average gain is raised considerably by the remarkable steer No. 30, which reached 2,820 lbs. at four and a half years old. He gains .53 lb. more per day than either of the others. It would be very interesting if we had the periodical gains of this steer for each six months of its life. This would give a most important lesson of the relative growth, according to age, of the same animal.

Let us see what an important lesson these periodical weighings would teach. We may reasonably suppose that the second group at this show were as thrifty and heavy at 569 days old as the first group; that is, that they weighed 1,249 lbs., and had gained 2.19 lbs. per day; but during the next 279 days they gain only 232 lbs., or .83 lb. per day. This is only 38 per cent., or a little more than one-third what they gained during the first period.

The third group of steers were better for their age than the second group; but if we compare the gain of this group with the first—they were 671 days older, and they gain in this time 620 lbs., or .92 lb. per day—much less than half of the gain of the first period.

But this does not show all the loss of feeding to such an age. If we had an exhibit of the food consumed by the steers of the first group in making an average growth of 1,249 lbs., and also the food eaten by the third group in reaching 1,869 lbs. weight, we should find the live weight of the latter to cost in food 40 to 50 per cent. more than the former; that is, steers not only gain less per day as they grow older, but they eat more food to make this small gain.

Steer No. 29, it appears, gained only 6 lbs. during the last year; and steer No. 28 only 90 lbs. Both of these steers consumed more food during the last year than during their second year of growth, when they undoubtedly each gained more than two pounds per day. The whole case cannot be understood until the exhibitors give a history of the food expended each year, as well as the gain. The reader will see what numerous questions arise on examining tables on next page.

## Chicago Fat Stock Shows.

*Law of Growth According to Age.*

### 1878.

| | Age. | Weight. | Grain per day. |
|---|---|---|---|
| **4 Steers:** | Days. | Lbs. | Lbs. |
| No. 7..... | 650 | 1,480 | 2.28 |
| " 8 .... | 670 | 1,275 | 1.90 |
| " 27 ..... | 656 | 1,420 | 2.16 |
| " 28...... | 701 | 1,520 | 2.17 |
| Average.. | 669 | 1,423 | 2.13 |
| **4 Steers:** | | | |
| No. 5...... | 969 | 1,705 | 1.76 |
| " 6 ..... | 978 | 1,600 | 1.64 |
| " 25...... | 962 | 1,885 | 1.96 |
| " 26...... | 962 | 1,560 | 1.62 |
| Average.. | 968 | 1,637 | 1.74 |
| **10 Steers:** | | | |
| No. 3...... | 1,280 | 2,115 | 1.65 |
| " 4...... | 1,220 | 2,060 | 1.69 |
| " 14...... | 1,080 | 1,470 | 1.36 |
| " 10.. ... | 1,188 | 1,285 | 1.08 |
| " 20...... | 1,267 | 1,475 | 1.16 |
| " 24.. ... | 1,298 | 2,305 | 1.78 |
| " 23...... | 1,328 | 2,185 | 1.65 |
| " 19...... | 1,371 | 1,655 | 1.21 |
| " 13...... | 1,356 | 1,760 | 1.29 |
| " 12...... | 1,336 | 1,705 | 1.20 |
| Average.. | 1,272 | 1,801 | 1.41 |
| **4 Steers:** | | | |
| No. 1...... | 1,880 | 2,085 | 1.11 |
| " 15...... | 1,677 | 1,595 | 0.95 |
| " 17...... | 1,658 | 1,645 | 0.99 |
| " 18.. ... | 1,652 | 1,870 | 1.13 |
| Average.. | 1,717 | 1,799 | 1.04 |

### 1879.

| | Age. | Weight. | Grain per day. |
|---|---|---|---|
| **5 Steers** | Days. | Lbs. | Lbs. |
| No. 8...... | 585 | 1,240 | 2.11 |
| " 16...... | 612 | 1,397 | 2.28 |
| " 17...... | 500 | 1,114 | 2.23 |
| " 26...... | 605 | 1,196 | 1.97 |
| " 27.. ... | 544 | 1,300 | 2.38 |
| Average.. | 569 | 1,249 | 2.19 |
| **5 Steers:** | | | |
| No. 5...... | 845 | 1,636 | 1.93 |
| " 6...... | 814 | 1,449 | 1.78 |
| " 7.. ... | 710 | 1,316 | 1.87 |
| No. 15...... | 939 | 1,474 | 1.57 |
| " 24...... | 932 | 1,532 | 1.64 |
| Average.. | 848 | 1,481 | 1.76 |
| **6 Steers:** | | | |
| No. 25...... | 1,059 | 1,534 | 1.44 |
| " 23..... | 1,284 | 1,649 | 1.28 |
| " 22...... | 1,294 | 1,986 | 1.53 |
| " 13...... | 1,359 | 1,968 | 1.41 |
| " 4...... | 1,311 | 2,019 | 1.53 |
| " 3...... | 1,335 | 2,069 | 1.54 |
| Average . | 1,240 | 1,869 | 1.45 |
| **4 Steers:** | | | |
| No. 1...... | 1,578 | 2,240 | 1.42 |
| " 2...... | 1,593 | 2,166 | 1.36 |
| " 14...... | 1,420 | 1,979 | 1.39 |
| " 21..... | 1,573 | 2,118 | 1.34 |
| Average | 1,541 | 2,125 | 1.37 |
| **4 Steers:** | | | |
| No. 11...... | 1,677 | 1,930 | 1.15 |
| " 12. .... | 1,689 | 1,974 | 1.17 |
| " 20...... | 1,804 | 2,134 | 1.18 |
| " 30...... | 1,643 | 2,820 | 1.71 |
| Average | 1,703 | 2,216 | 1.30 |

### 1880.

| | Age. | Weight. | Grain per day. |
|---|---|---|---|
| **6 Steers** | | | |
| No. 84...... | 721 | 1,590 | 2.20 |
| " 120...... | 710 | 1,115 | 1.57 |
| " 66...... | 671 | 1,395 | 2.07 |
| " 82...... | 696 | 1,580 | 2.27 |
| " 118...... | 642 | 1,245 | 1.94 |
| " 87...... | 585 | 1,490 | 2.54 |
| Average.. | 671 | 1,403 | 2.09 |
| **10 Steers** | | | |
| No. 70...... | 908 | 1,825 | 2.01 |
| " 79...... | 884 | 1,700 | 1.92 |
| " 121..... | 849 | 1,250 | 1.47 |
| " 68 ..... | 1,064 | 1,815 | 1.70 |
| " 80...... | 1,018 | 1,650 | 1.62 |
| " 64...... | 940 | 1,900 | 2.02 |
| " 76...... | 921 | 1,700 | 1.84 |
| " 56...... | 832 | 1,845 | 2.21 |
| " 38...... | 910 | 1,445 | 1.63 |
| " 57...... | 852 | 1,650 | 1.93 |
| Average.. | 917 | 1,678 | 1.83 |

CHICAGO FAT STOCK SHOWS—*Continued.*

| | Age. | Weight. | Grain per day. |
|---|---|---|---|
| 8 STEERS: | Days. | Lbs. | Lbs. |
| No. 60...... | 1,367 | 2,350 | 1.71 |
| " 18...... | 1,250 | 2,215 | 1.77 |
| " 55...... | 1,183 | 1,875 | 1.58 |
| " 54...... | 1,350 | 1,720 | 1.27 |
| " 115...... | 1,305 | 1,270 | 0.97 |
| " 116...... | 1,305 | 1,170 | 0.89 |
| " 27...... | 1,310 | 1,875 | 1.43 |
| " 36... .. | 1,275 | 1,575 | 1.23 |
| Average.. | 1,293 | 1,756 | 1.35 |

1881.

| | Age. | Weight. | Grain per day. |
|---|---|---|---|
| 6 STEERS: | | | |
| No. 21..... | 719 | 1,565 | 2.17 |
| " 59...... | 614 | 835 | 1.36 |
| " 60.. ... | 600 | 690 | 1.15 |
| " 60...... | 614 | 850 | 1.38 |
| " 74...... | 622 | 1,280 | 2.05 |
| " 86...... | 620 | 1,250 | 2.01 |
| Average.. | 631 | 1,080 | 1.69 |
| 8 STEERS: | | | |
| No. 23...... | 880 | 1,500 | 1.70 |
| " 58...... | 928 | 925 | 0.99 |
| " 58...... | 969 | 975 | 1.00 |
| " 59 ..... | 882 | 1,030 | 1.16 |
| " 95...... | 862 | 1.450 | 1.68 |
| " 114...... | 964 | 1,755 | 1.82 |
| " 113..... | 872 | 1,935 | 2.21 |
| " 117...... | 872 | 1,845 | 2.11 |
| Average.. | 903 | 1,4[illegible]6 | 1.58 |
| 17 STEERS: | | | |
| No. 8 ..... | 1,421 | 1,930 | 1.35 |
| " 10...... | 1,309 | 2,150 | 1.64 |
| " 11...... | 1,362 | 2,200 | 1.61 |
| " 24...... | 1,873 | 1,875 | 1.00 |
| " 25...... | 1,055 | 1,855 | 1.75 |
| " 34...... | 1,085 | 1,895 | 1.74 |
| " 42.. . . | 1,324 | 2,085 | 1.57 |
| " 45...... | 1,190 | 2,145 | 1.80 |
| " 47...... | 1,224 | 1,965 | 1.60 |
| " 48.. | 1 212 | 1,930 | 1.55 |
| No. 54...... | 1,326 | 1,335 | 1.00 |
| " 55...... | 1,777 | 1.410 | 0.79 |
| " 56..... | 1,328 | 1,230 | 0 92 |
| " 57...... | 1,268 | 1,075 | 0.84 |
| " 107...... | 1,237 | 2.095 | 1.61 |
| " 118 .... | 1,268 | 1,520 | 1.19 |
| " 122...... | 1,268 | 1,995 | 1.57 |
| Average.. | 1,325 | 1,804 | 1.38 |

1882.

| | Age. | Weight. | Grain per day. |
|---|---|---|---|
| 11 STEERS: | | | |
| No. 16. ... | 645 | 1,620 | 2.51 |
| " 29.... | 384 | 1,140 | 2.97 |
| " 29½... | 412 | 1,105 | 2.68 |
| " 169½... | 697 | 1,330 | 1.90 |
| " 21..... | 730 | 1,985 | 2.72 |
| " 148.... | 858 | 2,220 | 2.59 |
| " 22..... | 715 | 1,600 | 2.23 |
| " 38..... | 574 | 1,410 | 2.45 |
| " 53..... | 720 | 1,475 | 2.05 |
| " 22..... | 715 | 1,600 | 2.23 |
| " 44..... | 437 | 830 | 1.90 |
| Average.. | 626 | 1,483 | 2.38 |
| 15 STEERS: | | | |
| No. 109..... | 1,034 | 1,905 | 1.84 |
| " 111.... | 1,011 | 1,850 | 1.83 |
| " 17..... | 1,265 | 2,400 | 1.90 |
| " 113..... | 1,174 | 1,945 | 1.65 |
| " 35..... | 1,818 | 1,545 | 0.85 |
| " 169..... | 1,032 | 1,630 | 1.58 |
| " 58. ... | 1,077 | 1,940 | 1.80 |
| " 2..... | 1,121 | 1,765 | 1.57 |
| " 23..... | 1,404 | 1,865 | 1.32 |
| " 6..... | 1,316 | 1,840 | 1.40 |
| " 20..... | 1,299 | 2,060 | 1.58 |
| " 18..... | 1,305 | 2,335 | 1.94 |
| " 115..... | 1,613 | 2,565 | 1.59 |
| " 8. .. | 1,636 | 1,815 | 1.11 |
| " 116..... | 1,644 | 1,880 | 1.14 |
| Average.. | 1,316 | 1,956 | 1.55 |

We give these tables of five shows somewhat full, embracing nearly all the prize animals under five years old. As they have been the most instructive array of cattle ever exhibited, presenting the most convincing evidence of the growth of animals, at different periods, under the most liberal feeding. They were fed for exhibition, and would thus be fed as their exhibitors believed to be best calculated for rapid growth, and therefore are all fed under similar conditions. They should be thoroughly studied by the feeder.

It is interesting to trace the same animal from year to year. No. 56, 1880, 832 days old, weight 1,845 pounds, had gained 2.21 per day. He appears the next year as No. 45, 1,190 days old, weight 2,145 pounds, having gained 300 pounds in a year, or 0.82 pound per day, or only thirty-seven per cent. of its previous gain per day. No. 107 of 1881, 1,237 days old, weighed 2,095 pounds, gain, 1.61 pounds per day—appears as No. 115 of 1882, weight 2,565 pounds, having made the large gain of 470 pounds, or 1.28 per day. But as this was the champion steer of the show in 1881, also in 1882, it was fed in the very best manner, but still it fell nearly one-third of a pound per day behind its previous gain.

No. 116 of 1882, Lady Peerless, 1,644 days old, weight 1,880 pounds, appeared in 1881 as 1,268 days old, weight 1,520 pounds, with a daily gain of 1.19. The past 376 days she has gained 360 pounds, being a daily gain of 0.93 pounds. Here then, is a loss of twenty-two per cent. in gain. There are many such cases in the tables, showing the law of gain in the same animal, and that the *rate decreases* as the *age increases.*

## Cost of Production.

The managers of these fat-stock shows made a very praiseworthy addition to the prizes in the last, under the head of cost of production. This cost of production goes to the very root of the matter; and when taken in connection with law of growth, above discussed, it should be the key to decide the true system of feeding. If the young animal makes a more rapid growth, and if that growth costs less, and if the beef grown thus rapidly is of good quality, then it is simply throwing away food to feed the animals beyond the age producing the quality that the market demands.

The following table is very instructive on this question of cost at different periods. It will be seen that the first year produced a large profit, and the value was greater than the cost at the end of the second year, but the third year cost much more than the value of the growth, and the whole cost of the three years was considerably more than the market price of the animals.

COST OF PRODUCTION.

*From Birth to 12 Months of Age.*

| NAME OF ANIMAL. | Total cost for first 12 months. | Weight at 12 months of age. | Value at 12 months, 6 cts. per lb. | Cost per lb. up to 12 months. |
|---|---|---|---|---|
| | | | | Cts. |
| Jay, No. 101 | $31.30 | 800 | $48.00 | 3.91 |
| Experiment | 33.50 | 710 | 42.60 | 4.72 |
| Young Aberdeen | 31.67 | 1,000 | 60.00 | 3.47 |
| King of the West, No. 18 | 34.67 | 1,000 | 60.00 | 3.47 |
| Cassius 4th, No. 20½ | 31.47 | 1,000 | 60.00 | 3.15 |
| Cassius 5th, No. 29 | 38.15 | 1,090 | 65 40 | 3.50 |
| Hattie, No. 44 | 19.75 | 700 | 42.00 | 2.08 |
| Jim Blaine, No. 27 | 27.50 | 950 | 57.00 | 2.89 |
| Canadian Champion, No. 17 | 33.67 | 1,000 | 60.00 | 3.37 |

*From 12 to 24 Months of Age.*

| NAME OF ANIMAL. | Weight at 12 months of age. | Value at 12 months of age. | Total cost, 12 to 24 months. | Weight at 24 months of age. | Value at 24 months, at 6 cts. per lb. | Cost per lb., gain 2d year. |
|---|---|---|---|---|---|---|
| | | | | | | Cts. |
| Jim Blaine | 950 | $57.00 | $37.59 | 1,390 | $83.40 | 8.52 |
| Jay | 800 | 48.00 | 30.31 | 1,370 | 82.20 | 5.31 |
| Young Aberdeen | 1,000 | 60.00 | 52.12 | 1,600 | 96.00 | 8.68 |
| King of the West | 1,000 | 60.00 | 52.13 | 1,600 | 96.00 | 8.68 |
| Canadian Champion | 1,000 | 60.00 | 52.12 | 1,600 | 96.00 | 8.68 |

COST OF PRODUCTION—*Continued.*

*From 24 to 36 Months of Age.*

| NAME OF ANIMAL. | Weight at 24 months of age. | Value at 24 months of age. | Total cost, 24 to 36 months. | Weight at 36 months of age. | Value at 36 months of age, at 6 cents per lb. | Cost per lb., gain 3d year. |
|---|---|---|---|---|---|---|
| | | | | | | Cts. |
| Canadian Champion..... | 1,600 | $96.00 | $81.50 | 2,250 | $135.00 | 12.54 |
| King of the West ....... | 1,600 | 96.00 | 81.50 | 2,250 | 135.00 | 12.54 |

The two steers fed to three years old cost each $168.30, or 7.48 cents per pound. They might bring this as extra Christmas cattle; but it is evident that they give a better profit at 24 months. Their market price was then $10 per head more than they cost, and we have seen in the domestic market in England that such animals, or those some months younger, are preferred by critical customers.

## ENGLISH VIEW OF COST OF BEEF.

One of the most interesting questions relating to American agriculture at the present moment, is the cost of producing beef for export. Sir J. B. Lawes, probably the best scientific and practical authority in England upon questions relating to meat production, read an elaborate paper before the East Berwickshire Agricultural Association, in 1879, a large part of which was devoted to the cost of food in the production of beef. This was incidental to showing the cost of manure made from cattle upon British farms. He made a very liberal allowance for the value of the manure resulting from the consumption of this food, and then made the pertinent inquiry, whether the balance of the cost of the food, after deducting the value of the manure, is paid for by the increase in weight of the animal.

| Description. | Average age. | Average final weight per head. | Increase per day. | Increase per 1,000 lbs. live weight per week. |
|---|---|---|---|---|
| PRIZE CATTLE AT SMITHFIELD, 1878. | Weeks. | Lbs. | Lbs. | Lbs. |
| Devons | 116 | 1,301 | 1.60 | 14.8 |
| | 167 | 1,568 | 1.34 | 10.5 |
| | 215 | 1,785 | 1.19 | 8.3 |
| | 165 | 1,456 | 1.26 | 10.6 |
| Average | 165¾ | 1,527½ | 1.35 | 11.1 |
| Herefords | 118½ | 1,615 | 1.95 | 14.9 |
| | 165½ | 1,964 | 1.70 | 10.9 |
| | 221½ | 2,085 | 1.34 | 8.2 |
| | 178½ | 1,731 | 1.39 | 10.0 |
| Average | 171 | 1,848¾ | 1.60 | 11.0 |
| Short-horns | 120 | 1,698 | 2.02 | 14.8 |
| | 160 | 1,960 | 1.75 | 11.3 |
| | 163 | 2,352 | 2.06 | 11.3 |
| | 172 | 1,876 | 1.56 | 10.5 |
| Average | 153¾ | 1,971½ | 1.85 | 12.0 |
| Sussex | 116 | 1,588 | 1.96 | 15.2 |
| | 151 | 1,818 | 1.72 | 11.9 |
| | 203 | 2,390 | 1.68 | 9.1 |
| | 160 | 1,736 | 1.55 | 11.1 |
| Average | 157½ | 1,883 | 1.73 | 11.8 |
| General average | 162 | 1,808 | 1.63 | 11.5 |
| PRIZE CATTLE, CHICAGO SOCIETY, U. S | | | | |
| Steers—4 years and over, 1st prize | 268.6 | 2,085 | 1.10 | 7.1 |
| 4 years and over, 2d prize | 271.7 | 2,440 | 1.28 | 7.0 |
| 3 years and under, 1st prize | 182.9 | 2,115 | 1.65 | 10.4 |
| 3 years and under, 2d prize | 174.3 | 2,060 | 1.68 | 10.9 |
| 2 years and under 3, 1st prize | 138.4 | 1,705 | 1.76 | 13.5 |
| 2 years and under 3, 2d prize | 139.7 | 1,600 | 1.63 | 13.4 |
| 1 year and under 2, 1st prize | 92.9 | 1,480 | 2.28 | 20.0 |
| 1 year and under 2, 2d prize | 95.7 | 1,275 | 1.90 | 19 1 |
| Average | 170.5 | 1,845 | 1.66 | 12.7 |
| NIVERNAIS-CHAROLAIS—FRENCH. | | | | |
| No. 1 | 134.8 | 1,478 | 1.57 | 13.6 |
| No. 2 | 156.4 | 1,987 | 1.81 | 11.9 |
| No. 3 | 160.8 | 1,893 | 1.68 | 11.6 |
| No. 4 | 174.0 | 2,079 | 1.71 | 10.8 |
| Average | 156.5 | 1,859 | 1.69 | 12.0 |
| General average of all | 163.7 | 1,826 | 1.65 | 11.9 |
| Rothamsted adopted average | ........ | ........ | ........ | 10.11 |

With a view to furnishing data for the solution of this question, he gives this last table relating to the well-fed animals of several countries, including some at the Chicago Fat-Stock Show. He says, in reference to this table:

"Confining my attention to cattle, I shall first endeavor to show, by reference to published records relating to animals of certainly above average quality, and undoubtedly liberally fed, what is the probable rate of increase that may be expected in such cases; and, secondly, what is the average amount of food required to produce a given amount of increase."

He complains that feeding experiments have not been so full as to give all the points required to solve the question of cost. The food or some other element in the calculation is left out. As everything relating to this question is of interest to the feeder, we quote what he says of the food required to produce 100 lbs. of increase:

"Although the gross increase is less in proportion to the live weight as the animal matures, a larger proportion of such gross increase consists of carcass and of real solid matter, and a less proportion of offal and of water. In fact, the fattening process may be said to consist in great measure in the displacement of water by fat. At what cost of food has that increase been obtained? We have no records on this point in regard to any of the animals referred to in the table. We must therefore rely upon other data in arriving at a decision on this part of the subject. Our own estimate, founded on all the data at our command, partly relating to the recorded experience of others, and partly to the results of direct experiments of our own, led us many years ago to conclude as follows: Fattening oxen, liberally fed upon good food, composed of a moderate proportion of cake or corn, some hay or straw chaff, with roots or other succulent food, and well managed, will, on the average, consume 12 to 13 lbs. of dry substance of such mixed food, per 100 lbs. live weight, per week; and they should give 1 lb. of increase for 12 to 13 lbs. dry substance so consumed. In other words, there will be consumed from 120 to 130 lbs. of the dry substance of such mixed food per 1,000 lbs. live weight per week, producing on the average 10 lbs. of increase; and 1,200 to 1,300 lbs. will therefore be required to yield 100 lbs. increase in live weight. If the mixed food contain no straw chaff, and only a moderate amount of hay chaff, the average amount of dry substance consumed will be the less, and the average proportion of increase the more, or *vice versa*. Accordingly, we have assumed that on a liberal mixture of oil-cake, clover chaff, and swedes, as little as 1,100 lbs. dry substance may be required to produce 100 lbs. increase, and as much as 11 lbs. increase may be produced per 1,000 lbs. live weight per week. The articles which you are accustomed to speak of as dry foods, still contain some water. Thus cakes contain from one-eighth to one-ninth, and corn, hay and straw about one-sixth of their weight of water; while swedes do not contain more than 10 to 12, or mangolds more than 12 to 13 per cent. of really dry or solid matter; but the monster roots of which we hear so much, sometimes contain only about two-thirds as much dry matter as moderately-sized and well-matured roots should do. Of really dry substance, such as my estimates given above require, 1,200 to 1,300—say 1,250 lbs.—would, in round numbers, be supplied in the following amounts of each of the several descriptions of food enumerated, supposing them to be of fair average composition in that respect:

Amount of each food containing 1,250 lbs. dry matter:

| | | |
|---|---|---|
| Cakes | 12½ | cwt. |
| Corn or hay | 13 | " |
| Swedish turnips | 5 | tons. |
| Mangolds | 4½ | " |

"The question arises, what would be the cost of 1,250 lbs. of dry substance, made up of a suitable mixture of these various foods, to yield 100 lbs. increase in live weight, and whether this would be less or more than the 100 lbs. increase would sell for? Well-bred and moderately-fattened oxen should yield 58 to 60 per cent. carcass in fasted live weight; very fat oxen may yield from 65 to 70 per cent. But of the increase obtained during what may be called the fattening period of moderately-fattened oxen, it may be reckoned that about 70 per cent. will be carcass. Supposing you get 8d. per pound for this, the selling value of your 100 lbs. increase in live weight will be 46s. 8d. Now, I think if you try to make up 1,250 lbs. of dry substance by a suitable fattening mixture of the foregoing foods, you will find that it will cost you considerably more than 46s. 8d. Even if roots alone were used, which would not be considered good fattening food, the cost would be more if they were reckoned at their selling price, though less if taken at what is called their 'consuming value.' But with no good fattening mixture of cake or corn, hay, chaff and roots could 1,250 lbs. of dry matter be obtained for anything approaching the sum I have estimated as the value of the increase it will produce. It is further to be borne in mind that, weight for weight, store stock is generally dearer than fat stock. You have also to add to the cost of the food the various other charges, such as rent of buildings, appliances, attendance, and risk. Taking all these things into account, I think it is evident that there must always be a very considerable proportion of the cost of feeding, although varying greatly according to circumstances, which must be taken to represent the cost of the manure."

He then speaks of his tables, published some years ago, and many times republished in this country, in reference to the value of various cattle foods in the production of manure. He says this table of manure value was much criticised in England, as being too high an estimate; and as an answer to this he says:

"Accordingly, Dr. Gilbert and I selected linseed cake as the best-known article of purchased cattle food; and after deducting my estimate of the manure value from the cost of the cake, we endeavored to calculate whether the remainder of the cost could be recovered in the increased value of the animal. The best linseed cake was then quoted at £12 10s. per ton, and deducting the manure value as given in my table, namely, £4 12s. 6d., there was left £7 17s. 6d. to be charged against the animal; and calculation led us to the conclusion that it was extremely doubtful whether this amount could be recovered in its increased value. In fact, linseed cake appeared to us to command what may be called a fancy price. At any rate, it was quite certain that it could not be profitably used, if not fully as much or even more than the amount of my estimate were charged against the manure. If the same mode of calculation were applied to sheep and to pigs, it would be found, in their case also, that the cost of their food is more than the value of the increase it produces."

This shows us how difficult it must be in England to grow beef with such dear food, even with the exceptionally high price he mentions of about 11 cents, our money, per pound live weight for the increase. Dr. Lawes has studied this question more carefully than any other farmer in England, and in examining the experiments of others he finds this most important item almost universally left out of the statement—the amount and quality of the food fed to produce a given result, and the weight of the animals at the commencement of feeding is usually unstated. It seems that farmers in that country, usually regarded as in advance of nearly all countries of the world, are about as careless and inexact as their cousins on this side of the water. This want of exactness in all the details of feeding experiments is almost universal with farmers everywhere—the weight of the animals is often given without the age;

the weight and age are given, and no clue to the food; the kinds of food may be mentioned and nothing said about quantity. A complete experiment is seldom to be found, having all the elements stated necessary to determine the cost of beef at any age; and the reader may be a little surprised to find that Dr. Lawes himself, in speaking above of the amount of dry matter in food required for one pound increase in fattening cattle, should not give the proportions of such food, that the reader might know his exact ration. He speaks of a ration "composed of a moderate proportion of cake or corn, some hay or straw chaff, with roots or other succulent food, and well managed, etc." This he states to have been determined partly from experiments of his own, and it is hardly excusable that he should leave it so indefinite. What is a "moderate proportion of cake or corn?" A dozen farmers would very likely each give different answers. He is the most painstaking experimenter in England, and is said to keep most minute and accurate notes of all details, but here he leaves it to the judgment of every reader to determine the composition of the food, of which he says 12½ lbs. is required for 1 lb. of increase. But if the mixed food contains a liberal amount of oil-cake, clover chaff, and swedes, then 11 lbs. dry subsance of food will make 1 lb. of increase. You must determine what is "moderate" and what is "liberal" in cake and corn.

Dr. Lawes' estimate of 12½ lbs. dry substance of food to 1 lb. of gain, is no doubt an approximation to the facts of feeding in England and in this country, although we have had a better result than this in several cases of our own feeding, and have examined a number of other cases, in which the facts are authentic, with a higher result. We will give some of these, as bearing upon this question of the cost of beef. Some of these cases we have reported elsewhere, and will here give only a summary of them.

Mr. John Johnston, late of Geneva, N. Y., emigrating to this country from Scotland 50 years ago, and bringing with him the thrifty habits of a good farmer in his native country, placed a higher value upon the manure from fattening cattle than did the American farmers around him. He wished to produce all the manure he could for his wheat crop, and thus resorted to the purchase of cattle every year to be fed upon his straw and corn fodder, with grain as the principal staple of the food. Knowing the value of linseed oil-cake, he fed this with Indian corn-meal, to make a well-balanced ration, with straw and a portion of hay. When Mr. Johnston put up a lot of three-year-old steers to feed, he began with 2 lbs. of oil-cake and 3 to 5 lbs. of corn-meal, and this was increased gradually to 4 lbs. of cake and 8 to 10 lbs. of corn-meal. Sometimes wheat bran or pea-meal was substituted for a part of the corn-meal, and in this way he gave variety in the diet, which is very essential to steady thrift. He found, practically, that this mode of feeding would give him an increase of from 1½ to 3 lbs. per head per day, depending upon breed and thrift. Good grade Short-horns would occasionally make even more than 3 lbs. per day for 150 days, but this rate of gain was exceptional. His average was about 2⅛ lbs. per day for many years. He sold on an average, at two cents per pound more than the purchase price. He commenced feeding some time in October, and sold in March. If the steers weighed 1,000 lbs. at the time of purchase, and the price was $4 per hundred, they cost $40 per head; and at the end of 150 days would, as an average result with him, weigh 1,318 lbs., and bring six cents, or $79.08—nearly doubling in value. He fed of oil-cake an average of 3½ lbs. per day, or 525 lbs. per head; of corn-meal, 9 lbs., or 1,350 lbs.; of hay, 8 lbs., or 1,200 lbs.; of straw, *ad libitum*, or 1,500 lbs. Counting these at average rates of the last 18 years would give: Oil-cake, $9.18; corn-meal, $13.50; hay, $6 (straw not counted); in all, $28.68. This would leave $10.40 to pay for labor and straw, giving the manure free. His cattle were often purchased much lower, and oil-cake was $10 to $18 per ton during his early feeding. Mr. Johnston fed in an ordinary unbattened stable—not warm. He got his pay abundantly in his large crops of wheat. It will be seen here that the store stock cost less than fat stock, and thus gave a margin of profit by an increase in the value of the whole animal, otherwise Mr. Johnston's cattle would have often been fed at a loss. It will be observed, also, that if the dry substance of the food is all counted, including straw, it will amount to 26.23 lbs. per day; and Lawes' formula of 12½ lbs. to the pound gain is 26.40 lbs., proving very closely in this case the correctness of his estimate.

The author visited Mr. Otis S. Lewis, of Orleans County, N. Y., in 1870, who fed upon a somewhat different plan. His plan was to buy, in the Buffalo cattle yards, about the first of December, thrifty bullocks from the West, averaging 1,200 to 1,300 lbs. He selected, as far as he could, cattle that had been handled, so that they might take kindly to a warm stable. He bought them in a moderately fat condition, and fed them about one hundred days, in a warm stable, tied in a roomy stall, and they were not turned out until sold. The daily ration was made up of 5 lbs. of early-cut and nicely-cured clover hay, 15 lbs. of straw, 9 lbs. of corn-meal, and one-half bushel of swede turnips, pulped and mixed with the short-cut hay, straw, and meal, and then all thoroughly steamed together. Sometimes 4 lbs. of wheat middlings were substituted for so much of the corn-meal. This ration came out of the steam box with a most savory and appetizing smell, and the cattle ate it with great relish. His lot of 25 head at this time cost six cents, and averaged 1,250 lbs. per head. At the end of one hundred days they averaged 1,550 lbs., having gained 3 lbs. per day. They sold at 7¾ cents, bringing an average price of $120.12, and, costing $75 per head, gave an increase in sale price of $45.12. He estimated the cost of food, besides straw, at $20 per head, and the actual cost of labor at $4, leaving $20.12 to pay for straw and profit. In other years the cost and sale price of the cattle were different, but the result was nearly similar. This ration seemed to have the same effect upon the cattle as the most succulent grass, and produced a gain nearly equal to the most favorable pasturage at the best season. Mixing pulped turnips with other food, and steaming, diffused the odor through the mass, rendering the food so palatable that the animal ate with a zest to the limit of its digestion. It will be noted in this case that the total dry substance of all the food taken is only 28 lbs., which is only 9.33 lbs. of dry food to 1 lb. gain, instead of 12½ lbs., according to Lawes' formula. Is this the result of cooking—rendering so much larger percentage of food digestible? It will be observed that the quality of the food is hardly as good as that fed by Mr. Johnston. But there is another element to be taken into account—that of a warm stable—which would reduce the food required to sustain animal heat. Both of these facts may perhaps account for the difference.

The author has some cases to give of his own feeding. He bought 40 head of small cattle, of two and a half and three and a half years old, that had been fed so poorly that they were very light for their age, and, although healthy, many of them were in an unthrifty condition. The average weight of the lot was only 850 lbs. They were placed in a warm stable, and fed for sixty days before they got into a thrifty condition. During this sixty days they gained on an average only 35 lbs. per head. They were then put upon the following average ration for 90 days: oil-meal, 2 lbs.; wheat middlings, 4 lbs.; corn-meal, 6 lbs.; hay, 5 lbs.; straw, 11 lbs., per head per day. The oil-meal, corn-meal and bran were mixed with the short-cut straw, and all thoroughly steamed together. This was given in two feeds, morning and night, and 5 lbs. of long hay was given at noon. During the last sixty days one gallon of cheap molasses was dissolved in the water for wetting the straw for the steamed ration. This was a small amount of sweet to be diffused through 90 bushels, but it added so decidedly to its flavor as to stimulate the appetite. These steers gained, on an average, 201¼ lbs. per head, or 2.23 lbs. per day; this is equal to 10.67 lbs. of dry substance of food to each pound gain in live weight. This is 14 per cent. under Lawes' estimate of food to one of gain. This may also be owing to a warm stable, and cooking the food.

A few years later, we fed 10 head of three-year-old steers for 100 days, keeping an accurate account of the daily ration, and their increase each 30 days, for the whole period. They were of grade Short-horn blood (sired by a seven-eighths blood bull), had been well raised, as that term is generally understood, and accustomed from calf-hood to be handled and stabled. They averaged 1,210 lbs. per head, and cost 4½ cents, or $54.45 per head. Being in a thrifty condition, and accustomed to good shelter, they took kindly to their new quarters when put up, November 20th. This lot of steers, being in condition for rapid fattening, we gave the following combined ration, made by grinding together 10 bushels of corn (560 lbs.), 8 bushels of oats and peas, grown together (384 lbs.), and 1 bushel of flax-seed (56 lbs.)—making 1,000 lbs. This is the proportion, and, when evenly mixed and ground fine, furnishes a fattening ration most complete. This ration, then, cost $1.10 per 100 lbs. The ration of grain was increased gradually from 10 lbs. up to 15 lbs. per head, per day, and the average was 13¼ lbs. per day. This was mixed with 2½ bushels of short-cut straw, with 2 ounces of salt, all well steamed together, as the daily ration of each steer, given in two feeds, morning and evening, with 6 lbs. of long hay at noon. This proportion of flax-seed makes the ration just laxative enough for health, and its oil is also worth all it costs in laying on fat. The corn is very rich in starch, and the peas, oats and flax-seed in albuminoids; and the straw is so softened by the steaming, and so permeated with the flavor of the grain, as to give it a fine relish for the steers. The increase of the steers in live weight was 300 lbs. per head, or 3 lbs. per day. These steers sold for 6¼ cents live weight; and the account stood thus:

*Dr.*

| | |
|---|---|
| 10 steers, 12,100 lbs., at 4½ cents | $544.50 |
| 13,250 lbs. of grain, at $1.10 | 145.75 |
| 6,000 lbs. of hay, at 60 cents | 36.00 |
| 13,500 lbs. of straw, at 40 cents | 54.00 |
| | $780.25 |

*Cr.*

| | |
|---|---|
| By 10 steers, 15,100 lbs., at 6¼ cents | 943.75 |
| Balance to pay labor and profit | $163.50 |

Here the amount of dry substance in the food is only 9.51 lbs. for one pound increase, or 24 per cent. less than Lawes' estimate; and here, again, we see the effect of cooking and a warm stable. It is also evident that such thrifty steers will pay for feeding, while cattle of the slow-growing class are always fed at a loss. In this last case everything fed is charged at full prices, and yet the increase in weight fully pays all, with a respectable balance. It is true that the 3,000 lbs. increase, at 6¼ cents would not pay for the food; but this increase renders the whole carcass worth 1¾ cents per pound more, and this is a legitimate part of the increase. Here the actual cost of food for each pound increase was 7.83 cents; but Mr. Lawes says, that at this stage of feeding 70 per cent. of this increase consists of valuable carcass, and this would render it worth one-sixth more than the average of the whole carcass.

### Whole Cost of the Bullock.

But we can never arrive at the cost of beef until we include the cost of the animal from birth to the last day of feeding. The simple cost of food during the fattening period is very inadequate data for determining the cost of the carcass at the end. Besides, the proper system of feeding—that of early maturity—pushing the animal forward steadily to the market condition—will undoubtedly show a more favorable result than that of feeding through the fattening period. All experiments to that end have shown that it costs less to put a hundred pounds upon the calf than upon the yearling—less to put a hundred pounds upon the yearling than upon the two-year-old—less upon the two-year-old than the three-year-old, and so on. It also costs less to put a hundred pounds upon a thrifty animal of any age than upon an unthrifty one. We cannot, therefore, make much valuable progress in determining the cost of beef until the cost of feeding a given number of calves shall be accurately noted from birth till they are matured and ready for the butcher. These will be complete cases—all others partial and unsatisfactory. The cases given at the Chicago Fat-Stock Show for 1882 are in point as far as they go, and we gave, on page 250, the statement of Mr. Stanford, of England, as reported in the *Royal Agricultural Journal*, of the cost of a "baby bullock" 71 weeks old, specifying the food for each period of feeding. And this is based upon the accurately-observed and noted facts of feeding many such young bullocks. Mr. Stanford finds the cost to be $107.35 for 71 weeks, and he sells his "baby bullocks," on the average, for $108. He finds his profit in the manure. We estimated the cost of raising such animal in this country at $65. This was the difference in the cost of food. If these animals gained at the same rate as the prize young animals at the Chicago Fat-Stock Show, they would weigh about 1,150 lbs. alive. This would make the cost per pound about 5½ cents—a price that the home market would always warrant. It may be considered as a proof of the unpractical character of the management of our agricultural college farms that not one has yet given us a careful experiment, or, in fact, any experiment, to show the cost of raising a bullock. These farms are designed for this special work, in regions where cattle-feeding is one of the principal elements of agriculture. Here should be all the facilities for conducting accurate experiments, and just the talent required to make them in all respects complete. How many years must yet elapse before these institutions shall comprehend their mission?

## Growing Cattle for Beef.

When the farmer shall fully understand that all his success in cattle-feeding must depend upon skill in breeding and feeding, he will then commence the study of this subject in earnest. He will not expect to find a breed with such wonderful characteristics as to grow into capacious forms of beauty and profit without an equivalent expenditure of food.

We have treated of feeding young animals, and especially the calf, and made some estimates of the cost of raising a first-rate calf to one year old. We have illustrated the law of growth, by English examples, and by the premiums awarded at Chicago on the "cost of production," quoting also from the experiments of Sir J. B. Lawes on the cost of food to produce a pound live-weight, illustrated by English, French and American cattle, all proving, conclusively, the economy of early maturity.

We now propose to take these animals of a year or more old, and discuss their feeding till ripened for the market. And this subject grows more and more important every year. The history of the exportation of beef to England during the last few years, fully realizes the reasonable expectations of American cattle-growers. And, what renders the situation the more pleasant, the English farmers are becoming quite reconciled to this importation of dressed beef, because it enables them to prevent the importation of live cattle from the Continent, and thus prevent the destruction of their herds by disease. Here the American feeder may meet the English farmer in competition, at Liverpool or London, on even more than equal terms, because the cost of transportation is much less than the advantage possessed by the American farmer in cheaper land, and, consequently, cheaper food. Everything seems to point to the rapid growth of this trade in fresh meat and live cattle to be slaughtered on arrival; and it is highly probable that our cattle products will, in a few years, reach a figure in our exports little, if any, less than one hundred millions. We have, therefore, the greatest incentive to improve our process of cattle-feeding, that we may lay the foundation for the most provident and profitable system of tillage.

## Home-Bred Cattle.

Although breeding is not included in the plan we had laid out, yet judicious management of the animals is one of the primary considerations required in successful feeding. Kind treatment and growth, gentleness and the graceful lines of animal beauty, are all closely related to each other. The skillful feeder must study the effect of excitement upon the animal system, and of excessive muscular exertion upon the deposit of fat. When he learns that excitement will cause a cow to secrete milk almost devoid of cream, he will see that the steer cannot deposit fat when its nervous system is disturbed. Nervous excitement in the human race is known as always opposed to a fleshy habit. Nervous excitement seems to consume very rapidly the fat of the body. "Laugh and grow fat," has become a proverb. So the quiet, easy, undisturbed animal makes a good use of all its surplus food in laying on flesh and fat. How very important, then, that the feeder should rear all his animals in the atmosphere of kindness—that they should regard his presence with pleasure—and no roughness be used among them. Ill-temper in a herdsman may be almost as destructive to profits in cattle-feeding as pleuro-pneumonia in the herd. Home-bred animals, treated with this full measure of kindness, and fed intelligently, will make a steady growth from the beginning to the last day of ripening for market. It requires several months for cattle in a strange place to get over the nervous excitement consequent on the change. This is the strong argument for raising your own animals. They are kept on the same plan through the whole period—no new habits to learn, and, consequently, no checks in growth. The same system of full-feeding, described in previous pages, will continue through the second year of feeding on the early-maturity system, which endeavors to fit cattle for market in 24 to 30 months. This can only be done where the feeder raises his own animals, and supplies them with abundant and appropriate food from the first to the last day of his ownership.

## Summer Feeding.

Farmers regard this period in feeding as the most favorable and economical. It is no doubt the most favorable for producing growth, not only because succulent grass is the food, but the warm season is more favorable for laying on flesh and fat than the cold season, because so much less food is required to keep up animal heat. But it may be doubted whether feeding in summer actually costs less than in winter, because, as a general rule, the whole country over, it takes three times as many acres to summer the stock as to winter it; and only on the supposition that the labor in preparing the winter food costs more than the capital invested in the extra land used for pasturing, can it be considered more economical. Many of the best cattle-feeders, both in the United States and Europe, do not consider it economical to use so much land for grazing cattle, and, therefore, have sought to reduce this by soiling, partially or wholly, the stock in summer; but this question of soiling we have considered in Chapter VII, and here we will discuss the

### Management of Pastures.

A variety of food is as important in pasturing as in stall-feeding, and those pastures having the greatest variety of grasses are the best. Some old pastures contain a large number of varieties, each having its peculiar qualities of nutriment, aroma and flavor. Such old pastures produce the finest flavored beef, mutton and milk. Too little care is taken in seeding for pasture to select a sufficient variety. Sometimes only one grass, and that not the best for pasture, although unsurpassed for hay—timothy—is sown. Others, more liberal, sow red clover and timothy. Both of these should be used in any selection of pasture grasses. Timothy, with all its excellence as a hay crop, does not stand constant cropping off by animals as well as many others. Clover furnishes a large amount of most excellent pasturage, being rich in all the elements of growth, and starting again quickly after being cut or eaten off.

Blue-grass or June-grass (*Poa pratensis*) is native to the country, grows over a wide range, and has no superior as a pasture-grass. It is seen in its greatest luxuriance and perfection in warm, rich, strong limestone soils, and in the valleys west of the Alleghany Mountains. It produces very early herbage, and, when kept fed off, remains fresh till frost, and, under light snows, furnishes a winter pasturage. It stands close-feeding remarkably well, its creeping or stoloniferous root forming an impervious network of roots.

Flat-stalked blue-grass, or wire-grass (*Poa compressa*), is an early, low grass, common in the Middle and Northern States. It is a very nutritious grass, and, when cut early, makes excellent hay, but in small quantity; yet its greatest value is as a pasture-grass, as it covers the ground, and, when fed close, will furnish much green food. It is also very tenacious of life, and will stick to a field when it gets rooted; thus becoming a nuisance in a cultivated field, and requiring three or four plowings to eradicate; but in permanent pastures it is very desirable.

Rough-stalked meadow-grass (*Poa trivialis*) is also an excellent pasture-grass, and thrives well in shade. Its creeping root enables it to stand tramping by stock. As a meadow-grass alone, it is sometimes injured by a hot sun after cutting, but when mixed in with a variety of pasture-grasses, it is not injured by cropping in hot weather.

Meadow fescue (*Festuca pratensis*) is a foreign grass, but has become acclimated in this country, is relished by cattle in pasture or as hay—grows from three to four feet high in meadow, and has not been as well tested as it should be in pasture.

Sheep fescue (*Festuca ovina*) is a pasture-grass much esteemed on dry, sandy and rocky soils, on mountains. It forms the principal part of the sheep-pastures of the highlands of Scotland, where the shepherds have the highest opinion of its nutritiousness and value for their flocks. The Tartars seek an encampment where this grass is most abundant. There must be many locations in this country where it will have a high value for pasture. It grows somewhat in bunches.

Orchard-grass (*Dactylis glomerata*) is well adapted for pasturage, and on rich, inclining to heavy soils, will produce a large amount of excellent green food. It must be kept eaten close, and not allowed to get large, as it then becomes woody. It springs up very quickly after being eaten off, and will thus afford a constant pasturage through the whole season. This grass is much inclined to grow in tussocks, and leave vacant spaces to be filled by other grasses.

Red-top or herds-grass (*Agrostis vulgaris*) delights in a moist soil, and with this grows well on a soil of almost any texture. It should not be omitted in a pasture soil fitted to it. Although it is not quite as nutritious as June-grass, yet it makes good pasture, and very good stock hay.

Sweet-scented vernal grass (*Anthroxanthum odoratum*) is by some considered an excellent pasture-grass, which exhales a most agreeable perfume, and is often found in the hay of the Eastern States. It is said to give an agreeable flavor to milk, and assists in improving the flavor of beef grown upon it with other grasses. This grass affords both early and late pasturage, and flourishes best in a dry, sandy or gravelly loam. Some assert that cattle will not eat it in pasture, and that it is not valuable for hay, but the analysis given of it on page 153 shows it equal to red-top. It has a good reputation as a pasture-grass with many careful observers. It starts quick after cutting, and is thus considered valuable for lawns.

There are many grasses natural to the Missouri River region and the Rocky Mountain region, some of which will be found in our tables of analyses on pages 146–48, among which are *Andropogon furcatus*, called blue-joint, which is said to compose about 40 per cent. of the grass in Missouri River region, and one-sixth of the grass in the Rocky Mountain region; *Andropogon scoparious*, called broom-grass, occupying some 20 per cent. of the former and 10 per cent. of the latter region; *Sorghum nutans*, called wood-grass, is also largely found in these regions. The buffalo-grass (*Buchloe dactyloides*), of which so much is said in praise, covers only about one-twentieth part of these regions. Sheep fescue is said to cover some 20 per cent. of the Rocky Mountain region.

An old pasture has many more grasses than here enumerated among the cultivated grasses, and the greater the variety the better for the thrift of the cattle.

As a further aid to understanding the individual value of these grasses we refer to the analyses of them given on pages 153–7.

The whole list of grasses above described can only be used in permanent pastures, and for these too great a variety of successful grasses cannot be sown. We have a great number of natural grasses in this country which have never been tested in cultivation, but from which many might, no doubt, be selected to enrich our permanent pastures.

But we must have also in our rotation tillage,

## Temporary Pastures.

In the older-settled States there are comparatively few permanent pastures, except on land too rough or hilly to cultivate, or on woodland pastures. These have usually seeded themselves, but they may be benefited by sowing grass-seeds very early in spring or late in the fall over the spaces not well covered with grass. For this purpose red-top, wire-grass (*Poa compressa*) and orchard-grass may be sown. Mix them together in equal proportion, and sow at the rate of 15 pounds per acre. If this is dressed after sowing with 3 bushels of wood-ashes or one bushel of land-plaster to the acre, the seeding and dressing are likely to much improve the pasturage.

Temporary pastures are varied according to the methods of tillage. It is very common to till land for the various grain and cultivated crops for 8 or 10 years, then lay it down to pasture-grasses for 10 or more years, allowing it to recover for another period of grain tillage. We cannot say that we quite approve of this plan, but where such practice obtains, or where pastures are laid down for 10 to 15 years, a larger number of grasses should be sown than on pastures for a shorter period. The following grasses and clovers may be used: Timothy 8 lbs.; medium red clover 6 lbs.; Alsike clover 3 lbs.; June-grass (*Poa pratensis*) 5 lbs.; red-top 5 lbs.; orchard-grass 5 lbs., and flat-stalked blue-grass (*Poa compressa*) 4 lbs.—all sown in spring. These, sown upon an acre should give a good seeding. The timothy and clovers will give a crop the first year, which it is best, generally, to mow and not pasture the first season, as pasturing is likely to injure the young grass. Timothy does not stand close cropping and will not probably last beyond the second or third year, but the other grasses will be well established before that and the timothy will not be missed.

This pasture, if the land be in good condition, will go on satisfactorily to the time of plowing again. But in the grain districts the rotation is short, the land remaining in grass only from one to three years. In this case, only timothy and clover are sown, and in many districts only clover. The clover plant, with its long tap root, reaches down into the subsoil and attracts all the soluble plant-food within reach and brings it up to enrich the surface-soil. The root of timothy does not go much below the working-soil, and consequently does not enrich the soil like clover. The weight of clover-roots, to be plowed under, is considerably more than the crop above ground, and this is mostly the contribution of the subsoil. This renders it plain why clover is chosen to prepare the soil for a wheat crop. Clover also becomes a profitable crop, cutting from six to twelve tons of green food or from one and a half to three tons of hay. After the first summer clover stands pasturing well as long as it lasts. Alsike clover is a perennial plant, and is excellent for pasture.

If the land is to remain in grass or clover only two years, then timothy 10 lbs. and medium clover 10 to 15 lbs. will be all the seed required, or if clover alone is to be sown, then 20 to 24 pounds will be required. If the land is to remain in grass five years, then 10 lbs. of timothy, 12 lbs.

of June-grass (*Poa pratensis*), 10 lbs. medium clover. 6 lbs. Alsike clover, should be sown.

We have given only a few of the grasses that may be used in pasture; but deem it better to give a few that may be easily obtained than a larger list, many of which are not in the market. Pastures being the general reliance for feeding cattle in summer, particular attention should always be given to their condition and the quality of the food they furnish. We wish to point out the great error, too often committed by farmers, of compelling cattle to take what they can get in the pasture, whether it affords sufficient nutriment to keep up a full and steady growth or not. It often happens, in very dry seasons, and sometimes in very wet ones, that the grass is quite inadequate to produce a vigorous growth; and, lacking their full ration, the cattle make so little progress, that this most favorable season is practically lost—the gain being much less than the value of the pasture. Every consideration of economy demands

### Full-Feeding in Summer.

That this statement may be fully understood, let us consider the circumstances. Much of the food of support is required to keep up animal heat; and when the temperature is 70 degrees, it requires only food enough to raise this temperature to 100 degrees, or to overcome a difference of 30 degrees between the atmosphere and blood-heat. Now the fall and winter seasons will average a temperature of about 40 degrees in the Northern and Western States, and, consequently, the temperature must be raised 60 degrees to reach blood-heat; thus requiring as much again food to keep up animal heat in the cold as in the warm season. This is a large margin in favor of summer-feeding, and every farmer should make the most of it. How short-sighted, then, is that policy which keeps cattle upon scanty food in summer, expecting to do the heavy feeding in winter!

Another consideration of importance, favoring full-feeding in summer, is the fact that succulent grass is a great promoter of health, and grain-feeding, in connection with grass, is not so likely to disturb the digestive functions as grain-feeding with dry fodder. Nature furnishes its succulent food for animals combined with 75 per cent. of water, which has a sedative and cooling effect upon the stomach and alimentary canal. Heavy grain-feeding tends to produce unnatural heat and fever in the stomach, and, when given with dry fodder, this tendency is not sufficiently counteracted; but a grain ration, with scanty pasture, seems exactly to supply the deficiency and produce a healthy growth. It is, therefore, entirely safe to feed a small grain ration upon pasture, and, when done judiciously and systematically, it will produce nearly twice the gain, in live weight, as the same amount fed in cold weather.

The reader will remember that it takes about two-thirds of a full ration for the food of support, or to supply animal heat and waste, and the other third is the food of production. This food of production gives all the profit which can be realized. Up to that point, all is expenditure without profit. This fact applies as well to summer as winter-feeding. When we consider that the growth or increase comes from half the amount of food required to support the animal, how unwise it must be to withhold this small proportion of food, and thus receive nothing for the larger amount expended in keeping the animal alive. This fatal error is the cause of nearly all unprofitable cattle-feeding.

Some of our American feeders fully understand the importance of pushing their cattle in summer. That most successful feeder, John D. Gillette, of Illinois, possessing the most luxurious blue-grass pastures, still, all over his pastures, stocked with grade Short-horn year-olds and two-year-olds, will be found, all summer long, troughs filled with corn in the ear, that his steers may have their fill of the best grass and all the corn they desire. Thus he produces cattle that sell at top prices in our market and are sought as the most profitable cattle for exportation to England. Some of his neighbors, seeing his good works, follow his example.

Corn, as a single diet, is too carbonaceous to produce a proper nourishment of all parts of the body, and induces fever, but when mixed with good grass, is well balanced and makes the most rapid growth.

The best English feeders have adopted the plan of stocking their pastures fully, and then feeding linseed-cake, corn-meal, etc., to help out the pasture.

At a meeting of the London Farmers' Club, Mr. Tallant said he could afford to pay £12 per ton for linseed-cake, or £7 for cotton-seed-cake, and give it on second-rate pasture. It resulted in great advantage to the cattle, and to the pasture itself. He had tested this for some years upon light land pasture, and it was now able to carry double the animals that it could five years ago. This had been effected by the use of oil-cake, to give the animals full-feed on second-rate pasture. He was able by this process to turn out steers that sell for £30 to £35 each, at 24 to 30 months.

This shows what might be done to improve the pastures in our Eastern States, the improvement all being paid for by the beef grown. Here the cost of the extra food on pasture is not more than one-half the cost mentioned by Mr. Tallant.

We do not advise that grain be fed upon all pastures, for the best pasture-grass can scarcely be improved upon by the use of grain. Grass must be the main reliance for growing beef in summer; but there are times nearly every season when a little corn, oats, middlings, or cake, will pay a large profit to feed in small quantity on pasture. We have known many cases where 20 steers were kept in a field furnishing full-feed for only 15, and where a profit would have been made by selling two steers and buying grain to feed the other 18; the 18 being worth considerably more, at the end of the season, than the 20 kept on scant pasture.

Feeders are usually loth to feed grain on pasture, because this is increasing the expense of keep, and they are apt to infer increasing the cost of production. But the latter is an error. The grain increases the cost of keep, but, when properly given, cheapens the cost of the increase in weight. The grain may be so given as to be wholly the food of production, and it is only the food of production which pays. If the pasture (as is often the case) is only sufficient to keep cattle without growth, then the grain gives all the growth, and without the grain the pasture is thrown away, as the animals, not having gained anything in weight, are worth no more, if as much, as before they consumed the pasture.

But farmers usually hold the opinion that grain is dearer in proportion to nutriment than grass or hay, but this is also an error. Most intelligent farmers, when short of hay to winter a stock, find it cheaper to purchase grain than hay—feeding less hay and more grain. Of course a peculiar state of the market might reverse this, but as a general fact grain is quite as cheap as hay, and the farmer should never hesitate to feed a small amount of grain on pasture when the grass is insufficient, for it may be laid down as a rule, that scanty feeding, to a healthy beef-producing animal, is wasteful feeding at all times.

The soiling system, which has grown into favor with a considerable class, as an economical mode of summering stock, is treated at length in another chapter, and this system will be found a substitute for grain-feeding on pasture.

### Winter–Feeding.

And first, let us consider the true method of feeding the home-raised stock—those young animals reared in an atmosphere of kindness, that can be placed in stall, stanchion, shed or yard, without feeling the confinement irksome and becoming restive and nervous. The habits of animals must be respected by the skillful feeder, or his skill will not lead to profit. It is the indiscriminate confinement of cattle in stable that have been reared in the open field, which has furnished the facts for the unfavorable reports of comfortable stall-feeding as compared to open-air feeding in some of our Western States. Cattle that have been raised in the open field without handling, until two or more years old, had better be finished in the same state of freedom, only giving such shelter as may be enjoyed without confinement. But those animals that have been fed as calves in warm stables, have become familiar with their attendants, and take kindly to their comfortable quarters—these animals may be fed much cheaper and grow much faster by continuing them in this comfortable atmosphere. The feeder should always bear this in mind—that the animal is kept warm by the food it consumes; its animal heat always represents food, and the amount of this food is always in proportion to the temperature of the air surrounding the animal. A question of economy arises here: Is it cheaper to overcome the cold with food—that is, by consuming an extra amount of food in the blood of the animal—or to keep out the cold by artificial means? A warm stable, say that can be kept at a temperature of 50 degrees, will save a large amount of food during the cold season. Let us suppose that the out-door temperature in a large part of the cattle-feeding districts will average, for six months in the year, 25 deg. (F.), which would make a difference of 25 degrees in favor of a warm stable, this 25 degrees of temperature represents more food than most farmers suppose. If 20 steers, all brought up alike in comfortable stables, are separated the third winter, and 10 are fed in a stable of 50 degrees of temperature, and the other 10 are fed in the open air, it will take five tons of hay, extra, to keep those in the open air in as good condition as those in stable; this half-ton per steer represents the loss of food from 25 degrees of colder temperature. But if these steers have been brought up wild in the open air for two years, and the third winter 10 are tied up in a warm stable and the other 10 left out as usual, the latter will be likely to do better, even with this exposure, than the former in their comfortable quarters, chafing and under nervous excitement from the unusual confinement. Still, let it be remembered that the 10 accustomed to being confined in the warm stable will consume at least one-half ton per head less food in maintaining the same condition than the 10 wild steers in the open air. This is the result of the laws governing animal life, which no training nor circumstances can set aside. But a lot of wild Texan steers would be likely to lose more from the worry of confinement than from the extra cold in the open air, with freedom.

These principles need to be well understood, for they have been the cause of no little misunderstanding of experiments reported. And this will also show the great economy of rearing our stock in such habits as will enable us to keep them in a temperature as little below that of summer heat as possible. We may then put on a hundred pounds live-weight with the least amount of food.

## Out-door Feeding.

But these Chicago exhibitions of fat-stock have brought most prominently before the public the Western practice of out-door feeding, even for the best cattle; and although the fine animals there shown may very reasonably be considered as an argument and an encouragement to those feeders who have no shelter, to continue this open-air system, seeing that it has here produced animals of which any feeder might be proud ; and although it shows so clearly that no excellence can be reached without full-feeding, and that, with it, fine animals may be raised under the worst conditions of climate and exposure—thus fixing a most important principle in the philosophy of stock-growing—yet, if taken as a proof that out-door feeding is the best and most economical system in winter, it will disseminate a mischievous error, and one that ought to be thoroughly discussed and understood on the basis of first principles. It is not likely that Mr. Gillette himself, who has exhibited the most successful grade Short-horns, would insist that those steers had consumed no more food than they would have done had they been accustomed to and kept in comfortable quarters during the cold season. He probably does not believe that the same amount of food will keep a steer warm in a temperature of 20 degrees below zero as at 50 degrees above zero. He is well aware that this 70 degrees lower temperature must be overcome by the heat produced from the food eaten. It is not then economy of food that leads him to feed in the open air; but he will probably say that, in his situation, it costs less to bestow this extra food than the expense of buildings to house them, and the extra labor required to feed in barn from calf-hood. It will be noted, in the accounts given, that some of these steers were so wild that they could not be measured—and, being thus reared, they would not do well in confinement as we have mentioned in a previous paragraph.

This question must be discussed from the standpoint of scientific facts, not of opinions. Mr. Gillette has been so successful in showing farmers how they may grow fine animals under all the ordinary disadvantages that surround them, without shelter, and with only the canopy of heaven over them, he is admirably situated, in the extent of his cattle-feeding, to give a large illustration of the comparative advantages of the two systems of out-door and in-door winter-feeding. As he mostly raises his own steers, he might rear 100 head to be fed in stable or under comfortable shelter, accustoming them to it, so that they would take to it kindly, housing them at the first cold storms in the fall, and continuing their winter-feeding in comfortable quarters till ripened for market. These should be contrasted with 100 head, of the same age and quality, fed in the open air, according to his present plan; both lots of steers to be fed upon the same quality of food, and according to his excellent custom, full-fed, keeping a strict account of the amount of grain and winter fodder eaten by each lot. The record of these lots of steers, compared at thirty months or three years, with the half-yearly and final weights, would be most instructive, and entitle Mr. Gillette to the grateful thanks of the farmers of America. We trust that Mr. Gillette will consider this, and consent to undertake the settlement of this important question in this demonstrative way. His facilities are more ample than those of any experimental farm attached to our agricultural colleges; and as he makes it his principal business to feed steers for market, his methods would be likely to be more accurate—and tested on such large numbers as scarcely to admit of any important error.

Mr. Gillette can also do a great service, even in his present mode of feeding, by weighing his steers at the commencement of summer-feeding, and at the beginning of winter-feeding, noting the gain during each of these periods, as well as the extra or grain food given, per head. The question of the effect of temperature may be solved quite effectually in this way. No observing feeder doubts that it requires a large portion of the food to keep up animal heat during the cold season, but precisely what percentage is required has not been accurately settled on a sufficiently large scale. It would not involve very much labor to note these facts in Mr. G.'s feeding, and, when accurately noted, would become important scientific data.

These fat-stock shows have been most pertinent illustrations of the principles we have discussed. They demonstrated most completely that profitable feeding must not extend beyond three years, and that the greatest profit will find a limit at 20 to 24 months. This simple lesson, taught in such a practical, eye-opening way, was alone sufficient doubly to compensate for all the expense of the show. The tenacity with which old opinions and traditional practices are held and followed by the mass of farmers, is proverbial. They have seen their fathers, and heard of grandfathers and great-grandfathers, feeding steers till four and five years old for beef, and they look with suspicion upon any shorter cut to market. And with this four-year system has grown up the starving or half-feeding period, which still further reduces the profit; for, when making no progress, beef animals pay nothing for the food they eat. If the four to five-year system were one of constant, liberal feeding, producing an average of 2,000 to 2,400 pounds' weight, and this the best quality of meat, the loss would be comparatively small to that of the periodically suspended growth system, which produces a weight of only 1,300 to 1,600 lbs. in the same time—the one might excite the pride of the feeder, if it brought no profits, but the other would bring both mortification and loss. These contests for prizes in the fat-stock show ring will constantly point the feeder to the true economical system of growing beef; and these exhibitions will be such an unanswerable demonstration of the right way, that the old system will soon have no place, except in history. The farmer cannot see the force of an argument for a change, unless backed by numerous examples.

## German Feeding Standard—Cattle Rations.

We gave tables of analyses and the feeding value of the larger share of foods used for cattle and other farm animals, on pages 153–158. To know the best combinations of foods for growing and fattening cattle is the first requisite of successful feeding, and we shall extend this discussion to the mention of the most important points. The German experiment stations have experimented with cattle of various ages and under various conditions, and have given formulas for average feeding standards, in which they state the quantities and proportions of the digestible food elements required for cattle at different ages, and fed for different purposes. We are indebted to Prof. S. W. Johnson's report of the Connecticut experiment station for the tables translated from the German of Dr. Wolff. We believe Prof. Johnson was the first to bring these experiments definitely before American cattle-feeders. We do not, however, think these feeding standards can be regarded as anything more than approximative—only as showing what has been found to work well in practice on a small scale, and as exhibiting the practical principles on which rations may be compounded. These feeding standards, used in connection with our extensive tables of analyses of different foods, will enable any one to make up feeding rations for himself. But we would caution the reader against supposing these to show the only practical standard of the proportion of elements in rations. We shall see that great variations are made from this standard in large and successful feeding operations.

## Feeding Standards.

*Per Day, and Per 1,000 Pounds, Live Weight.*

| Animals. | Total organic dry substance. | Nutritive Digestible Substances. Albuminoids. | Carbo-hydrates. | Fat. | Total nutritive substance. | Nutritive ratio. |
|---|---|---|---|---|---|---|
| | lbs. | lbs. | lbs. | lbs. | lbs. | lbs. |
| 1. Oxen at rest in stall | 17.5 | 0.7 | 8.0 | 0.15 | 8.85 | 1 : 12 |
| 2. Oxen moderately worked | 24.0 | 1.6 | 11.3 | 0.30 | 13.20 | 1 : 7.5 |
| 3. Oxen heavily worked | 26.0 | 2.4 | 13.2 | 0.50 | 16 10 | 1 : 6.0 |
| 4. Oxen fattening, 1st period | 27.0 | 2.5 | 15.0 | 0.50 | 18.00 | 1 : 6.5 |
| Oxen fattening, 2d period | 26.0 | 3.0 | 14.8 | 0.70 | 18.50 | 1 : 5 5 |
| Oxen fattening, 3d period | 25.0 | 2.7 | 14.8 | 0.60 | 18.10 | 1 : 6.0 |
| 5. Cows in milk | 24.0 | 2 5 | 12.5 | 0.40 | 15.40 | 1 : 5.4 |
| 6. Growing Cattle: *Age. Months.* — *Average Live Weight Per Head.* | | | | | | |
| 2 to 3 — 150 pounds | 22.0 | 4 0 | 13.8 | 2.0 | 19 8 | 1 : 4.7 |
| 3 to 6 — 300 pounds | 23.4 | 3.2 | 13.5 | 1.0 | 17.7 | 1 : 5.0 |
| 6 to 12 — 500 pounds | 24.0 | 2.5 | 13.5 | 0.6 | 16.6 | 1 : 6.0 |
| 12 to 18 — 700 pounds | 24.0 | 2.0 | 13.0 | 0.4 | 15.4 | 1 : 7.0 |
| 18 to 24 — 850 pounds | 24.0 | 1.6 | 12.0 | 0.3 | 13.9 | 1 : 8.0 |

*Per Day and Per Head.*

| Growing Cattle: *Age. Months.* — *Average Live Weight Per Head.* | | | | | | |
|---|---|---|---|---|---|---|
| 2 to 3 — 150 pounds | 3.3 | 0.6 | 2.1 | 0.20 | 3.00 | 1 : 4.7 |
| 3 to 6 — 300 pounds | 7.0 | 1.0 | 4.1 | 0.30 | 5.40 | 1 : 5.0 |
| 6 to 12 — 500 pounds | 12.0 | 1.3 | 6.8 | 0.30 | 8.40 | 1 : 6.0 |
| 12 to 18 — 700 pounds | 16.8 | 1.4 | 9.1 | 0.28 | 10.78 | 1 : 7.0 |
| 18 to 24 — 850 pounds | 20.4 | 1.4 | 19.3 | 0.26 | 11.96 | 1 : 8.0 |

Dr. Wolff gives an illustration of the standard for a milch cow, by saying that 30 lbs. of young clover-hay will keep a cow in good milk; and that this contains of dry organic substance 23 lbs., of which is digestible—albuminoids 3.21, carbo-hydrates 11.28, and fat 0.63. This is .71 lbs. albuminoids more, and .22 lbs. of carbo-hydrates less, with .13 lbs. of fat more, than the standard. Then he takes the richest and best meadow-hay, of which 30 lbs. contains of organic substance 23.2 lbs., having digestible—

albuminoids 2.49 lbs., carbo-hydrates 12.75 lbs., and fat .42 lbs. This is almost exactly the feeding standard. But to show how a ration for milk cows may be compounded of poorer hay, oat-straw, roots, and grain, he gives the following:

RATION FOR MILCH COWS.

| RATIONS. | Dry organic substance. | DIGESTIBLE. Albuminoids. | Carbo-hydrates. | Fat. |
|---|---|---|---|---|
| | lbs. | lbs. | lbs. | lbs. |
| 12 pounds average meadow hay | 9.5 | 0.65 | 4.92 | 0.12 |
| 6 pounds oat straw | 4.9 | 0.08 | 2.40 | 0.04 |
| 20 pounds mangolds | 2.2 | 0.22 | 2 00 | 0.02 |
| 25 pounds brewers' grain | 5.6 | 1.20 | 2.81 | 0.30 |
| 2 pounds cotton-seed cake | 1.6 | 0.66 | 0.35 | 0.12 |
| | 23.8 | 2.81 | 12.48 | 0.60 |
| Standard | 24.0 | 2.50 | 12.50 | 0.40 |

Prof. S. W. Johnson gives the following rations, calculated from the table:

| | | | | |
|---|---|---|---|---|
| 20 pounds cured corn-fodder | 13.7 | 0.64 | 8.68 | 0.20 |
| 5 pounds rye straw | 4.1 | 0.04 | 1.82 | 0.02 |
| 6 pounds malt sprouts | 5.0 | 1.25 | 2.62 | 0.05 |
| 2 pounds cotton-seed meal | 1.6 | 0.66 | 0.35 | 0.12 |
| | 24.4 | 2.59 | 13.47 | 0.39 |
| Standard | 24.0 | 2.50 | 12.50 | 0.40 |

Or, again:

| | | | | |
|---|---|---|---|---|
| 15 pounds corn-fodder | 12.1 | 0.16 | 5.55 | 0.04 |
| 5 pounds bran | 4.1 | 0 59 | 2.21 | 0.15 |
| 5 pounds malt sprouts | 4.1 | 1.04 | 2.19 | 0.08 |
| 3 pounds corn-meal | 2 5 | 0.25 | 1.82 | 0 14 |
| 2 pounds cotton-seed meal | 1.6 | 0.66 | 0.35 | 0 12 |
| | 24.4 | 2.70 | 12.12 | 0.53 |

A practical ration we have used to feed 40 steers, weighing an average of 900 lbs., and gaining 2½ lbs. per head, per day, is the following:

| Rations. | Dry organic substance. | Digestible. | | |
|---|---|---|---|---|
| | | Albuminoids. | Carbo-hydrates. | Fat. |
| | lbs. | lbs. | lbs. | lbs. |
| 12 pounds oat-straw | 9.80 | 0.17 | 4.81 | 0.08 |
| 5 pounds hay | 3.98 | 0.27 | 2.05 | 0.05 |
| 6 pounds corn-meal | 5.04 | 0.50 | 3.64 | 0.28 |
| 4 pounds bran | 3.22 | 0.40 | 1.80 | 0.12 |
| 2 pounds linseed-meal | 1.61 | 0.55 | 0.68 | 0.06 |
| | 23.65 | 1.89 | 12.98 | 0.59 |
| Standard for fattening cattle of this weight | 24.30 | 2.25 | 13.50 | 0.45 |

It will be seen that this practical ration corresponds quite closely with the German standard, only the albuminoids are slightly less, and the fat more. One gallon of cheap molasses was added to the ration of hay for 40 head, which would nearly bring up the carbo-hydrates to the standard.

The following is a practical ration which we fed to 10 steers for 90 days; their average weight for the 90 days being 1,348 lbs.; and this was the average ration fed—the average gain being 3 lbs. per head, per day:

| | | | | |
|---|---|---|---|---|
| 15 pounds oat-straw | 12.25 | 0.21 | 6.01 | 0.10 |
| 6 pounds hay | 4.77 | 0.32 | 2.46 | 0.06 |
| 7 pounds corn-meal | 5.86 | 0.59 | 4.24 | 0.33 |
| 3 pounds pea-meal | 2.48 | 0.60 | 1.63 | 0.05 |
| 3 pounds oat-meal | 2.48 | 0.29 | 1.29 | 0 14 |
| 1 pound flax-seed | 0.86 | 0.17 | 0.18 | 0.35 |
| | 28.70 | 2.18 | 15.81 | 1.03 |
| Standard for fattening cattle of this weight, 3d period | 33.70 | 3.63 | 19.95 | 0.80 |

This appears to be a pretty wide departure from the German standard for fattening cattle in the 3d period; but as this experiment was carried out under our own personal supervision, and as great care was taken to have weights as exact as could have been taken in the establishment of the standard, we must conclude that the quality of the food or its condition will vary the ration and its effect. That all the conditions may be understood, it should be stated that the corn, peas, oats and flax-seed in the proportions stated, were mixed and ground together, and then 14 lbs. of the mixed meal was mixed with the 15 lbs. of oat-straw, cut into inch lengths, and all well cooked together—that is, 420 lbs. of the ground meal was mixed with 450 lbs. of cut oat-straw, placed in a steam-box and well cooked with steam, and this served for three days' rations for the 10 head, except that 6 lbs. of long hay was given to each at noon. Perhaps the explanation is, that the cooking rendered a so much larger percentage digestible, that it was, in effect, equal to the German standard. These steers weighed 1,210 lbs. when the experiment began, and 1,485 lbs. at the end of 90 days; so that 1,348 lbs. was the average weight during this period. The meal ration was but 10 lbs. during the first two weeks, and increased gradually up to 16 lbs., at the end of 60 days; making the average ration 14 lbs. per day.

We have always thought the English feeders inclined to feed oil-cakes too liberally; that they feed albuminoids to excess; and it is quite possible that the Germans err in the same way. If we examine the ration for the "baby bullock," on page 250, we shall find the albuminoids very large for so young an animal, during the last sixteen weeks, when its average weight was under 1,000 lbs. The 8 lbs. of cake and meal contained 1.89 lbs. albuminoids, the mangolds .33 lbs., and the grass, clover, etc., must have contained 1 lb.—making 3.19 lbs. albuminoids; whilst in the case we gave, on page 252, the 3 lbs. cake, 5 lbs. cornmeal and grass, would not exceed 2.13 lbs. of albuminoid substance.

## Clover and Corn.

American feeders must learn to make the best use of what they can produce easily on their own farms. Clover, with proper management, is an easily-produced and abundant crop; it is also the richest of our artificial grasses in albuminoids. When fed in its succulent state, or cured at or before blossom, its albuminoids are more soluble and digestible, and answer as a substitute for oil-cake or other nitrogenous grain food; and Indian corn, our most abundant grain food, will furnish the needed oil and easily-digested carbo-hydrates. Let us give from the tables a ration combined of these two easily-obtained foods:

*Clover and Corn Ration for Fattening Cattle of 1,200 Pounds.*

| Rations. | Dry organic substance. | Digestible. | | |
|---|---|---|---|---|
| | | Albuminoids. | Carbo-hydrates. | Fat. |
| | lbs. | lbs. | lbs. | lbs. |
| 20 pounds best clover-hay | 15.20 | 2.14 | 7.52 | 0.42 |
| 5 pounds straw or corn-stalks | 4.10 | 0.04 | 1.82 | 0.02 |
| 14 pounds corn-meal | 11.77 | 1.27 | 8.48 | 0.67 |
| | 31.07 | 3.45 | 17.82 | 1.11 |
| Standard for fattening cattle of 1,200 pounds, 2d period | 31.20 | 3.60 | 17.70 | 0.84 |

*Or Peas and Oats, dried in Blossom, with Corn-meal.*

| | | | | |
|---|---|---|---|---|
| 27 pounds pea and oat hay | 20.60 | 2.16 | 9.61 | 0.48 |
| 12 pounds corn-meal | 10.09 | 1.00 | 7.27 | 0.57 |
| | 30.69 | 3.16 | 17.88 | 1.05 |

*Winter Ration of Western Cattle—Corn and Stalks.*

| | | | | |
|---|---|---|---|---|
| 20 pounds dry corn-stalks | 16.32 | 0.16 | 7.30 | 0.08 |
| 20 pounds ear-corn | 16.82 | 1.68 | 12.12 | 0.96 |
| | 33.14 | 1.84 | 19.42 | 1.04 |

We have given this latter ration to show how far it comes short of the German standard for fattening cattle. It is given as if the whole corn were as digestible as meal; and even then, it only shows about half of the albuminoids of the standard. The 20 lbs. of corn can hardly be estimated as affording more digestible nutriment to cattle than 12 lbs. of meal, as much of it passes the cattle whole; and if we estimate the real digestibility as only equal to 12 lbs. of corn-meal, then the albuminoids will only amount to 1.16 lbs., instead of 2.70 lbs. It is very evident that any ration, composed of corn in the shock or corn standing on the hill, must be much below the German standard in albuminoids. And when we consider the fact, that millions of cattle are thus fed every year in the West, and that these cattle are among the best in the market, we must conclude that the German standard is only approximate, and determined from too small a range of experiments to be implicitly relied upon. In fact, until the full statement of the German experiments is published in this country, we cannot judge of the evidence to sustain their feeding standards.

There can be no doubt, however, that this standard corresponds pretty closely with the practice of the best English feeders, and with American feeders in the Middle and Eastern States, where oats, oil-cake, bran, peas and clover are fed to some extent with Indian corn. But it requires careful experiments, on a large scale, carried on for years, to settle practically the permissible limits of the feeding standard for animals of different ages intended for meat. And this is just the work to be undertaken and carefully worked out by our agricultural colleges on their experimental farms. Here should be all the facilities for the most accurate determination of these questions; and, as its determination is of the greatest practical importance in the profitable feeding of all our farm animals, there should be no further delay in instituting these experiments. They would reach a broader interest in agriculture than any other single set of experiments could. They would necessarily take in the comparative aptitude of the different breeds for laying on flesh and fat, secreting milk, and growing wool; or, in other words, would determine the most economical meat, milk and wool-producing breeds under precisely the same circumstances.

## Waste-Products in Cattle-Rations.

As we have given a long list of refuse products in the tables, let us give special applications of some of the most easily obtained of these in fattening cattle. We will suppose the feeder to be within easy reach of large quantities of corn-sugar meal, and that it contains 28 lbs. of dry matter to the hundred pounds, as found at the manufactory, and its cost is 25 cents per barrel, or 12½ cents per 100 lbs. It would not be profitable to handle it at a higher price, where the distance of carriage is more than five miles, and it may often be obtained at 20 per cent. less. A great variety of combinations may be given, among which take the following:

### Rations for Fattening Cattle.

*Per* 1,000 *Lbs. Weight.*

| Rations. | Dry organic substance. | Digestible. | | | Cost of ration. |
|---|---|---|---|---|---|
| | | Albuminoids. | Carbo-hydrates. | Fat. | |
| | lbs. | lbs. | lbs. | lbs. | $ cts. |
| 18 pounds of winter-wheat straw......... | 14.6 | 0.14 | 5.19 | 0.07 | .... |
| 40 pounds corn-sugar meal ... ........... | 11.2 | 1.28 | 7.72 | 0.72 | 0.05 |
| 4 pounds cotton-seed meal............... | 3.6 | 1.32 | 0.70 | 0.24 | 0.05 |
| | 29.4 | 2.74 | 13.61 | 1.03 | 0.10 |

Or this :

| RATIONS | Dry organic substance. | DIGESTIBLE. Albuminoids. | DIGESTIBLE. Carbo-hydrates. | DIGESTIBLE. Fat. | Cost of ration. |
|---|---|---|---|---|---|
| | lbs. | lbs. | lbs. | lbs. | $ cts. |
| 12 pounds clover-hay | 10.2 | 1.02 | 4.59 | 0.20 | 0.06 |
| 6 pounds oat-straw | 4.9 | 0.08 | 2.40 | 0.04 | .... |
| 40 pounds corn-sugar meal | 11.2 | 1.28 | 7.72 | 0.72 | 0.05 |
| 2 pounds linseed-meal | 1.6 | 0.55 | 0.68 | 0.06 | 0.03 |
| | 27.9 | 2.93 | 15.39 | 1.02 | 0.14 |
| Standard German ration | 27.0 | 2.50 | 15.00 | 0.50 | .... |

Or this :

| | | | | | |
|---|---|---|---|---|---|
| 12 pounds oat-straw | 9.80 | 0.17 | 4.81 | 0.08 | .... |
| 10 pounds wheat-bran | 8.20 | 1.18 | 4.42 | 0.30 | 0.05 |
| 40 pounds corn-sugar meal | 11.20 | 1.28 | 7.72 | 0.72 | 0.05 |
| | 29.20 | 2.63 | 16.95 | 1.10 | 0.10 |

Or this :

| | | | | | |
|---|---|---|---|---|---|
| 15 pounds corn-fodder | 12.7 | 0.16 | 5.55 | 0.04 | 0.04 |
| 5 pounds malt-sprouts | 4.1 | 1.04 | 2.19 | 0.05 | 0.03 |
| 3 pounds corn-meal | 2.5 | 0.25 | 2.05 | 0.14 | 0.02 |
| 40 pounds corn-sugar meal | 11.2 | 1.28 | 7.72 | 0.72 | 0.05 |
| | 30.5 | 2.73 | 17.51 | 0.95 | 0.14 |

Or again :

| | | | | | |
|---|---|---|---|---|---|
| 20 pounds best clover-hay | 15.2 | 2.14 | 7.52 | 0.42 | 0.10 |
| 50 pounds corn-sugar meal | 14.0 | 1.60 | 9.85 | 0.90 | 0.06 |
| | 29.2 | 3.74 | 17.37 | 1.32 | 0.16 |

It will be seen that the dry matter is nearly the same in all these combinations; but the albuminoids are considerably more in the last ration, composed of clover-hay and sugar-meal. If we substitute straw or corn-fodder for clover-hay, then we must add some very nitrogenous food to make up that element. Straw might substitute one-half of the clover-hay. But if we take ration No. 4 and omit 3 lbs. of corn-meal and make the corn-sugar meal 50 lbs., it will be a well-balanced ration and cost one cent less.

It is evident that the feeder can make a profitable use of this refuse when he can get it at about the price mentioned, or lower; but if he attempts to feed this sugar-meal with only straw, or some food poor in albuminoids, he will not succeed in the end. A little dry, ground fish scrap—say 2 lbs. per day—would balance the ration with sugar-meal and straw. The reader will see that these combinations may be very numerous. Where oats are cheap, a few quarts would balance this ration with straw or corn-fodder. Malt sprouts are often purchasable at 40 cents per hundred pounds, in which case this may be the cheapest mixture, as in ration 4. Marsh hay is very plenty in many places, and may be fed to fattening cattle, to good advantage, with sugar-meal and 2 lbs. of linseed or cotton-seed meal. It is only profitable to use the decorticated cotton-seed cake or meal. This marsh hay is much better than straw, as it contains three times the proportion of albuminoids contained in straw, and more fat.

It will also be noticed, from tables given, that weeds can be turned to account. Even the white daisy, when cut before blossoming, is nutritious food, and the analysis shows it to be quite superior to the best cured corn-fodder. It is a vile weed when suffered to ripen; but, if cut when young and tender, makes a good fodder.

### Linseed and Cotton-seed Cake.

These waste products, properly utilized in growing beef and dairy products, represent a most important element in American agriculture. The extensive purchase of these products by English farmers during the last 50 years has largely increased the productiveness of British soil. It cannot be a matter of indifference to thoughtful American farmers that the most important elements in the great cotton crop, flax crop and hemp crop are exported. The fibre of the cotton contains no important element of fertility, although this is the principal value of the crop, commercially; and the oil expressed from the seed contains only carbon and water, which is supplied from the atmosphere; but the cotton-seed cake is rich in mineral elements derived from the soil, and in nitrogen, regarded as an essential element in our commercial fertilizers. It is the same with the flax crop. The fibre contains little of manurial value, and the oil still less; but the linseed-cake is extremely rich in all the elements of fertility; and when this is fed, and the manure returned to the soil, comparatively little is lost to the soil. It is, therefore, one of the reforms needed in our agriculture to use these oil-cakes for home feeding, and thus get a more valuable return in beef for export than if the cakes were exported, besides, saving the great amount of fertilizing matter to replenish our soil. Sir J. B. Lawes estimates the manurial value of cotton-seed and linseed-cakes as greater than the average price for which they are sold in this country for export—the former at about $29, and the latter at $23 per ton. This estimate is made by the most accurate experimenter in England. Does it not appeal to the American stock-feeder and farmer to closely study the value of these oil-cakes as cattle foods? These refuse products are estimated, in the tables given, as worth from 60 to 100 per cent. more than corn-meal for fattening cattle—they can usually be purchased at the mills at from $20 to $25 per ton—being exceedingly rich in albuminoids, and containing from two to three times the digestible oil in corn-meal. These are very concentrated foods, and only a small ration can profitably be fed. We have often expressed the opinion that English cattle-feeders employ these cakes to excess, or beyond the point of profitable feeding. Eight pounds is a common ration with them for a 2½-year old steer, and for older animals sometimes 10 to 12 lbs. per day. This appears to be a simple waste of albuminoids and oil; for this part of the ration alone would give from 2.70 lbs. to 3.30 lbs. of albuminoids—when the whole ration, according to German experiments, only requires 2.50 lbs., and from 0.80 to 1.60 lbs. of oil, instead of 50-100 pounds.

The true use for these concentrated foods is as a mixture with straw, poor hay, chaff, corn-fodder and roots, or other food poor in albuminoids. A million of cattle are fattened every year in the West upon corn and its stalks. This grain is our best fattening food, but is deficient in albuminoids, and, from its excess of starch, is apt to create a feverish condition of the system. Now the use of even two pounds of oil-cake or meal per day will counteract this, and keep the stomach and bowels in proper condition. Cattle that are kept upon corn and dry corn-stalks through the winter are often attacked with what is called "impaction of the manifolds," or third stomach. This would seldom, if ever, occur with a moderate use of oil-cake; for this would counteract the feverish tendency, supply what the corn is deficient in, and, by its oil, keep up a healthy condition of the whole system. We have found linseed-oil cake to have a similar effect upon cattle in winter as grass in summer; and there can be no doubt that this and decorticated cotton-seed cake are of great value to be fed with other foods. That the reader may see how various are the combinations that may be made of these cakes with other foods, we will give some examples.

## RATIONS FOR FATTENING CATTLE.

*Per 1,000 Lbs. Weight.*

| Rations. | Dry organic substance. | Digestible. Albuminoids. | Digestible. Carbo-hydrates. | Digestible. Fat. | Cost of ration. |
|---|---|---|---|---|---|
| | lbs. | lbs. | lbs. | lbs. | $ cts. |
| 20 pounds wheat-straw | 17.14 | 0.16 | 7.12 | 0.08 | .... |
| 8 pounds timothy-hay | 6 86 | 0.40 | 3.47 | 0.11 | 0.04 |
| 6 pounds cotton-seed cake | 5.56 | 1.99 | 1.05 | 0.36 | 0.06 |
| | 29.56 | 2.55 | 11.64 | 0.55 | 0.10 |
| Standard ration | 27.00 | 2.50 | 15.00 | 0.50 | .... |

Or this:

| | | | | | |
|---|---|---|---|---|---|
| 20 pounds corn-fodder | 17.00 | 0.22 | 7.40 | 0.06 | .... |
| 6 pounds Indian corn | 5.13 | 0 50 | 3.63 | 0.28 | 0.06 |
| 6 pounds linseed-cake | 5.45 | 1.65 | 1.65 | 0.36 | 0.09 |
| | 27.58 | 2.37 | 12.68 | 0.70 | 0.15 |

It will be observed that both of these rations are deficient in carbo-hydrates; but the excess in fat will nearly make up the difference, as one pound of fat is equal to two and a half pounds of carbo-hydrates in form of starch, gum, etc. We will give a few more rations, by simply giving the proportions of the foods:

| No. 1. *lbs.* | Cost. *cts.* |
|---|---|
| 18 oat-straw | — |
| 5 bean-straw | — |
| 6 cotton-seed cake | .06 |

| No. 2. | |
|---|---|
| 20 barley-straw | — |
| 5 pea-straw | — |
| 2 wheat-bran | .01 |
| 5 linseed-meal | .07 |

| No. 3. | |
|---|---|
| 20 poor hay | — |
| 5 corn-meal | .05 |
| 5 cotton-seed cake | .05 |

| No. 4. *lbs.* | Cost. *cts.* |
|---|---|
| 20 wheat-straw | — |
| 5 wheat-bran | .03 |
| 3 corn-meal | .03 |
| 4 linseed-meal | .06 |

| No. 5. | |
|---|---|
| 20 fresh marsh hay | .05 |
| 5 corn-meal | .05 |
| 5 cotton-seed meal | .05 |

| No. 6. | |
|---|---|
| 10 good meadow hay | .05 |
| 10 rye-straw | — |
| 3 wheat-bran | .02 |
| 5 linseed-meal | .07 |

### Ration for Oxen at Hard Work.

| *lbs.* | No. 7. |
|---|---|
| 20 | best meadow hay. |
| 10 | corn-meal. |

| | No. 8. |
|---|---|
| 17 | clover-hay. |
| 3 | wheat-bran. |
| 10 | corn-meal. |

| *lbs.* | No. 9. |
|---|---|
| 25 | oat-straw. |
| 5 | wheat-bran. |
| 4 | linseed-cake. |

| | No. 10. |
|---|---|
| 20 | corn-fodder. |
| 5 | clover-hay. |
| 2 | wheat-bran. |
| 3 | cotton-seed cake. |

These rations are not given to be followed strictly, but only as suggestions of the proper combination of food for fattening cattle and for oxen at work. The reader will see what almost endless combinations may be made from the food-tables given at pages 157–8. Oxen at rest do not require so nitrogenous a diet as when at work, or as growing or fattening cattle. The proper nutritive ratio for oxen at rest in stall is 1:12; the same heavily worked, 1:6; cows in milk, 1:5.5; fattening oxen, 1st period, 1:6.5; 2d period, 1:5.5; 3d period, 1:6; young growing cattle, 1:4.7; those older, 1:5; 18 months old, 1:6; 24 months, 1:7.

We have dwelt longer upon this matter of rations because it is only recently that farmers have recognized the necessity of a change of ration for all the different conditions; and they have been wont to consider a single food sufficient for the wants of cattle. These tables, showing how various are the qualities of the foods given to our animals, and how deficient many of them are as a complete ration, will give a better idea of the necessity for combining the different foods together, that our cattle may have the proper elements to meet all their wants. In our pastures all of these wants are provided for in the ten to fifty species of grasses found growing there. Some old pastures contain probably nearer one hundred species than fifty, and these furnish a bovine ration in absolute perfection. Young grass contains a larger proportion of albuminoids than when nearer maturity; and it is found that cattle fatten faster upon grass 2 to 4 inches high than when of ranker growth. Each of these numerous foods of which we have given the analyses has some quality or combination of qualities in excess of all the others. It is, therefore, certain that the practical feeder will be much better qualified for his task after he has made himself acquainted with these qualities, and learned to combine them in the rations for his stock. A little study in this direction will enable the farmer to turn into money everything grown upon his farm. Every refuse product will then have a definite value, and swell the income of the farm.

### How to Feed the Corn Crop.

Indian corn is the great American cattle crop. Any improvement in handling this crop has a wide degree of usefulness. A slight saving of labor upon each bushel fed would amount to millions of dollars. It is but a few years since that the general practice in the West was to let the cattle harvest this crop. They fed through the fall and winter in the field, eating the ears and as much of the stalks as they desired. By this plan much of the corn was wasted; but the saving of labor compensated for the loss. The cost of shocking and husking the corn was more than the value of the corn wasted. So it went on for many years, and is still continued by some Western feeders. In the older States the corn has been shocked and husked, and, in most cases, shelled and ground into meal, before feeding. Here is a large amount of labor expended, amounting to nearly as much in harvesting and feeding as in raising the crop. If this great crop can be utilized with a less expenditure of labor, the same result being reached, it will be so much added to the profits of cattle-feeding. Fed in the ear, or, as it is in the West, in the field, the greatest loss in grain occurs from want of proper mastication. Cattle perform the principal mastication of their food in rumination. When grain is eaten alone it is not raised and remasticated with the cud, but passes on to the third stomach. This is the cause of so much corn passing Western cattle without digestion, which is found in a softened state by the hogs that follow the cattle.

Now if the cattle could eat the corn and fodder together, the grain would be so mixed with the fibrous mass of corn-stalks that all would be raised and remasticated together. The grain would thus be so ground up as to prevent any considerable portion from passing undigested, and the whole would be utilized. The author, some years ago, recommended a method of feeding the whole crop of corn together, by running stalks, ears and all through a large cutter, and reducing it all to fine chaff. By using a power cutter, run by steam or large horse-power, the whole may be reduced to fine shavings with great rapidity—two tons per hour. This renders the stalks much more digestible, because the cutter reduces the fibre to a finer condition than the animal will masticate; and then when this fine chaff is taken into the rumen and softened, and then raised with the grain and remasticated, it gets thoroughly mashed and fitted for the reception of the manifolds and the final action of the fourth or true stomach. When cut into fine shavings, the hard rind of the stalk is broken into shreds, and is eaten without any irritation of the mouth. When cut into pieces one and a half to two inches long, remaining there in a solid chunk with sharp edges, they sometimes irritate the mouth. We have recommended, where large numbers of cattle are fed, and a steam-engine is employed for cutting, to run the cut chaff into a steam-box, and, turning on the steam, soften it to a pulp. We have no hesitation in saying that, thus fed, corn will lay on as many pounds to the bushel as if it were husked, shelled, ground and cooked; for the steaming more thoroughly disintegrates the grain than any possible grinding can do.

But it is not necessary to success in this method of feeding the corn crop to steam it; for cutting, in the manner mentioned, secures the remastication of every part, and the cutter reduces the cob to so thin a scale that it can be easily masticated.

This system of feeding the corn crop will enable the farmer to shock the crop while the stalks are still green; and thus the fodder will have thrice the value of stalks standing on the hill with the life dried out of them. As soon as the corn is sufficiently matured as not to spoil in the shock, it should be cut and bound in small shocks, so as to be easily handled when brought to barn for cutting and feeding. If the corn is cut by hand, it would be most convenient to bind in moderate-sized bundles, and set these in shocks. These bundles would be run through the cutter whole, and thus save time in handling. The earlier the corn is cut, the more valuable will be the fodder; and corn does not require to be so far advanced in ripening as farmers usually suppose before it can be safely put in shock. When the kernel is in the dough state, it may safely be shocked if the weather is favorable. We have had corn ripen properly in shock when cut in the milk, the butts being placed on moist ground. This is a matter of the greatest importance; for the fodder, when cut at the proper time, has a value nearly equal to common hay; and after the corn has stood to fully ripen on the hill the stalks have little value as food. When cut early, the stalks make sufficient fodder to be given to fattening cattle with the grain growing on the same ground, and the cost of feeding is, therefore, much reduced.

## Mode of Cutting and Handling.

The straw-cutter should be arranged with a carrier, which will deliver the chaff and corn in a feeding-car upon the feeding-floor in the stable below. Over the feeding-car should be a pipe, from which water may be drawn upon a sieve and sprinkled over the chaff, to moisten it. This sprinkling is done as fast as the cut corn is delivered in the car. The water is regulated by the quantity of corn delivered. Then, by allowing it to remain in mass for 12 to 18 hours, it will become warmed up by incipient fermentation, somewhat softened and rendered more easy of digestion. This is the best way to handle it when not steamed. The author has used it with this slight fermentation, as well as with steaming; and, although the latter is preferable where every convenience is had for it, yet moistening and fermenting is a skillful way of handling it, and will give good returns. An acre of corn will produce about 50 per cent. more beef in this way than by allowing the cattle to harvest it for themselves, even when the weather is comfortable, and 100 per cent. more in the coldest weather.

It will be seen that the labor of harvesting and feeding is no more, on this plan, than of harvesting and feeding a crop of fodder corn. The fact that it is a large crop of grain does not add at all to the labor. Most good feeders in the Eastern States, as a matter of economy, run the fodder corn through a straw-cutter, except when fed green. There can be no doubt that the corn crop is much better utilized on this plan than when husked and shelled and the corn fed whole, for it will not then be remasticated, and much of it will pass the cattle without digestion.

This mode of feeding the corn crop can be carried on upon a large or small scale—the larger the scale, the less labor proportionally. Where one hundred head of cattle are fed, it will cost less in proportion than for twenty head, because the power and the cutter will be larger, and the work done more rapidly. With an engine and a large cutter, with a proper carrier and sprinkler for moistening it, one man can prepare the ration, feed and care for one hundred head of cattle. In this case the manual labor of cutting the corn into chaff, depositing it in the feeding-car, and moistening it, consists merely in feeding the corn into the straw-cutter—the carrier delivers it in the car, and the water-pipe moistens it, without any hand labor. It would require 3,000 to 3,500 lbs. of shock corn per day, and an active man could, in good weather, bring this in from the field, prepare and feed it. The feeding-car would run on a track on the feeding-floor, and hold a day's feed. The cattle would stand on each side of the floor, and, as the car is moved along, the cattle are fed right and left. Where a large number of cattle are kept two feeding-cars are required—one to feed from while the other is filling and fermenting.

## Improvement of the Corn Ration.

We have just seen how the whole corn crop may be fed together, saving stalks as well as grain, and with much less labor than is usually bestowed. But the stalks and grain, taken together, are too poor in albuminoids to make a complete ration alone. It is true that great numbers of Western cattle are fattened every year wholly upon corn; but this ration is so easily improved that, where the crop is handled in the manner described, this deficiency may be supplied with two or three pounds of linseed-cake or cotton-seed cake. This cake (or better in form of meal) may be added to each corn ration when fed, and with this addition cattle would be made to fatten most satisfactorily. As before explained, one of these oil-cakes is better than other nitrogenous foods, because of the large percentage of oil, this overcoming the tendency to constipation from dry fodder and the large percentage of starch in corn. Yet four pounds of wheat-bran will answer a very good purpose when cake cannot be had.

### Beef to the Acre of Corn.

It may be of interest to examine the probable result of feeding an acre of corn in this way. Farmers would be better prepared to understand their business if they were in the habit of determining the result per acre of all their crops. We have a small experiment of our own to give as to the pounds of beef produced per acre of corn cut and fed as described, without steaming, but merely slightly fermented, as mentioned. We were feeding ten steers, of 1,175 lbs. average weight. The corn was shocked September 10th, and we began feeding November 1st. The corn was estimated to yield 40 bushels per acre when properly dried. It was shocked when the ear was in the soft dough state and the stalks were green. At first the average ration was 40 lbs. per head, per day, of the corn in the shock, which was run through a straw-cutter with a 3-16 inch cut. Two pounds of linseed-oil meal was given to each steer per day, mixed with the corn ration. The corn was cut so fine that, after a slight fermentation, it was eaten clean. Four acres were accurately measured, and lasted 70 days. The average weight of the steers at the end was 1,375 lbs., or a gain of 200 lbs. each. The oil-meal cost 2 cts. per pound, and the steers had gained in value $14 per head, or 7 cts. per pound gain. Now if we deduct the price of the oil-meal, it takes 40 lbs., at 7 cents, to pay it. This would leave as the product of the corn crop 160 lbs. per head, or 1,600 lbs. for the 4 acres—400 lbs. of beef per acre of corn, or 70 cents per bushel for the corn, not counting the stalks. With this mode of feeding, there is no doubt that good corn may be made to average 400 lbs. of beef per acre on cattle of 1,100 to 1,200 lbs. weight, and still more in feeding younger cattle. The food of support is greater in an animal of 1,100 lbs. than in one of 600 to 800 lbs.

## CONDIMENTAL FOODS.

The true feeder, who, as is said of the poet, must "be born, not made," always studies the likes and dislikes of his animals. He knows that the pleasure of eating has much to do with the thrift of his cattle; so he not only takes into consideration the nutriment that a food contains, but whether the flavor is agreeable to the taste, and will be eaten with a relish. Mere flavoring materials that contain little or no nutriment often have a decided influence upon the growth and thrift of animals; and it is based upon this fact that the compounders of condimental foods find a market for their cheap materials at such high prices as have left a fortune to some of them for profit. Our readers may, therefore, thank us for showing them how to manufacture their own condimental foods at the simple cost of the raw materials. Sir J. B. Lawes, of Rothamstead, effectually exposed the pretentions of Thorley in reference to the wonderful virtues of his "Condimental Food for Cattle," showing that it had no such value in fattening animals as the price for which it was sold should lead one to expect; that it was a mere appetizer, and should only be used as such. It was sold at $8 per 100 lbs., and had only a nutritive value slightly over that of corn-meal. As there are a good many of these mixtures sold in this country, it may be useful to give the analyses of two of the most celebrated of these foods sold in England. Dr. Cameron, of Dublin, made the following analyses, some years ago:

CONDIMENTAL FOOD—ANALYSES.

| | *Thorley's.* | *Bradley's.* |
|---|---|---|
| Water | 12.00 | 12.09 |
| Albuminoids | 14.92 | 10.36 |
| Oil | 6.08 | 5.80 |
| Sugar, gum mucilage | 56.86 | 60.21 |
| Woody fibre | 5.46 | 5.32 |
| Ash | 4.68 | 6.22 |
| Total | 100.00 | 100.00 |

It will be noted that neither of these foods is as nutritious as linseed-cake; but they compare favorably, except in an excess of albuminoids and sugar, with corn-meal. This large proportion of sugar explains an important point in condimental foods. It seems that these compounders had noted the fact, that animals are very fond of sweet foods. The author became aware of this many years ago, and employed sugar, in the form of cheap molasses, not only as an appetizer, but as an excellent fattening food. It is well known that a horse is very fond of his lump of sugar; and cattle, pigs, and sheep are equally fond of it. Sugar is wholly carbonaceous; and although it is more easily digested than the carbo-hydrates of the grains and grasses, yet it can only be used properly with some other very nitrogenous food. Take the best quality of clover-hay, which has an excess of albuminoids, and a small quantity of molasses will give a remarkable relish to the clover for cattle; so that they may be rapidly fattened upon merely clover and molasses. We have had steers gain, in September, three pounds live-weight per day upon 28 lbs. of early-cut and well-cured clover-hay sweetened with three pints, or four pounds, of sorghum molasses. Nine pounds of cut clover-hay were moistened with six quarts of water, in which had been dissolved one pint of molasses. This feed was given three times daily. This experiment was tried on six steers for forty days. Let us see how this ration compares with the German standard for cattle weighing 1,100 lbs. Twenty-eight pounds of best clover-hay has, of dry organic substance, 21.42 lbs., and 4 lbs. of sorgham 2.80 lbs.—making 24.22 lbs.; of albuminoids, the clover has 2.99 lbs., molasses none; of carbo-hydrates, clover has 10.52 lbs , the molasses 2.80 lbs.—making 13.32 lbs.; of fat, clover has .58 lbs., and molasses none. It will be seen that the carbo-hydrates are deficient nearly 3 lbs., the other two elements not quite so much; but this ration, although apparently deficient in quantity, is very nearly right in proportion, and proved, practically, a full ration for these steers. It is quite certain, in this case, that the 4 lbs. of sorghum molasses added much to the gain. We had previously tried a like experiment upon a work horse that had become thin, and added 100 lbs. to his weight, in 35 days, with the three pints of molasses upon clover-hay, but the clover-hay was given *ad libitum*, and not weighed. The author has often used one pound of molasses simply to flavor the food, and found it to pay excellently well, by inducing a better appetite for food, so that more has been eaten. In England, the locust bean (so called, being made from the fruit pods of the locust tree raised in Southern Europe), which contains a large amount of sugar has been used; but I am not aware that it has ever been imported here.

A very good condimental food may be made by combining the following materials:

| *Articles.* | *Lbs.* | *Articles.* | *Lbs.* |
|---|---|---|---|
| Linsed oil-cake | 25 | Gentian | 0½ |
| Flax-seed | 10 | Cream of tartar | 0⅛ |
| Molasses | 20 | Sulphur | 1 |
| Corn-meal | 40 | Common salt | 1 |
| Ground turmeric root | 1½ | Coriander-seed | 0⅝ |
| Ginger | 0⅛ | | |
| Carraway-seed | 0⅛ | Total | 100 |

The flax-seed may be boiled in 10 gallons of water until it forms a thin mucilage; then stir in the turmeric, ginger, carraway, gentian, cream of tartar, sulphur, common salt and coriander; now add the molasses, then the corn-meal and ground oil-cake, stirring it well together. If it is designed to keep it long, it may be dried in a hot-air chamber or oven, at about steam heat, after which it will require grinding for convenient use; but the materials may all be ground together in their natural state if manufactured for commercial purposes. There may be a great variety of formulas; but this is as good as any of the condimental foods, and is not expensive.

## Feeding on Small Farms.

There are many small farms in the Eastern and Middle States, near cities and villages, on which grain and garden truck are raised almost constantly; and the question often arises, "How shall this system be continued without a ruinous outlay for commercial fertilizers, or the absolute exhaustion of the soil?" Those farmers of this description who have been fortunate enough to obtain manure cheaply from the city or town have continued to raise good crops for a long series of years, whilst others, not so successful in obtaining manure, have seen the soil constantly growing less and less in production, year by year, and yet appear never to have discovered the great resource they may have at their own doors for constant renewal of the fertility of their lands. There is usually a large amount of straw and various kinds of coarse fodder produced upon such farms, which might furnish that part of the ration for feeding cattle; and by purchasing freely of grain, bran, oil-cake, corn-starch feed, malt sprouts, cotton-seed meal, or any of the various kinds of cattle-foods, manure, in large quantity, may be made upon each of these farms, the growth in beef paying the cost of purchased food, leaving the fertilizer free.

By having well-arranged stables, each of these garden farmers may keep one or two head of cattle to each acre; and, under this management, everything raised—not even excepting weeds—will be saved, and turned into active manure for his crops. With warm stables, a large part of the feeding may be done in fall and winter, when the crops do not require attention, and the labor will be little felt.

Young and thrifty steers are always to be found at the cattle-markets in cities; and, when these are fattened, a market for the beef will usually be found at the village or market town.

When feeding is conducted for the fertilizer, as in this case, there will be no motive for scanty feeding; as the richer the food, the richer and more valuable the manure. These farms are particularly favored for this kind of feeding, as the cattle and the feeding stuffs are all near at hand. We know of a few instances where a steady profit is made upon the animals fed, besides all the manure, which is indispensable for the land. In these instances there is good judgment used in the purchase of the cattle and the feeding stuffs, and then the animals are pushed till well fattened, and find a ready sale, at good figures, in the local market.

Dairy cows may be kept instead of steers, if the situation is favorable for the sale of milk, which always pays better than other branches of dairying. Dairying interferes more with other work than does steer-feeding, and the manure from milch cows is not so rich as that from fattening cattle; but the milk produced from a cow often pays more money than the greatest growth in flesh. Milk, at 4 cents per quart, will give a daily income through the year, from an extra cow, of 40 cents, which cannot be made from the growth of flesh and fat. The dairyman, under such circumstances, can afford to give the best and richest food, so that the manure will be excellent. Butter-making may also be conducted on these small city or village suburb farms, and then the refuse milk may be fed to pigs, with grain; and the manure, in that case, will be worth quite as much as that from fattening cattle. One of these systems of feeding may be practiced, with great profit, on all these small farms, and will, in the future, be their great resource for keeping up fertility.

# CHAPTER IX.

## DAIRY CATTLE.

"FIRST catch your hare," was the preliminary advice for cooking it. So, likewise, first select your dairy cattle before you feed them. We do not propose to determine which is the best breed for the dairy, but merely to mention a few general principles that apply in the selection of dairy cows of any breed.

The dairy cow is almost an artificial creature. In a state of nature the dam gave only milk enough to furnish food for the calf during a short period, when her milk secretions ceased. The capacious udder of the improved cow; the long period of lactation; her wedge shape, caused by the broadening of her hips, to make room for her great laboratory to work up raw materials into milk, the stomachs; her greater rotundity and fullness of frame—all these represent a great many generations of special breeding and feeding to these ends. The bull that represents the longest line of great milk-producing ancestors, on both sides, is the most prepotent for the purposes of the dairyman.

Those breeds that have been longest bred and used specially as milk producers, must contain the largest proportion of profitable milkers; and selections from these will be the best breeders of dairy stock.

The common dairy stock in this country has such a mixture of blood, that they cannot be depended on as breeders, especially when bred to males of the same class.

Every dairyman who desires a herd of great excellence must use females only of the common stock, and breed these to the best thoroughbred male of the strain of blood he thinks best adapted to his specialty in dairying. These females should be selected with great care.

## Selecting Dairy Cows.

Look first to the great characteristics of a dairy cow—a large stomach, indicated by broad hips, broad and deep loin and sides, a broad or double chine—these indicate a large digestive apparatus, which is the first essential requisite to the manufacture of milk. Secondly, a good constitution, depending largely upon the lungs and heart, which should be well developed, and this is easily determined by examination; but the vigor and tone of the constitution is indicated by the lustre of the hair and brightness of the eye and horns, and the whole make-up. Thirdly, having determined her capacity for digesting surplus food for making milk, look carefully to the receptacle for the milk—the udder—and the veins leading to it. The cow may assimilate a large amount of food which goes mostly to lay on flesh and fat; but if she has a long, broad, and deep udder, with large milk veins, it is safe to conclude that her large capacity for digestion and assimilation are active in filling this receptacle. In fact the udder is the first point to look at in a cursory examination of a cow, for Nature is not apt to create in vain. If it reaches to the back line of the thighs, well up behind, reaches well forward, is broad and moderately deep, with teats well apart, and skin soft and elastic, it may be inferred that Nature has provided means for filling it.

If the udder be a small round cylinder, hanging down in the front of the thighs, like a six-quart pail, the cow cannot be a profitable milker, whatever digestive apparatus she may have.

A yellow skin and a yellow ear (inside) is almost universally regarded as present in a cow that gives rich yellow milk; but after you find the indications mentioned above, you may admire as many other points as you please; such as a first-class escutcheon, a long, slim tail, a beautifully-turned dishing face, a drooping, waxy horn, a small, straight, slim leg, or any other fancy points; but do not look for these till you have found the essentials.

Again: When you have found all these essentials, if the cow is five years old and does not yield 5,000 pounds of milk per year, she is not worth possessing as a milker or breeder. Let good appearances be coupled with performance; yet, if the cow be five years old, and actually yields 6,000 or more pounds of good milk, you may safely buy her, without regard to her points. She must digest the food to make it, and her machinery is so far above criticism.

But the length of her period of lactation must not be forgotten; this is a quality inherited as much as her capacity for quantity. A cow that, well fed, will not milk for ten months, is not to be desired. A moderate and nearly uniform quantity continuing for ten months, will produce a larger aggregate yield than heavy milking for a short period. Twenty-three pounds per day for ten months will give 7,000 lbs.; while a short period of seven months would require 33 lbs. per day. Nearly all great annual yielders of milk have long periods. This is a matter of so much consideration, that a cow having a short period of lactation should be rejected as a breeder, as this would be inherited by her offspring.

Still another important consideration, even in the selection of a common-blood cow, is her pedigree. If you can find her descent from a large-milking dam, grandam, and great-grandam, this will greatly increase the probability of your success in breeding her to a thoroughbred bull from deep-milking ancestors.

Now a few cows selected with all these requisites will lay the foundation for breeding such a herd of dairy cows as will be a source of perpetual delight and profit to the owner. On the other hand, it is simple folly to rear a calf for the dairy from a poor milker. It is bad enough to keep an unprofitable cow for a season, but it is deliberately throwing away good food to breed from such a cow, with the proof before you that the heifer will never pay for her keep. Of course no males will be kept of such crosses for breeding purposes.

A thoroughbred male must always be used to insure any proper measure of success. A large dairyman may replace his herd with cows of his own breeding on this plan, by having one-third to one-half of his cows selected for breeders. But the calves from these selected cows, sired by a thoroughbred bull, must also be selected after they have grown to sufficient age to determine their qualifications. This process of selection should be also rigidly enforced in thoroughbred breeding. Had this been done rigorously with all our pure dairy breeds, it would now be simply necessary to purchase a Jersey, an Ayrshire, or a Holstein, to possess a good cow of either particular breed; but they have been bred so indiscriminately, and all their progeny kept till a thorough weeding out is necessary.

Let no dairyman be content to purchase the first male or female he may find of either of these breeds, but in all cases learn the actual performance of the animal and its ancestors. A poor Jersey or Ayrshire is no better than any other poor cow; and if it be a male, he is likely to do great harm, by distributing his worthless blood, and thus bringing disappointment to the purchaser and discouragement to the extension of the breed. The male in a system of improved breeding is chosen for his prepotency; and it is not sufficient that his blood is of the breed desired, but he must bring with him the blood of a long line of ancestors, proved, by actual performance, to possess the qualities desired. The only pedigree of real value represents performance in the ancestors of the animal. It is necessary to make this point strongly, because breeding, for the last twenty years, has had little reference to anything save purity of blood and sundry fancy points. We have entered upon a realistic period, which demands real merit first, leaving fancy where it belongs—in the rear. Witness the tests of butter cows for the last few years; the great prices brought by those having the great butter yielders in their line of ancestors.

## Size of Dairy Cows.

The question of size in dairy cows has a bearing upon the economy of feeding, but the exact law practically governing the expenditure of food proportioned to the size of the animal in production has not been fully settled; yet experiments have been made which throw some light upon it.

Natural principles applied to it would appear to favor large cows, as they have less external surface for the radiation of animal heat than smaller ones, in proportion to weight. It is well settled that two animals weighing 2,400 pounds will consume less food of support than three of the same aggregate weight. It may be stated as a general law, that the food of support decreases proportionally with the increase of size in animals. We find an article in a paper illustrating this point, without credit to the author; but we think it was written by Prof. Arnold. He sets out by stating this difference in the food of support according to size, but doubts its application, practically, to the production of milk; and he illustrates it by reference to three dairies: the first grade Short-horns, the second natives, and the third Jerseys and their grades. He says:

"The dairy of Mr. I. Boies, of Illinois [about 100 cows], is a good one for setting the use of large cows in its best light. In the first place, Mr. Boies is widely known as one of the best of dairy managers. He buys and milks a great many cows, and his experience and close observation have made him one of the best judges of milking qualities. He never selects a poor cow. He buys large cows, and, feeding with a very liberal hand, his herd is heavy. Reviewed in June, the year following their yield of 314½ lbs. of butter per cow, they were estimated to have an average live weight of 1,200 lbs. per head. They were in high order, and many of them could have been sent to the shambles at a good price. It would be very interesting to compare the products of his dairy with those of another having an equal number of Jerseys, or other small cows, which were treated as well as he treats his. But no such herd can be named. Good managers of less herds of smaller-sized cows are often met with. Mr. Oliver Bronson, of Chautauqua County, New York, has a herd of twenty natives which, viewed in May last, were estimated to weigh 150 lbs. per head less than the herd of Mr. Boies. They are kindly cared for, and produced last year 302 lbs. of butter per cow. Mr. O. C. Blodgett, of the same county as Mr. Bronson, has a herd of twenty-five Jerseys and their grades, all small cows. Viewed also in May, they were estimated to have an average live weight of 780 lbs. Though very skillfully managed and fed, their yield last year was 234½ lbs. of butter to a cow—a diminutive yield, compared with those of Messrs. Boies and Bronson, of 80 lbs. per cow less than one, and 67½ less than the other. Judged by the usual standard of product per cow, this dairy would by most dairymen be at once set down as the least desirable and the least profitable of the three. But, in fact, the reverse is true. Mr. Blodgett's dairy is the most profitable in the list, for he gets the most butter in proportion to the food consumed [that is the question at issue]. As 234 is just three-tenths of 780, each of his cows (omitting the odd ½ lb. of butter per cow) produces annually three-tenths of her live weight in butter."

The conclusion here is based upon an assumption contradicting his statement, that the food of support decreases in proportion as the size increases. Had the food actually consumed by these herds been noted, the results, compared, would have been of great value. But, although we have no carefully-tried experiments in this country to determine the comparative economy in milk production of large and small cows, and the opinions of those who keep the different breeds is in accordance with the size kept, yet this question has received practical attention in Europe, where, by numerous experiments, the relation of food to product, in dairy cows of different weights, has been very well settled, so far as to quantity of milk; but as to quantity of butter, we are not aware of any experiments settling it.

Baron Ockel, of Frankenfelde, experimented with Ayrshires and Holland cows, with the following result: The average weight of the Ayrshires was 806 lbs., and of the Hollanders 1,016 lbs. The Ayrshires ate 3.3 lbs. of hay for each 100 lbs. live weight, while the Holland cows consumed 2.8 lbs. Of the feed consumed, 1-60th of their live weight only was required as food of support to the Hollanders, while 1-50th was required as food of support to the Ayrshires. He then tested the effect of size on the same breed. He took four Holland cows, the two heaviest of which weighed 2,112 lbs., on June 14th, and the lighter two 1,537 lbs. He then placed the two heaviest in one stall, and the two lightest in another, and fed them separately for 16 days, the feed being weighed as fed to each lot, and, if not all eaten, what remained was weighed and deducted. Their live weight remained unchanged during the time—with the following result:

| Cows. | Green Lucerne eaten by cows. | Milk yielded by cows. | Milk for 100 lbs. Lucerne. | Lucerne eaten per 100 lbs. live weight. |
|---|---|---|---|---|
| | lbs. | qts. | qts. | lbs. |
| Heavy cows.................. .. ....... ...... | 4,921 | 340 | 7.4 | 14.6 |
| Light cows.................................. | 3,859 | 240 | 5.5 | 16.0 |

This experiment shows that the same law holds with different weights of the same breed, as in different weights of different breeds; and that it is the natural effect of size upon the food of support, and that this is probably in proportion to the area of outside surface of the animal.

In 1852, a series of experiments were made at 11 different localities in the kingdom of Saxony, by order of the Royal Agricultural Society, during a period of five years, the cows selected being of the best "scrubs," Allgauers, Oldenburgers, and Hollanders, the last two being really of the same breed, the difference relating merely to the management in different localities. The results, per annum, for five years, were reported as follows:

WITH COMMON FEED AND CARE.

| | | |
|---|---|---|
| Scrub cows averaged.............. | 1,437 | quarts per annum. |
| Allgauers " .............. | 2,334 | " " |
| Oldenburgers " .............. | 2,220 | " " |
| Hollanders " .............. | 2,062 | " " |

WITH THE BEST OF FEED AND CARE.

| | | |
|---|---|---|
| Scrub cows averaged.............. | 2,365 | quarts per annum. |
| Allgauers " .............. | 3,000 | " " |
| Oldenburgers " .............. | 3,712 | " " |
| Hollanders " .............. | 3,232 | " " |

The scrub cows were much lighter than the others. One dairy of Hollanders, of 190 cows, averaged 4,076 quarts per cow. These latter experiments seem to have been undertaken principally to determine the breed of cows producing the largest product, and these were found to be the largest cows; but it does not appear that an account was kept of the amount of food given to each kind.

In regard to size, Caspari made 18 experiments in feeding milch cows, with a view of ascertaining how many pounds of hay, or its equivalent, it required to make 100 lbs. of milk. He found, in Prussia, 100 lbs. of hay, fed to Holland cows, made 25½ quarts of milk; and the same fed to the Allgauers, made 30.98 quarts of milk. At 11 dairies in Saxony 100 lbs. of hay fed produced, in—

| | | |
|---|---|---|
| Oldenburgers | 25.40 | quarts. |
| Hollanders | 26.10 | " |
| Allgauers | 30.00 | " |
| Scurbs | 23.65 | " |

Villeroy's experiments resulted as follows:

| | | | | |
|---|---|---|---|---|
| Hollanders | 28.92 | quarts per | 100 lbs. | hay. |
| Yorkshires | 27.45 | " | " | " |
| Devons | 19.13 | " | " | " |
| Herefords | 15.97 | " | " | " |
| Jerseys | 26.33 | " | " | " |
| Allgauers | 27.61 | " | " | " |

These experiments all seem to tell the same story. The Jerseys are the smallest, and peculiarly a milking breed; but they produced less, per a given quantity of food, than either of the larger milking breeds. We should put the Hollanders against the Jerseys as a fair test, because both have been bred for a long period expressly as milk yielders, and they both have a high reputation in that specialty.

We will now give the German mode of feeding in Dr. Rhode's

MILK RATION, AT ELDENA,

in Pomerania. This is one of the most celebrated agricultural schools in Prussia. He details those experiments in his chapter "On the Breeds of Cattle in the Kingdom of Holland." We do not propose to go into the characteristics of the breeds he describes, but merely to consider the ration, and the result upon large and small cows.

| Cows. | Aggregate yield per year. | Yield per cow, per year. | Per cow, per day. | Per cow, per year. |
|---|---|---|---|---|
| SMALL COWS. | qts. | qts. | qts. | lbs. |
| 3 Ayrshire cows.......................... | 5,386 | 1,795 | 5.00 | 4,485 |
| 4 Tondern cows.......................... | 9,337 | 2,334 | 6.30 | 5,835 |
| LARGE COWS. | | | | |
| 3 Breitenburg cows ... .................. | 8,594 | 2,865 | 8.00 | 7,161 |
| 22 Holland cows.... ...................... | 78,100 | 3,550 | 9.85 | 8,875 |

The highest yield of the Ayrshires was 5,582 lbs., and the lowest 3,537 lbs.

The highest yield of the Tondern cows was 7,012 lbs., and the lowest 4,640 lbs.

The highest yield of the Breitenburg cows was 7,365 lbs., and the lowest 7,050 lbs.

The highest yield of the Holland cows was 15,355 lbs., and the lowest 6,315 lbs.

The average winter ration was composed of 10 lbs. of straw of summer grain, 2½ lbs. of oat and wheat chaff, 25 lbs. of turnips, 10 lbs. of hay, 8 lbs. of brewers' grains, wet, and 3 lbs. of rye bran. This contained of digestible nutriment 3.28 lbs. of albuminoids, and 14.3 lbs. of carbo-hydrates, having a nutritive ratio of 1:4.2—equal in nutritive value to 42 lbs. of hay.

The average ration in summer is 135 lbs. of green clover, and 8 lbs. of dry hay. The hay is to modify the succulence of the clover. Dr. Rhode says this ration is equal to 45 lbs. of hay, and contains of digestible albuminoids 5.7 lbs., and of carbo-hydrates 14.91 lbs.—nutritive ratio 1:2.5.

He says the small cows did not eat so much as the large Holland cows, though the food of each was not weighed; yet when the same amount of food was placed in two racks, it was found that 9 large cows ate as much as 10 small cows per day, and he thus counted them as 9 to 10, in proportion of food; or the small cows consumed 45 lbs. of hay, or its equivalent, while the large consume 50 lbs. According to the specified yield, they severally require of food for the production of one quart of milk:

| | |
|---|---|
| Holland cows, little more than........ | 5.00 lbs., hay value. |
| Breitenburg cows, little more than.... | 6.25 " " |
| Tondern cows, little more than........ | 7.00 " " |
| Ayrshire cows, little more than........ | 9.00 " " |
| The Holland cows weigh from......... | 1,200 to 1,400 lbs. |
| The Breitenburg cows weigh from..... | 1,100 " 1,300 " |
| The Tondern cows weigh from........ | 900 " 1,000 " |
| The Ayrshire cows weigh from........ | 800 " 900 " |

By this it appears that the large cows were the more economical milk producers. Here Dr. Rhode, at the head of the Eldena Agricultural School, found a pretty wide difference between the Hollanders and Ayrshires; and we are quite inclined to think, if the food of each separate class of animals had been accurately kept through the year, the difference could not have been so large as he makes the production from the same food—80 per cent.—in favor of the Holland cows. Dr. Rhode remarks on this:

"It cannot be questioned, from these results, to which race belongs the advantage. They value none in Eldena for milk but the Holland cows."

It is to be regretted that at so celebrated a school of agriculture the most careful record should not be kept of the exact difference in the amount of food required for cows of the different breeds and sizes, and also the comparative butter as well as milk yield of the cows, so that a just conclusion might be arrived at as to the productive value of the two breeds, fed under precisely the same circumstances. Still the experiments have an important bearing in the evidence as to the relative cost of feeding large and small animals.

So far, then, as the evidence is before us, we must conclude that *size*—all other things being equal—is favorable to the economical yielding of milk—that it actually takes less food to produce 100 lbs. of milk with a cow of equal merit, weighing 1,000 lbs., than one weighing 800 lbs. In accordance with these experiments, then, we may infer that Mr. Israel Boies' dairy produced milk at a less cost of food than Mr. Blodgett's; but we cannot pronounce on the question of the cost of butter, for that has not been as yet tested; at least we have seen no well-authenticated experiments reported which settle it. Mr. Blodgett's Jerseys may possibly yield milk so much richer than Mr. Boies' large grades as to make up the difference in quantity; but the probabilities are, even here, against the small cows, as the difference in quantity of milk must have been very large. The argument of the writer of the article comparing the three dairies mentioned, is to show the probable waste of the food of support in keeping cows of 1,200 lbs., as the 400 lbs. above the weight of the Jerseys he supposes to be mere surplusage, and maintained gratuitously. Those European experiments given, utterly overthrow this supposition, and show that the heavier cows require less food in proportion to production of milk. We may, therefore, assure the dairyman who keeps large cows, of good milking quality, that he is not throwing away food upon size.

Yet we do not think the large cows are necessarily the most economical for all purposes. The Jerseys and Ayrshires are peculiarly adapted to large districts of this country—hilly regions, rough pastures, but bearing grasses of the finest quality for dairy products. We could profitably use twenty times as many as we now have of Jerseys and Ayrshires. Besides, the Jerseys yield a highly-colored butter, of such fine quality and great popularity as to bring the highest price in market.

It will have been noted in this discussion of the best cows to feed for dairy purposes, that cows of poor appetite and small eaters are not wanted—that cows which have the best appetites and the largest digestive power are to be sought for—the best possible machines for turning food into milk.

## Feeding Dairy Cattle.

We have treated of the selection of dairy cows, and the effect of size upon the economy of milk production. We are now prepared to discuss the effect of food and care upon dairy stock. And here the author must be pardoned for quoting a few paragraphs from a paper which he read before the American Dairymen's Association, in January, 1878. If dairymen could only be impressed with the fact, and firmly believe that whatsoever is produced in beef, milk or wool, must come from the food which the animal eats, what a great and salutary change would at once take place all over the country!

There is not a movement made by any creature that must not be compensated for by the food. How directly this bears upon the profits of the dairyman! If cows are allowed to go two miles, or even one mile, to pasture, or anyone is allowed to misuse them, it must be paid for in food. If cows are driven hurriedly, or chased by dogs, the quality of their milk is changed: it becomes poor—deficient in oil—the nervous excitement uses it up. How evident, then, is it, that all exercise must be paid for in food, and that the dairyman should most judiciously regulate this exercise!

Again: there is not one degree of heat that is not produced by the food. The slightest change affects the food. If cows are exposed to a temperature of 15 degrees below zero, food enough must be consumed by the animal to overcome the effects of this intense cold.

We want to emphasize this great *law of equivalence.* There must be something paid for everything. Something cannot be produced from nothing.

Then, again, the cow must be supported first. She must be sustained before she can produce any milk whatever. Some dairymen appear to think that a cow may be kept poor through the winter, and produce the same milk in the spring as if she were in good condition; but this is a fatal mistake. It will take nearly all a poor cow can eat to supply the wants of her own system: and what this supply of the living wants of the system is, few understand. It requires two-thirds of a full ration to keep a cow in fair condition—her food of support—before there is any milk production. This has been carefully tested by many experimenters. We have proved it in a number of instances. It is a sound general statement that two-thirds of the food goes to keep the animal alive. Up to that point all is expenditure and no return.

A growing animal that weighs four, five or six hundred pounds in the fall, and only weighs the same in the spring, is more than unprofitable; the food consumed to keep it over is utterly thrown away; it is as effectually lost as wood that has been burned in a stove. All that is got from the cow is its droppings, as there remains the ash from the wood. It will thus be seen that all the profit, if there is any, must come from the last third of food given the cows; and, if that be withheld, only loss is the result.

In regard to dairy profits, the cow is simply a machine for producing milk—precisely as much as a steam-engine is a machine for producing power and motion; if the steam-boiler is supplied with just as much fuel as is required to keep the water warm there is no power; the boiler must have sufficient fuel to produce extra heat before any work can be accomplished.

It makes a considerable difference what kind of a cow is kept to produce milk, just as it does the kind of boiler and engine used to produce motion and work; and, therefore, it is important in purchasing and breeding cows for dairy purposes to look to the capacity of the cow to turn the food into milk. But, without generous and judicious feeding, breed is of little consequence. If a cow only produces 3,000 pounds of milk per year, she is kept at a loss. A good cow, well fed, will yield 6,000 pounds of good milk; and the cost of producing this will be only one-eighth more than the 3,000 pounds from the poor cow. Without selection of cows, and judicious and abundant feeding, dairymen cannot receive anything worthy of their labor.

## Special Feeding for Milk.

Since certain very partial experiments were made in Germany to test the effect of special feeding upon the composition of milk, dairymen have been told to *seek quality of milk in the breed and not in the food.* We are always ready to admit and emphasize the value of breed; but, as we have seen, the best breed of cows must have judicious feeding to render their qualities of any material value. Had food nothing to do in fixing the excellent qualities for which each breed is so much prized? As far back as the history of the cow reaches, the belief of the learned and unlearned has been, that the quality may be improved, and the flow of milk increased, by special feeding. Virgil, in his "Georgics," makes special mention of articles of food peculiarly adapted to cause a flow of rich milk. Darwin mentions many instances where food has been the cause of variation in animals, while selection and breeding afterwards perpetuated that variation. There is no room to doubt, on philosophical principles, that variation from a fixed type of animal has been caused by food and climate. Suppose the renowned Bakewell, who made such a transformation in long-horn cattle and long-wooled sheep, had practiced on this doctrine, that a selection of the breed and not the food would lead to the highest excellence, does anybody, after due consideration, believe that if he had merely studied the external characteristics of animals, and used the greatest skill in coupling those having a proper combination of points, without seeking any improvement in feeding, he would now be regarded as the greatest improver of cattle and sheep? Perhaps some one may answer that breeding and feeding for beef is different in principle from feeding for milk; but, since milk is made from the blood at the same degree of elaboration, as fits it for assimilation into the tissues, and that what goes to lay on fat or build up flesh in the stall-fed animal goes to the udder in the milch cow, whatever food will do in increasing the aptness of an animal to fatten, and in laying on and flavoring flesh, it will do, directed by intelligence, in increasing the secretion and improving the quality of milk. In philosophy and fact, the quality and quantity of milk is as perfectly controlled by quality and quantity of food as is the quality and weight of flesh laid upon a stall-fed animal. When, by skill in feeding, you have developed a particular part or secretion, you may often succeed in fixing this in the progeny by breeding. We may, therefore, properly credit feeding with the beginning of all development. Food must first create the improvement, and then breeding and feeding must continue it. This statement has no reference to the improvement made on scrub animals by crossing thoroughbreds on them. Here the improved blood raises the standard of the inferior blood; but the progeny is only an improvement on the inferior animal. When we speak of improvement by feeding, we mean an improvement on the best blood of the race experimented on. Example: Suppose we take a Short-horn, Ayrshire, Jersey or other breed, the improvement must be over any of its known ancestors. All these improvements require much time; and, therefore, an improved milking strain of blood is of great value, and its value is in proportion to its fixed character. But these fixed characteristics cannot stand long against an entire change of the food and surroundings which produced them.

That you can take an ordinary cow, of good constitution and form, and greatly improve both the quality and quantity of milk, we have demonstrated in several instances. Let us take some examples: First, a heifer with her third calf, at four years old, that had in her first and second years given a very moderate quantity of milk; and, on a test during the fourth week of her second lactation, made 5 pounds of butter from 150 pounds of milk, and during the fourth week of her third season made 5⅛ pounds of butter from 160 pounds of milk. At the close of this second test we began the experiment of developing her. She was a cow of rather spare habit. It was the latter part of January, and her ordinary food had been timothy and clover hay, with one peck of carrots daily.

The additional food began with one pint of oil-meal and three quarts of bran per day, which was gradually increased during the first month to six quarts of bran; the second month, to one quart of oil-meal, six quarts of bran and two quarts of corn-meal; and this feed was continued till grass came, when one pint of oil-meal and four quarts of bran were continued through the summer. A test at the end of the third month gave a yield per week of 6 pounds of butter from 170 pounds of milk. A test in July gave 6½ pounds of butter in seven days, from 165 pounds of milk. During the whole of this season her yield of milk was much more uniform, though there was but a small increase in quantity or improvement in quality. Before dropping her fourth calf, at five years old, she was fed specially for six weeks with one quart of oil-meal and four quarts of bran and one quart of corn-meal per day. This had a remarkable effect in developing her udder. Had to milk her a few days before coming in. Fed her, after coming in, as the year before. Tested her milk during 14 days, commencing the fifteenth day after calving. Result: 20 pounds of butter from 462 pounds of milk. This second season was an astonishing improvement on the last, producing about 60 per cent. more throughout, with only ten per cent. additional food. This cow was kept till 18 years old, and she proved a first-class cow for quantity and quality, the quality being improved more than the quantity.

That we might determine whether the result in this first case might have been largely due to the natural development of a heifer, a six-year-old cow, that had been purchased the May previously, and found to be a very ordinary cow, yielding only 25 pounds of milk per day, in the flush, and commenced feeding her ten weeks before coming in. The ration of extra feed at first was small, as with the first cow, and increased, week by week, until a week before she dropped her calf, when the extra feed was discontinued, to prevent a feverish state of the system at that critical period.

Her udder increased much beyond its previous dimensions; and, on testing for quantity during the third week, she gave an average of 30 pounds per day, yielding 8 pounds of butter. This cow was fed like the former through the season, and showed an increase of milk much beyond that cow the first season. This was attributed to the extra feeding for over two months before coming in. She was fed in like manner two months before dropping her next calf; and her udder was so largely increased in size that she required milking ten days before calving. On a test, during the third week, she gave 280 pounds of milk, and made 12 pounds of butter. This was an increase of one-third in quantity of milk, and one-half of butter. This cow was kept till 20 years old, and she gave 6,278 pounds of milk during her nineteenth year. Both of these, after development, became profitable cows.

A circumstance worthy of mention is, that a heifer calf was raised from each of these cows before development, and both proved to be very ordinary milkers; but heifer calves were also raised from each of them after development that proved to be excellent milkers. It would seem that a strong milking habit acquired by each of these cows became transmissible to the progeny. They also illustrate another point of some importance—the effect of high feeding upon the health and future usefulness of the cow, upon her constitution and capacity to yield milk for a series of years.

It has often been asserted that high feeding shortens the life and usefulness of the cow. These two cows each gave milk in very profitable quantities for fourteen years after high feeding commenced. On this point we can also refer to the experiments reported by Dr. Rhode, mentioned on page 177, in which some 35 cows increased a yearly average of 2,930 quarts to 4,000 quarts, in seven years, with the best of health. What is called high feeding is often very injudicious feeding, consisting of highly concentrated and heating food, given without due admixture of coarse or bulky food. But these cases cannot be cited against full feeding directed by a proper knowledge of the wants of the animal system.

## The German Experiments.

The effect of special feeding upon the quantity of milk has been so often proved in large and small experiments that there is no further doubt about it. But the German experiments at first appeared to show that the food did not change the proportion of the chemical constituents of milk; that when cows were fed a ration of meadow hay, and in addition a highly nitrogenous food, or again one highly carbonaceous, for periods of 14 days, the chemical constituents of the milk remained essentially the same. But Dr. Kühn, in further trials, extending through a period of 30 days, found the element of oil to be slightly increased on the use of a highly carbonaceous food; and thus it was proved that special feeding might change the proportion of the constituents of milk. In the experiment we have given, in developing the two cows by special feeding, an increase in the element of butter, in the same cow, of about 18 per cent. is shown after long feeding; proving that the German experiments were too short to determine the effect of special feeding. These experiments seem to have been conducted on the theory that the constitution of the cow is exceedingly flexible, if 14 to 30 days could very materially change the proportion of the secretions. In all these experiments the ration of meadow hay furnished all the elements of milk in the normal proportions, and it could not reasonably be expected that additional food, rich in either albuminoids or carbo-hydrates, could change the proportion of the elements in milk, except in a long course of feeding. A steady course of special feeding will work a gradual but sure change. In confirmation of this, let us present a large experiment, carried on for several years, and giving most conclusive proof of the increase of oil, or butter, in the milk. The Hon. Zadock Pratt, of Greene County, N. Y., reports to the New York State Agricultural Society, the yield of his 50 cows for five consecutive years, beginning with 1857 and including 1861. The first year it required 39.2 pounds of milk for 1 pound of butter; the second, 33.3 pounds; the third, 29 pounds; the fourth, 23.3 pounds; the fifth, 21 pounds. The amount of butter per cow per year increased in the same proportion. This herd was made up of so-called "native cows," and consisted substantially of the same animals, there being only the ordinary changes in such a herd. In 1862 he reports 64 cows, many of them heifers, yet requiring only 19.7 pounds of milk for 1 pound of butter; his average of butter per cow reaching 223 pounds. The next year, with 82 cows, he reached an average of 224 pounds of butter per cow. He was constantly improving his yield of butter by special feeding; and, contrary to the German experiments, this increase in butter was not from an increased yield of milk, but from an improved quality. His improved quality resulted from feeding through the winter, and till the tenth of May (when grass became good), a ration of corn, oats and buckwheat, ground together; and from May tenth grass alone till the latter part of August, when fodder, corn and pumpkins were given in addition to grass during the fall and early winter. His constant improvement of the quality of the milk, year by year, was just what might, philosophically, have been expected. And as the yield of milk, per cow, was no greater at the end of seven years than at the beginning (5,094 pounds in 1857 and 5,017 pounds in 1863), this must be regarded as a demonstration that this special feeding affected, radically, the quality of the milk.

We have illustrated this point of special feeding at considerable length, because many intelligent feeders have been discouraged from any attempt at improvement in the quality of the milk of common cows by supposing that science had proved its futility. The common understanding of all good feeders, that cows may be improved, both in quantity and quality, by intelligent feeding to that end, has not been weakened by any just interpretation of any experiments, scientific or otherwise.

Having considered the selection and size of dairy cows, the effect of temperature and exercise, special feeding, and the German experiments on the effect of feeding upon the quality of milk, we are now ready to consider practical modes of feeding for milk.

The dairy industry is so extensive in this country—involving one of the largest agricultural products—that the most careful consideration of it is required.

## The Cow as a Food Producer.

The large eating capacity of a good dairy cow is proverbial; which will be easily understood if we make a cursory examination of her production. Suppose a cow weighing 900 lbs. yields 6,000 lbs. of milk in nine or ten months. This milk would contain 780 lbs. of dry matter, counting it 87 per cent. water. Here she yields 6⅔ times her own weight in milk, and the dry substance in the milk is twice that in her own body. The cow is the most remarkable food producer among animals. She produces twice as much food in her milk as does the beef animal of the same weight in its gain in flesh, during the same time. It seems that this remarkable economy of production in the cow was observed and discussed by Payen, in 1843, whilst associated with Dumas and Boussingault, in "Researches on the Fattening of Cattle and the Formation of Milk." These observations were published in *Les Comptes Rendus*, Feb. 13, 1843. After giving experiments he says:

"The cow which has consumed 10 kilogrammes (22 lbs.) of hay above the ration of support, yields 10 litres (22.6 lbs.) of milk, which represents one kilogramme 400 grammes of solid matter; while the ox has increased only one kilogramme with the same food, and of this the water absorbed into the tissues of the animal ought certainly to be counted as the half. * * * A milch cow, then, draws to the profit of man, from the same pasture, a quantity of matter for the food of man which may be more than double that extracted from it by a fattening ox. * * * There exists the most perfect analogy between the production of milk and the fattening of animals, as the rearers of stock had anticipated. But, nevertheless, the fattening ox turns to use less of the fatty matter, or azotized substances, than the milch cow. And this last merits, in an economical point of view, the preference, when the question is to get from pasture the greatest amount of product useful to man."

This gives us a clear explanation of the reason for the large consumption of food by the best milch cows. As the milk is made from the extra food consumed by the cow over what is necessary to supply the waste of her own system, we see it is quite necessary that she should be a good eater and digester.

COMPOSITION OF THE 6,000 LBS. OF MILK.

| *Dry Substance.* | *Lbs.* |
|---|---|
| Casein and albumen | 234 |
| Fat, or butter | 228 |
| Milk-sugar (whey) | 278.4 |
| Salts, or ash | 39.6 |
| Total dry substance | 780.0 |
| Water | 5,220 |

This statement of the elements of the dry substance in the 6,000 lbs. of milk yielded by a cow in her milking period, shows that the food should be rich in albuminoids and fat, or the elements out of which fat is elaborated, in the animal system.

## How Fat is Produced.

Animal chemists and physiologists are not agreed upon this question of the formation of fat in the animal body. Some quite elaborate experiments made by Voit, Pettenkofer, Henneberg, Wolff, and some other German experimenters, led them to believe that the albuminoid matter eaten as food was a large source of the fat laid up in the animal system, and that this and the oil in the food eaten constituted the sources from which all the fat in animals is produced. Almost all kinds of fodder contains fat, but not in quantity sufficient to account for all the fat laid up by the fattening animal or the fat in the milk of the cow. The urea constantly extracted from the blood by the kidneys comes from the albuminoid matter. The extraction of urea leaves a kind of fatty matter, as the residue of the albuminoids, and this is used to keep up animal heat, and the surplus goes to lay on fat or produce oil in milk. These chemists were inclined to doubt whether carbo-hydrates, such as starch, sugar, gum, and cellulose, were ever used in the animal system to produce fat, as Leibig had held many years before; but their experiments were far from being conclusive, as they had omitted to experiment upon the pig. Lawes and Gilbert carried out a thorough series of experiments upon pigs, that fully corroborated Liebig's views, and proved quite decisively that carbo-hydrates were transformed into fat. The pigs were fed upon barley-meal, and the fat and albuminoid matter in the barley-meal were wholly insufficient to account for the fat formed in the bodies. It has been stated that these German chemists have recently acknowledged the correctness of the experiments of Lawes and Gilbert, and that carbo-hydrates must be considered as a source of fat in animal bodies. In this they acknowledge the far-sightedness of their great predecessor, Leibig, whose mind seemed to grasp great truths intuitively, and who was much less liable to error than those who draw general conclusions from limited practical experiments.

The practical common sense of feeders has taught them that foods having a large proportion of starch, such as corn-meal, barley-meal, rye-meal, and fine middlings from wheat, are particularly adapted to produce fat, or milk rich in butter. And these impressions, derived from general practice, have withstood all the doubts of scientific investigators based upon inadequate experiments.

## Variety of Food for Milk.

We have seen that milk is a very complex fluid, containing all the component elements of the animal body. The food, therefore, to produce it, should be rich in all these elements. The error too frequently committed by dairymen is, in supplying a ration from one kind of fodder, instead of giving a variety. If the hay be cut from an old meadow it will have a variety of grasses, and the wants of the system will be fully supplied. There are very few old meadows that contain less than twelve to fifteen species of grass. Old pastures often contain three to four times that number of grasses. It is from this fact that butter has a higher flavor when produced from old pastures. When milk is produced wholly from red clover, one of our best artificial grasses, its flavor is quite inferior to that produced from several varieties. This has been so often observed as not to admit of a doubt. Each species of grass or grain has its own peculiar aroma and flavor, and the greater the number of varieties the finer the flavor of the milk, butter, or other product. Every dairyman should therefore study the nature of the foods he uses, that he may produce the best result. The unfavorable opinion expressed by some dairymen of fodder-corn, fed green, has been from not understanding that this is only a partial food, and not adapted to be used as a complete ration. It is very deficient in albuminoids, which are found in so large proportion in milk. Green corn is excellent as part of a ration for milk cows, but it should always be given with more nitrogenous food, such as clover, oats and peas, millet, malt sprouts, oil-cake, bran or middlings. There must always be a variety of food in the milk ration, and with a little study of his resources the dairyman may always give such variety.

## English Practice.

Let us examine the system of feeding adopted with success by Prof. Horsfall, of England, some twenty years ago, and carried out for many years. We may not be able to use the exact foods in his ration, but American dairymen may use those of the same chemical elements. He mentions, by way of preface, that it requires 20 lbs. of good meadow hay, besides the food of support, to produce 16 quarts (40 lbs., English measure) of milk per day. But you cannot induce a cow to consume this amount of hay above the ration for her maintenance, and he had therefore to seek his extra food in more concentrated substances, such as are rich in albumen, oil, and phosphoric acid; and he selected these with reference to economy of cost. His stables in winter were kept at a temperature of 60°.

In describing his ration, he says:

"My food for milch cows, after having undergone various modifications, has for two seasons consisted of rape cake, 5 lbs.; and bran, 2 lbs.; for each cow, mixed with a sufficient quantity of bean-straw, oat-straw, and shells of oats, in equal proportions, to supply them three times a day with all they will eat. The whole of the materials are moistened and blended together, and after being well steamed are given to cows, in a warm state. The cows are also allowed from 1 lb. to 2 lbs. of bean-meal per day, according to the quantity of milk given by each. This bean-meal is given dry, mixed with the steamed food as given to each cow. When this is eaten up, green food is given, consisting of cabbages, from October to December; kohl-rabi, till February; and mangolds till grass-time. To preserve a nice flavor, I limit the supply of green food to 30 or 35 lbs. per day to each; after each feed four lbs. of meadow hay, or 12 lbs. per day is given to each cow; they are allowed all they will drink of water twice per day.

"My experience of the benefits of steaming is such, that if I were deprived of it I could not continue to feed with satisfaction. As I mix bean-straw, bran, and malt-combs, as flavoring materials, with oat-straw and rape-cake, the effect of steaming is to volatilize the essential oils, in which the flavor resides, and diffuse them through the mess. The odor arising from it resembles that observed from the process of malting. It imparts a relish which induces the cow to eat it greedily; besides which, I think, it renders the food more easy of digestion and assimilation. I use this process with advantage for fattening when I am short of roots, adding one-half pound of linseed oil. With this ration, cooked, I have been able to make an average gain of 14 lbs. per week on heifers and dry cows, from March to May—a result I could not accomplish from the same materials uncooked.

"To one leading feature of my practice I attach the greatest importance—*the maintenance of the condition of my cows giving a large yield of milk.* I am enabled, by the addition of bean-meal in proportion to the greater yield of milk, to avert the loss of condition in those giving from 16 to 18 quarts per day; whilst on those giving a less yield, and in health, I invariably effect an improvement. Albuminous matter is the most essential element in the food of the milch cow, and any deficiency in the supply of this will be attended with loss of condition and a consequent deterioration in the quality of her milk."

The ensilage system lately introduced will, when put in practice, quite supersede the necessity of steaming, and give cows nearly all the advantages of pasture. It will also fully take the place of roots in the English system.

## Fatten Cows in Milk.

There are some features in Mr. Horsfall's practice worthy of careful consideration of American dairymen. He was in the habit of buying strippers, or cows some six months from calving, putting these into his herd and making a good profit on them This would generally be considered a very unwise thing for a dairyman to do. But this fact shows that Mr. Horsfall had such complete control of the condition of his cows that he could take these strippers (which he was careful to have under six years old), and so increase their yield of milk as to produce a fair profit upon this alone; and also so increase the weight and value of the carcass in six to ten months as to sell them 50 per cent. above the purchase price. A system that could produce milk profitably while fattening the cow, must have some merits worthy of adoption. He gives the key to his "leading feature" of practice, as "the maintenance of the condition of the cow under a large yield of milk." This he does by giving a portion of food rich in albuminoids. Milk being a highly albuminous product, it draws strongly upon these elements in food. If we take his example of feeding six cows 191 days—examine his ration, weight of his cows at beginning and end of experiment, product of milk, etc.—it will give the best insight into his practice.

| No. of Cow. | When calved. | Greatest yield per day. | Weight, October 8th. | Weight, March 4th. | Average yield per day. | Total yield. | Gain in Weight. |
|---|---|---|---|---|---|---|---|
| | | lbs. | lbs. | lbs. | lbs. | days. lbs. | lbs. |
| 1................ | July 28 | 30¾ | 1,064 | 1,148 | 25⅝ | 203—5,202 | 84 |
| 2................ | Aug. 25 | 46⅛ | 1,120 | 1,260 | 41 | 189—7,749 | 140 |
| 4................ | July 28 | 46⅛ | 952 | 1,120 | 38½ | 217—8,354 | 168 |
| 6................ | Sept. 8 | 41 | 1,176 | 1,204 | 38½ | 175—6,725 | 28 |
| 7................ | Sept. 8 | 41 | 1,176 | 1,232 | 38⅓ | 175—5,833 | 56 |
| 11................ | Aug. 25 | 41 | 1,036 | 1,064 | 34½ | 189—6,652 | 28 |
| Average of all.. | | 41½ | 1,087⅓ | 1,171⅛ | 35⅙ | 191—6,752 | 84 |

FOOD SUPPLY TO SIX COWS DURING 191 DAYS, AND ITS COMPOSITION.

| | Per day. | Total weight of food. | Cost per ton. | Total cost. | Weight of food dried. | Albumen. | Starch. | Oil. | Fibre. | Ash. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | lbs. | lbs. | lbs. | lbs. | lbs. | lbs. |
| Meadow hay.. | 56 | 10,696 | $17.76 | $84.90 | 9,420 | 990 | 4,257 | 287 | 2,933 | 953 |
| Rape cake ... | 30 | 5,740 | 28.80 | 73.67 | 5,456 | 1,803 | 2,177 | 611 | 494 | 171 |
| Malt combs... | 9 | 1,722 | 24.20 | 18.46 | 1,660 | 411 | 791 | 51 | 320 | 88 |
| Bran ........ | 9 | 1,722 | 28.86 | 22.20 | 1,500 | 246 | 800 | 96 | 258 | 100 |
| Bean-meal .... | 9 | 1,722 | 41.48 | 31.90 | 1,500 | 464 | 774 | 34 | 176 | 53 |
| Roots and cabbages ...... | 204 | 39,032 | 2 22 | 38.88 | 5,740 | 862 | 3,074 | 115 | 1,448 | 541 |
| Oat straw..... | 50 | 9,566 | 7.77 | 33.08 | 8,407 | 287 | 3,066 | 100 | 4,526 | 428 |
| Bean straw... | 12 | 2,296 | 7.77 | 8.00 | 1.964 | 376 | 725 | 51 | 594 | 217 |
| Total ...... | 379 | 72,496 | ...... | $311 09 | 35,647 | 5,439 | 15,664 | 1,345 | 15,664 | 2,551 |

Here the cost of the food was $311.09, or 27 cts. per day for each cow—a pretty large price for keeping—but the milk (16,000 quarts), at two pence (3.7 cts.) per quart, amounted to $592, leaving the handsome margin of $281, or $46.83 per cow. We may consider this a pretty high price for milk, but it is only equal to $1.44 per 100 lbs.—a price dairymen often reached at cheese factories with high prices.

## VALUE OF COW MANURE.

But one important consideration of profit which an English farmer never forgets, but which an American farmer often leaves out of his estimate of profit, is the manure. Mr. Horsfall sent to the laboratory of Prof. Way samples of the manure from these six cows, while the experiment was going on, for analysis. According to his analysis of several samples, these cows produced, during 191 days, the following amounts :

| | *Pounds.* | *Cts.* | *Value.* |
|---|---|---|---|
| Nitrogen ............ | 414............ | @20.......... | $ 82.80 |
| Phosphoric acid....... | 393............ | 12.......... | 47.16 |
| Potash............... | 585............ | 8.......... | 46.80 |
| Total value, at commercial prices | | .............. | $176.76 |

This is equal to $29.49 per cow, and the estimate of value is that made for commercial fertilizers in our own markets. The experiment was conducted some twenty years ago, and Mr. Horsfall then figured the value at $17.28 per cow. We have figured it on the basis of prices laid down by Prof. S. W. Johnson, of the Connecticut Experiment Station. It will be well for our farmers to look after the value of the home-made fertilizer; and as the experiment was carried out with care, we give it as forming a basis of calculation of manurial value when cows are full-fed, so as to gain in weight. Had they been scantily fed, the manure would have been of much less value. Here was abundance of food for respiration, or the production of animal heat, to supply the natural waste of the animal body, to produce an average of 35 lbs. of milk per day, and, besides, to increase the weight of the cow 84 lbs. in 27⅓ weeks. These six cows were fresh in milk, to show the effect of full feeding with full production; for it is much easier to add to the weight of the cow after she has been in milk six months than while in flush of production. This case will show clearly how he could buy strippers and greatly increase their yield of milk, while he added about 8 to 10 lbs. to their weight per week. As we have strongly illustrated in previous pages that there can be no production until after the food of support, and that the highest profit is only reached by the highest consumption of food, this practice of Prof. Horsfall is a valuable addition to evidence under that head.

## Food of Production.

As the author's great object in writing this book is to give practical instruction that will assist the feeder, in any specialty, to increase his profits, let us, before leaving Mr. Horsfall's experiments, show how these illustrate the proportion of the food of production to that of support. This is the most important point of all to be understood by the feeder; that is, *what part of a full ration is really used for production or profit?* We greatly need accurate and thorough experiments to determine this to an approximate fraction. There are many cases that throw light upon it. The German experimenters have undertaken to lay down the rule that 2 per cent. of the live weight of cattle of the dry substance of meadow hay is required as a daily ration of support, without gain. If this rule is taken, then, as Mr. Horsfall's six cows averaged 1,078 lbs., it would require 21.74 lbs. of dry substance for the food of support. The averaged amount of dry substance eaten by each cow per day was 31.11 lbs., as appears by the table given on a previous page. This would be nearly .7 (seven-tenths) required as the food of support, and a little over .3 (three-tenths) as the food of production; and yet these cows yielded 35 lbs. of milk per day, besides increasing in weight. This must be considered as a remarkable result. We have usually estimated two-thirds of a full ration as required for the food of support, and this rather more than sustains that estimate. Let us see if we can find the elements in ⅓ of the ration given by Mr. Horsfall to produce the 35 lbs. of milk, or 40,512 lbs. in 191 days, besides a gain in the weight of the cows of 500 lbs. Mr. H. supposed that this gain in weight was composed of 300 lbs. of fat and 200 lbs. of lean flesh. This would give only 46 lbs. of dry flesh, or fibrin, and about 270 lbs. of solid fat. The 40,512 lbs. of milk would contain the following substances:

| | |
|---|---|
| Casein (albuminoid) | 1,815 lbs. |
| Fat or butter | 1,276 " |
| Milk sugar | 1,932 " |
| Mineral matter (ash) | 243 " |
| Water, 87 per cent | 35,246 " |
| | 40,512 |

If we add the fat and fibrin of 500 lbs. gain, it will stand—

| | |
|---|---|
| Casein and fibrin | 1,861 lbs. |
| Fat and butter | 1,446 " |
| Milk sugar | 1,932 " |

One-third of the elements of the food is—

| | | |
|---|---|---|
| Albuminoid | (⅓ of 5,439 lbs.) | 1,813 lbs. |
| Oil | (⅓ of 1,345 lbs.) | 442 " |
| Starch | (⅓ of 15,664 lbs.) | 5,221 " |

Here it will be seen that the oil in the food is not sufficient to supply the fat for the butter, and the increase in weight, even if none is consumed in the maintenance of the cow, as there is only 1,345 lbs. of fat in the whole food, and there is required, besides, maintenance, 1,446 for the milk and the gain in weight. This only shows that the oil contained in food is not sufficient to supply the necessities of the animal, and that it must be derived from the carbo-hydrates of the food. The surplus starch over maintenance amounts to 5,221 lbs.; and if we deduct the milk sugar, 1,932 lbs., from this, we shall have left 3.289 lbs. If we deduct the 442 lbs. of fat over the maintenance ration from the 1,446 lbs. of fat in the butter, and gain of the cows, it leaves a deficiency of 1,004 lbs., and if we estimate 2½ lbs. of starch as equal to 1 lb. of fat, it will take 2,510 lbs. of starch to produce this deficiency of fat; but this still leaves a surplus of 779 lbs. of starch, so that the production of fat can be accounted for out of one-third of the food. The casein in one-third of the food, 48 lbs., is short of supplying the casein in the milk and fibrin in the increase of weight in the cows. But it may well be that the nitrogen in two-thirds of the food is more than the waste of the system requires, and the deficiency is but a trifle (8 lbs.) to each cow. It thus appears, on a careful examination, that one-third of a full ration is quite sufficient to furnish the elements in a large yield of milk. This ought to be an interesting illustration to all dairymen. These cows were fed very liberally, and produced a little over 35 lbs. of milk per day for 191 days, besides gaining in weight, and still two-thirds of the food was used as the mere ration of support—one-third only devoted to production. This experiment was made by Prof. Horsfall, before the German experiments, determining the precise digestible constituents of food. Under the German formula, the amounts of albuminoids, carbo-hydrates, and oil represented as digestible would be considerably less, but the result would be the same. If dairymen once become fully convinced of the fact that *two* parts of all food goes to keep the cow alive, and only *one* part to production and profit, it must soon change the habit of scanty feeding, which means feeding without any hope of profit.

## American Rations for Milk.

Our dairymen have a great variety of foods out of which to make up the milk ration. It is true that we cannot get bean-meal or rape-cake, two of the foods used by Prof. Horsfall—the former of which had a peculiar significance in his system of feeding, as he regarded it as an important agent in keeping up the condition of the cow under a large flow of milk, by its large percentage of muscle-forming matter—but we can replace this with decorticated cotton-seed meal, which is still richer than bean-meal in albuminoid matter, besides having six times as much oil; or its place can be filled (in some parts of the country) with pea-meal, a food very similar, or it may be replaced with linseed oil-cake. We have not yet become accustomed to raising roots or cabbages for cattle feeding to any extent, and it may be doubted, whether, with our rates of labor, we can afford to raise turnips, beets, etc., instead of the grain crops. Many close figures make the raising of an acre of Indian corn, oats and peas, millet or barley, cheaper than the same quantity of nutriment from roots. The effect of roots in the promotion of the health of the cow, by their cooling and relaxing effect upon the stomach and bowels, is often dwelt upon, and with good reason; but the same effects may be produced by the use of 2 to 4 lbs. of oil-cake in combination with bran, or oats and corn ground together, and good hay.

And the American dairyman now has, or may easily have, green succulent food, in the form of ensilage, to produce all this beneficial effect upon the stomach and digestive organs.

A ration of equal nutritive power with Prof. Horsfall's can be found here, at less cost. Take the following:

| | | *Cost.* |
|---|---|---|
| 10 lbs. | Clover-hay | 4.0 cents. |
| 10 " | Straw | 2.0 " |
| 4 " | Linseed-oil cake | 6.0 " |
| 4 " | Wheat bran | 3.0 " |
| 2 " | Cotton-seed cake | 2.5 " |
| 4 " | Corn-meal | 3.0 " |
| | Average value of ration | 20.5 cents. |

This ration is fully equal to Mr. Horsfall's, and yet costs only three-fourths as much, or the following:

| | | *Cost.* |
|---|---|---|
| 16 lbs. | Meadow hay | 6.4 cents. |
| 8 " | Wheat bran | 6.0 " |
| 2 " | Linseed-meal | 3.0 " |
| 6 " | Corn-meal | 5.0 " |
| | | 20.4 cents. |

Or this:

| | | *Cost.* |
|---|---|---|
| 18 lbs. | Corn-fodder | 4.5 cents. |
| 8 " | Wheat bran | 6.0 " |
| 4 " | Cotton-seed meal | 5.0 " |
| 4 " | Corn-meal | 3.0 " |
| | | 18.5 cents. |

Or this:

| | | *Cost.* |
|---|---|---|
| 15 lbs. | Straw | 3.0 cents. |
| 5 " | Hay | 2.0 " |
| 4 " | Cotton-seed meal | 5.0 " |
| 4 " | Bran | 3.0 " |
| 4 " | Corn-meal | 3.0 " |
| 3 " | Malt sprouts | 2.0 " |
| | | 18.0 cents. |

The following would be easily obtained in many districts:

| | | Cost. |
|---|---|---|
| 10 lbs. Corn-fodder | | 2.0 cents. |
| 10 " Oat straw | | 2.0 " |
| 2 " Linseed-meal | | 3.0 " |
| 4 " Malt sprouts | | 2.0 " |
| 10 " Oat and corn-meal | | 10.0 " |
| | | 19.0 cents. |

Or this:

| | Cost. |
|---|---|
| 60 lbs. Corn ensilage | 7½ cents. |
| 5 " Hay | 2½ " |
| 2 " Linseed-meal | 2½ " |
| 4 " Bran | 3.0 " |
| | 15½ cents. |

Or this:

| | Cost. |
|---|---|
| 60 lbs. Clover ensilage | 9.0 cents. |
| 4 " Corn-meal | 4.0 " |
| | 13.0 cents. |

Or this:

| | Cost. |
|---|---|
| 40 lbs. Corn ensilage | 5.0 cents. |
| 40 " Clover " | 6.0 " |
| 4 " Bran | 3.0 " |
| | 14.0 cents. |

Or this:

| | Cost. |
|---|---|
| 40 lbs. Corn ensilage | 5.0 cents. |
| 40 " Clover " | 6.0 " |
| 40 " Millet " | 6.0 " |
| | 17.0 cents. |

Any of these rations would produce a large flow of milk and fully keep up the condition of the cow, adding to her weight, if her live weight were not over 1,000 lbs. In many parts of the West the fifth ration would not cost more than ten cents per day. All these rations would also produce a good quality of butter in winter. The ensilage rations are the cheapest and would produce the largest flow of milk.

## Water for Milch Cows.

All dairymen have observed that cows require a very large amount of water whilst in full milk. Prof. Horsfall made a comparison as to the water drunk by fattening cattle and milch cows of the same weight. He found that cows, when giving only 20 lbs. of milk per day, drank 40 lbs. of water more than fattening cattle of the same weight, and he inferred from this that the cows gave off from the lungs and the pores of the skin over 20 lbs. of water per day more than fattening cattle of the same weight, since the water contained in the milk yielded was only about 17½ lbs., whilst the cow consumed 40 lbs. of extra water. On examining the manure from cows and fattening cattle, he found the amount of moisture the same in both cases. This is an interesting comparative experiment of the capacity for water drinking in the fattening animal and milch cow, whether we accept the theory of its use or not. The experiments have not been numerous and exact enough to determine the precise method of the expenditure of all the water; but the large capacity and necessity for water in the milch cow is abundantly proved; yet it may be worth while to mention the experiments of M. Dancel, reported to the French Academy of Sciences. His experiments were to determine the effect of quantity of water upon quantity and quality of milk. He says that by inducing cows to drink more water, the quantity of milk yielded by them can be increased in proportion up to many quarts per day, without perceptibly injuring its quality. The amount of milk, he states, is proportional to the quantity of water drunk. In experimenting upon cows fed in stall with dry fodder that gave only 9 to 12 quarts of milk per day, but when this dry food was moistened with from 18 to 23 quarts of water daily, their yield was then from 12 to 14 quarts of milk per day. Besides this water taken with the food, the cows were allowed to drink the same as before, and their thirst was excited by adding a little salt to the fodder. The milk produced under this additional amount of water, on analysis, was pronounced of good quality; and when tested for butter, was found satisfactory. A definite amount of water could not be fixed upon for each cow, since the appetite for drink differs widely in different animals. He found, by a series of observations, that the quantity of water habitually drunk by each cow during twenty-four hours was a criterion to judge of the quantity of milk that she would yield per day. And a cow that does not habitually drink as much as 27 quarts of water daily must be a poor milker—giving only from 5½ to 7 quarts per day. But all the cows which consumed as much as 50 quarts of water daily were excellent milkers—giving from 18 to 23 quarts of milk daily. He gives a confident opinion that the quantity of water drunk by a cow is an important test of her value as a milker.

These experiments, although they may not be quite sufficient to induce confidence in M. Dancel's rule, yet it is certain that abundance of pure water is an absolute necessity to be provided by a successful dairyman. As water permeates every part of the system of the cow, its purity is of the first consideration. The quality of the water effects the health of the cow and the healthfulness of her milk. The impurities of stagnant water, in the form of organic germs, pass in a dormant state into the circulation of the blood, and thence into the secretions of milk; and so powerful are these taints that it is not unfrequently, at cheese factories, that the milk of one cow spoils a large vat of milk. So important is the quality of water for the cow, that it is none too severe a test to say that no water is fit for a milch cow that is not fit also for man to drink. Water should also be easy of access, both in winter and summer. In winter it should either be given them where they stand in the stall, or near by, so guarded that they may drink unmolested.

In summer, if possible, water should be furnished in each pasture field. Cows should not be required to travel for it, because they will not do this on a hot day, unless very thirsty, and consequently they will not drink as much as a large yield of milk requires. When a farm affords a small, running stream, this should be conducted into every pasture field, if practicable, or every pasture should be connected with the stream. Or, where a spring is located upon an elevated part of the farm, the water from it should be carried in pipes to each pasture field, and caused to run into troughs which are always kept full. And, where water can be had by sinking wells, these should be furnished in each field, and the water pumped by wind or hand, so as to give the cows free access to water at all times. The cost of sinking these wells will often be repaid in a single season. Some dairymen are content to drive their cows to water, even in summer, only once per day. But such dairymen are destined to constant disappointment in the profits of the dairy.

To induce cows to drink often, some of the most successful dairymen, where water was pumped by hand into large troughs, put from ½ to 1 lb. per cow of oil-meal into the water-trough daily, with ½ oz. of salt, and, stirring this well in the water, gives it a taste so much relished by the cows that they come often and sip a few quarts. By this means they were not only induced to drink much water, but the small amount of oil-meal assisted in increasing the yield of milk. Bran or middling may be used instead; and we can assure every dairyman that the cows will return this liberality, with compound interest, in milk.

We have, perhaps, elsewhere, sufficiently urged the importance of giving cows, in winter, water of moderate temperature. It is doing violence to the system of the cow to require her to drink large quantities of ice-cold water, and warm this in her stomach, producing a chill of the whole system. Such a method of watering must be unsuccessful in winter dairying, for this cold water retards digestion, when given in large quantity. It can only safely be given in one or two gallons at a time, and this would entail more expense than furnishing water at a temperature of 60 degrees. When cows are kept in a warm stable, and water can be brought to the stable from a spring, in pipes laid below frost, it may be run into a trough within reach of the cows, the surplus running off; or water may be furnished from a large reservoir, which will stand constantly at about 60 degrees. There are many ways in which water at moderate temperature may be furnished to cows in winter.

### Pasturing Dairy Cows.

As this is the almost universal method of keeping dairy cows in summer, it becomes important to discuss the most economical use of pasturage. Our readers will hardly be at a loss to know what we mean by economy. Economy requires the dairyman to get the largest production from each acre of his pasture, and this can be done by keeping only so many cows as his pastures will yield full rations to. Overstocking can result only in a lessened production.

### Variety of Grasses.

In laying down pastures for dairy cows great care should be exercised in selecting the seed of a large number of grasses. This is important; first, because the land will produce a much larger yield of food from a large number of different grasses which completely occupy the soil, than from two or three that leave spaces unoccupied; and, secondly, and still more important, because animals require variety in their food, and especially the milch cow, that yields so abundant and complex a product in her milk. Milk contains all the elements of the living animal body in solution. The cow must, therefore, have a great variety, or complex food, out of which to elaborate this production. The dairyman cannot give this too much consideration. Many of our natural pastures contain from thirty to sixty species of grasses; and when good cows are fed upon such pastures they are noted for the high quality of their milk and butter and cheese. Some of these wild grasses are classed as weeds by farmers when they come into their grain-fields, but they are highly relished by cattle in their succulent state. All of these wild grasses cannot be sown in pasture; but they will frequently maintain a foothold with the cultivated grasses sown. It is well known that dairy products do not have that extra fine flavor when produced on a pasture of timothy and clover alone; and, therefore, permanent pastures have been much advocated. But American farmers have not been so careful in selecting a variety of the cultivated grasses as they might have been. It is quite unusual for our dairy farmers to sow on pastures more than timothy (*Phleum pratense*) and red clover (*Trifolium pratense*), occasionally adding June grass (*Poa pratensis*), or orchard grass (*Dactylis glomerata*), or white clover (*Trifolium repens*), and in very exceptional cases all of them. If this list were generally used, it would greatly improve the pastures of the whole country; but this meagre list should be enlarged by those who desire the great advantages of variety in the food of their cows, and are endeavoring to establish permanent pastures. It is true that red clover is usually a biennial, and will not last long, yet will be of much service in the beginning; but there is a perennial variety of red clover (*Trifolium pratense perenne*), and is found in almost every field of clover. That enthusiastic botanist, the late John Stanton Gould, says of the perennial:

"It may be distinguished, in general, at a glance, by its deeper, bluish-green color, the greater narrowness of the leaves, its more straggling, and the greater number, greater length and greater stiffness of its hairs. The root of this variety differs considerably from the biennial kind; it is somewhat creeping and fibrous, whereas the biennial has an almost spindle-shaped root, with less fibres. The root is the best test in doubtful cases."

Mr. Sinclair says this variety is found in great abundance in Lincolnshire, England, and that it flourishes better on clayey or peaty soils than the biennial. This perennial clover-seed cannot now be found in the market; but a little attention of cultivators might soon furnish the seed, which would be a great gain to pastures. White clover is apt to come of itself on lands suited to it; but it would be well to sow two or three pounds of the seed per acre.

Red-top, or herds grass (*Agrostis vulgaris*), should never be omitted where the land is moist, for it is a constant resource in pastures, as it grows equally throughout the season. It starts much sooner after cropping or cutting than timothy. It has thick, interlacing roots, and on wet lands it consolidates and toughens the sward, making such a firm matting that the feet of cattle do not easily break it. It has a high reputation among dairymen as producing a large amount of food and improving the flavor of the butter.

Of the *Poas*, Kentucky blue-grass, or June-grass, stands at the head, and is too well known to require any description or commendation; but wire grass, also called blue-grass (*Poa compressa*), which is found indigenous in many localities, is not so well understood, and requires some attention. This is in meadows often considered a nuisance, because it holds its footing so strongly as to run out other grasses, and produces a small bulk of hay, but very heavy for its bulk. It is one of the most nutritious grasses in our whole list. It starts early in spring, and keeps green and succulent even after the seed is ripe. We think it very valuable as a pasture grass. Mr. Gould mentions that it did not form a close turf with him; but, with us, no grass forms a closer and tougher sod. It seems to be less affected by drouth or wet than many other grasses, and cows yield well when supplied with it in pasture or stall. It is so nutritious, when cut in season and properly cured as hay, that cows will yield more milk upon it than any other hay we have tried; and horses will work upon it as well as upon timothy, with a moderate feed of oats. It should have a place in all pastures where the natural grasses flourish.

Sweet-scented vernal grass (*Anthoxanthum odoratum*) should not be forgotten in the list of pasture grasses for milch cows. It starts very early in spring and flowers in May. Its odor in blossom seems to be too strong for the taste of cattle when grown alone; but, if mixed with other grasses in pasture or in hay, it is eaten with a relish, and is thought to give a fine flavor to milk. It does not produce a large weight of hay; but its odor and flavor and early growth in spring will warrant the use of about two pounds of seed to the acre.

American dairy farmers have given quite too little attention to keeping up the condition of their pastures. Since the system of pasturing is almost universally followed, and the principal income from their dairy herds depends upon the supply and condition of food there furnished, the most imperative necessity demands that they study the means of improving them. Meadows are often considered worthy of attention and fertilization; but pastures are not thought to need such attention, because cattle leave their droppings upon them; yet it must be remembered that the milch cow carries off from the pasture—never to return—the fertilizing matter in her milk. The cow that yields 6,000 pounds of milk will carry off about 40 pounds of ammonia and 40 pounds of mineral matter. And it is easy to see that pasturing for a long series of years must gradually carry off the fertility of the soil. It is, therefore, necessary that there should be some provision for fertilizing permanent pastures used for the production of milk.

## Extra Food to Fertilize Pastures.

We think one of the best methods of keeping up the fertility of cow-pastures is to give the cows extra food during the pasturing season. This extra food will be repaid in extra milk every week, and so enrich the droppings as to fully compensate the pasture for all the grazing. This extra food can be given at such times as the condition of the pasture requires to give the cows full rations. Under this system a few more cows may be kept than the pasture is sufficient to furnish food for; and thus the pasture will be cropped evenly over the whole field, and the grass all economized. While the grass furnishes abundance of food, it will not be necessary to add the ration. This extra food will come in to keep up a proper balance between the requirements of the cows and the condition of the pasture. This extra food may all be given in green clover, rye or other green food grown upon other fields, or fed to the cows in racks arranged in the pasture, or in stable, with the manure distributed over the pasture as a top-dressing; or this extra food may be given in bran, corn-meal, linseed-oil meal, cotton-seed meal, barley sprouts, or other grain food. Some think it quite as economical to use one or more of these extra foods during the period before green corn, millet, peas and oats, etc., can be sufficiently matured for this purpose. They reason in this way: If the extra milk will fully pay for these foods, then it is better to use them, because this extra fertilizing matter is brought to the land, instead of being taken from it. Hundreds of experiments have shown that good cows will yield more than extra milk enough to pay for these extra foods. Poor cows will not respond so much to extra feeding, and will not, in fact, pay a profit under any system of feeding; they are not, therefore, to be considered in this statement.

Peas and oats, grown together, just when the peas are past the blossom, make an excellent extra food to make up for deficiency of pastures.

Sweet corn—early and late varieties—is most excellent food for the production of milk. The early varieties will come on the latter part of July, and give the cows a much-relished food.

Stowell's evergreen is an excellent late variety which may be fed through September and October, and even later. This corn, to be fed green, should be cultivated in the same manner as when intended for market. Thick sowing is now quite abandoned by the most careful feeders. It should be planted in drills at least 32 inches apart, and cultivated two or more times, according to the condition of the soil. Sweet corn for such feeding is altogether to be preferred to common field corn, because of its remaining succulent so much longer, and also because it contains much more sugar and less starch. The sugar is more easily digested and assimilated, and makes better flavored milk. It is intended to allow the sweet corn to mature to nearly the same stage as when it is sent to market for culinary use. It is in the best condition for feeding after being run through a straw cutter; but cows will eat it greedily without cutting. Sweet corn has a larger percentage of albuminoids than common corn. This corn is also excellent to feed with late cuttings of clover, and with green peas and oats. If the dairyman will prepare the land, and put in one acre to each five cows in his herd with sweet corn, peas and oats, or millet, to be fed at the proper season, he will not only get the best yield from his cows, but keep up the fertility of his pastures.

# CHAPTER X.

## HORSES.

We will now give our attention to another great class of farm stock, that which furnishes the motive power upon the farm and in the cities—horses.

We must here also first discuss the wants of the young animal, as the proper management of the young is the first requisite to success. It is not within our province to discuss the question of breeding, but must take the animals as we find them and make the most of their capabilities. Much improvement of the constitution and vital forces of animals may be made by breeding; but as the finest pattern of boiler and engine are useless without fuel to make steam, so the finest animal forms are quite unprofitable without skillful feeding to develop and round out all their proportions.

The horse is kept for his muscle, and his food must be such as to develop the frame and muscular system. The feeder must have a clear idea of the purpose for which an animal is reared, and a comprehension of the office performed by the food. The food should present the precise elements in the proper proportion required for the uses of the animal. Animals kept for the production of flesh as food, can use a larger proportion of carbonaceous elements than those valuable only for muscle. Indian corn is the great crop of the West, and is the best type of fattening food, and has abundant use in the production of beef, mutton and pork. It may also properly form a part of the food of horses, and even for colts, but to the latter must be fed very sparingly. Bear in mind, it is chiefly the muscle and the finest quality of springy bone that requires development in the

## Colt.

As we are now studying the proper development of the colt, let us see what Nature provides for its early growth. It will be seen from the analysis of the mare's milk, which we gave on page 138, that the casein, or muscle-forming element, is 3.40 per cent., butter 2.50, milk sugar 3.52, ash .53 per cent., and water 90.05 per cent. The mare's milk contains a larger percentage of water than cow's milk, but the relative proportion of the food elements is nearly the same. There is 9.95 per cent. of dry matter (food) in mare's milk, and of this the food of respiration and fat production (butter and milk sugar) amount to 6.02 per cent., so the casein amounts to 3.40 per cent., or more than one-third of the whole. This gives a little more than one of nitrogenous to two of carbonaceous elements. The colt thus receives food, in the mother's milk, in the proportion of one of nitrogenous (muscle-forming) to 1.92 of carbonaceous elements. This tells us, in the strongest possible language, that the colt requires food rich in muscle-forming elements, and that it is a great mistake to use food rich in starch, such as corn, or even barley, for the young colt.

For four to six months the colt takes its natural food—the milk of the dam. If this is in liberal supply, the colt will be sufficiently nourished with the addition of the grass it will get in pasture. But care must be taken to ascertain whether the dam gives sufficient milk to produce a strong growth. Scanty nourishment at this period is often fatal to full development afterward. The whole system of the young animal is plastic in the hands of the skillful feeder.

Full rations of appropriate food will give it the habit of strong and rapid growth, which is easily continued after weaning; but, on the other hand, deficient nourishment will not only contract its present growth, but also contract its powers of digestion so as to incapacitate it for using sufficient food to give full growth after weaning. The vigorous growth of a colt while young is too important to be neglected on any pretext, such as that "whip-cord muscle and solid bone must be grown very slowly that the fibres may become perfect," etc. There is a vast amount of such humbug afloat. Slow growth presupposes scanty food; does insufficient nutrition produce the most perfect development? Taking a lesson from tree growth: How does the fibre of the slow-growing, large, forest hickory compare with that of the rapid, open field, second-growth hickory—the grain of the latter being twice or thrice the thickness of the former? Will the expert, who wants an ax-helve or spokes for a trotting sulky, choose the slow-growing hickory in preference to the rapid second-growth? The same rule will hold between two colts, the one scantily and the other abundantly fed. But as in this case of the rapidly-growing hickory, we wish it seasoned to give us the full force of its springy fibre; so likewise the rapidly-growing colt must have a time of seasoning to perfect, by temperate use and intelligent training, its wonderful power of muscular endurance. It seems this foolish prejudice against good feeding for colts has arisen from the fact that high feeding and fattening have been considered synonymous. Such food as would produce fat rather than muscle cannot be too strongly condemned.

### Milk Ration for Colt.

If the dam yields too little milk to produce vigorous growth in the colt, it should be increased by food of as nearly the same composition as may be. This is nearly always at hand in cow's milk. A little practice will soon teach the young colt to take cow's milk with a relish. New milk may be given at first, but soon replaced with skim-milk, which, possessing so large a proportion of casein, or muscle-forming food, and phosphate of lime, is exactly adapted to the growth of muscle and bone. This is also so cheap that vigorous growth may be kept up at very small cost. For colts one or two months old, one quart of milk given morning and evening will be sufficient. It may be sweetened a little at first to render it more palatable. Colts, like children, are fond of sweets; but sugar should only be added as a temptation in teaching them to eat, for it is a fattening food and improper to be given as a diet. This use of cow's milk in growing colts is not a mere theory with the author, he has tested it in many instances, and found it admirably adapted to the purpose. He remembers two colts that were fed a little skim-milk after two months old till weaned, and then continued in larger quantity after weaning and through the first winter. They were given from four to six quarts of milk each, per day, with hay and one quart of oats, till one year old. These colts grew very steadily, developing all parts of the body evenly, and made horses 100 lbs. heavier than either sire or dam. They were much inclined to exercise, and test comparative speed, at all periods during growth, and more muscular horses, of their inches, are seldom seen. We once purchased some colts six months old, of a good breed, that had been kept on insufficient food, and not properly developed for that age. To make amends for this want of care and food, four quarts of skim-milk was given to each colt for one month and then increased to six quarts, which ration, with two quarts of oats per day, was continued for six months, or till one year old. This produced a development which no grain ration could have done. The advantage of the milk ration over a like amount of food, containing the same elements, in another form, is, that the food in the milk is in solution and very easily digested. Stress is laid upon this milk feeding for colts, first, because it is a most appropriate food; secondly, because in large portions of the country skim-milk can be had cheap, and it may be thus turned to the best account, for horse-flesh is more valuable than that of other animals. If milk is not easily obtained, then the colt may be fed a pint of oats twice a day, in addition to the milk of its dam, if that is too small in quantity. Before the colt is weaned, it is well to teach it to eat a little linseed-meal with its oats. When deprived of the dam's milk this linseed-meal will prevent constipation and furnish a large proportion of muscle-forming food as well as bone material. About one pint of linseed-meal per day will be sufficient. Another food, which we have used very profitably for the young colt, is linseed or flax-seed. A half-pint of flax-seed boiled in four quarts of water, and then two quarts of bran or oatmeal boiled with it, makes an excellent day's ration for a colt eight months old, given in two parts—the oil and the albuminoids seem to be in just the right proportion. We have found this ration of flax-seed and oatmeal gruel the best preventative of relaxation or constipation of the bowels, both in the colt and the calf. If the colt is in good condition, half the quantity here mentioned is sufficient. The small quantity of oil seems to be very soothing to the alimentary canal, and it gives a smooth, glossy coat.

## Food for the Dam.

The condition and health of the dam has much to do with the health of the colt. Great care should be taken that the dam does not heat her blood, and thus affect the healthfulness of her milk. The milk secretions are very sympathetic with all nervous excitements. This has often been tested in the milk of the cow. The chemical composition of the milk has been largely changed in its proportions by a little worry and excitement, such as rapid driving, or being worried by a dog. There is no objection to light work for the dam after the foal is two weeks old; but this should be such work as she can do without worry or too much fatigue. The foal should early be accustomed to being left in a loose box or stable. That the dam may be able to furnish a generous supply of milk to the foal, she must have a liberal supply of food herself. It must be remembered, that the dam requires food for the support of two lives, and that, if she is required to do light labor in addition, she must have a ration in proportion. We have seen, from the composition of the mare's milk (page 138), that it is rich in albuminoids, and, therefore, her food must be rich in albuminous elements. Pasture grasses, when a few inches high, contain a much larger percentage of albuminoids than when in the mature state. This accounts for the large yield of milk by cows, and the rapid laying-on of flesh by steers, when feeding upon such vigorously-growing young grass. Clover, before blossom, is also a most excellent food for the dam and for the colt. But the dam should also have a small grain ration, even upon good pasture, when she is required to perform labor. Good wheat bran is a very appropriate extra ration for the dam, because it contains from 12 to 16 per cent. of albuminous food; but oats are equally rich in nitrogen, and are always proper food for the brood mare. If the dam is being fed upon hay, then she should have a daily bran mash, with one pint of oil-meal added—such sloppy food will increase the secretion of milk when upon dry fodder. The new process linseed-meal will be found profitable food for the dam in small quantity, say one to two pounds per day. It is more important if the dam is on dry food. The dam, during this period, should be treated with great kindness and gentleness, avoiding all excitement. If the foal is allowed occasionally to go to the field with the dam while at work, and also on the road, for very short drives, it will familiarize it with such objects as will surround it afterwards, and it will thus be made more fearless.

The colt should be handled almost daily while with the dam, and made familiar with men. Great care should be taken to avoid frightening it. It should be taught to regard man as its greatest friend, from whom it may always expect a pleasant caress, or something agreeable to eat. This is not only important in reference to its future temper and usefulness, but vastly important to its rapid growth. Animals do not thrive under excitement and irritation. There is no place for a passionate man among young animals, and not a very profitable place for him anywhere. We often hear of very different results from the same food, upon animals of the same age and class; but our experience has proved that this is caused in more cases by the feeder than the animal. If, then, the colt-raiser desires to produce the greatest result with the least food, he must accompany the food with the kindest and most pleasant treatment.

## Weight and Growth of Foals.

The rate of growth in foals, and the food required to make a pound growth, have not been much studied. Indeed, we are aware of but one published experiment as to the weight and growth of foals, besides the one made by the author. Some years since he weighed three foals at birth; the dam of No. 1 weighing 1,000 lbs.; of No. 2, 1,025 lbs., and of No. 3, 950 lbs. The sire (a good general purpose horse) weighed 1,120 lbs. The following table will show the weight and growth of these foals for two separate periods, as well as those in the experiments of Boussingault:

| NAMES. | Weight at birth. | Weight at 90 days. | Increase in weight. | Increase per day. | Weight at weaning, 150 days. | Increase per day, last 60 days. |
|---|---|---|---|---|---|---|
| | lbs. | lbs. | lbs. | lbs. | lbs. | lbs. |
| No. 1, Filly | 108 | 280 | 172 | 1.91 | 400 | 2.00 |
| No. 2, Colt | 116 | 301 | 185 | 2.05 | 410 | 1.81 |
| No. 3, Filly | 111 | 310 | 199 | 2.21 | 390 | 1.33 |
| BOUSSINGAULT. | | at 87 days | | | at 152 days | |
| No. 1, Filly | 110 | 294 | 184 | 2.1 | ........ | ........ |
| No. 2, " | 113 | 286 | 172 | 1.9 | 358 | 1.10 |
| No. 3, " | 113 | 354 | 241 | 2.7 | ........ | ........ |
| | | | | | at 169 days | |
| No. 4, " | 110 | 295 | 185 | 2.05 | 396 | 1.10 |
| | | at 128 days | | | at 179 days | |
| No. 5, Colt | 110 | 337 | 227 | 1.8 | 490 | 1.4 |

The first four in Boussingault's experiment were weaned at 87 days, and No. 5 at 128 days. The second period was after weaning, and the gain was much slower. The mean increase of his foals during the period of suckling was 2.11 lbs per day. Our three foals had only the milk of the dams during 90 days, and the average gain per day was 2.06 lbs. The next 60 days they each had one pint of oats per day, in addition to milk of dam, and the average gain per day was 1.71 lbs. Had the extra feed been one quart, they would probably have gained as fast as during the first 90 days. The colt, however, is no exception to other animals, in that the increase is more rapid, on the same food, while under three or four months old than afterward.

We continued the experiment by noting the gain in weight of our three colts for 180 days longer, weighing the food given, so as to determine the cost in food of each pound of live weight. Each colt had two quarts of skim-milk, commencing on the 16th of November, given with oat-meal at the time of weaning, and continuing for 30 days. The average ration per day for the whole 180 days, from the 16th of November to the 15th of May, exclusive of milk, consisted of 22 lbs. of clover hay, 6 lbs. of oat-meal, 3 lbs. of wheat bran, and 2 lbs. of oil-meal, for the three, making a daily allowance per head of 11 lbs. of this mixed food. The weight of each on the 15th day of May, was, No. 1, 634 lbs., a gain of 1.3 lbs. per day; No. 2, 616 lbs., a gain of 1.14 lbs. per day; No. 3, 630 lbs., a gain of 1.33 lbs. per day; being an average gain of 1.26 lbs. per head per day, during the cold season, on 11 lbs. of mixed food. This gives a pound live weight for 8.72 lbs., of mixed food. European feeders are much accustomed to estimate all foods on the basis of hay; thus the 11 lbs. of oats and other grain would be equal to 17 lbs. of hay, making the whole ration equal to 39 lbs. for the three colts, or 13 lbs. per head. This would make a pound gain in live weight cost 10.31 lbs. of hay.

Boussingault mentions that he tested the quantity of provender consumed by foals in full growth by taking Nos. 2, 4 and 5 when their united weight was 1,106 lbs., or their average weight 368.6 lbs., and found that they consumed 19.8 lbs. of hay and 7 lbs. of oats, which he calls equal to 11 lbs. of hay—all equal to 30.8 lbs. of hay, or 10.26 lbs. each. On this they made an average gain of 1.2 lbs. per day. This was doing slightly better than our three colts; but he does not state how long this experiment continued, and we are left to infer that it was not long. Both of these cases show that the colt utilizes his food as well, and adds a pound live weight from about the same food as the calf. If we take the united weight (1,200 lbs.) of our three colts on the 16th of November, and their united weight (1,880 lbs.) on the 15th of May, we shall find that their average weight during that 180 days was 1,540 lbs., or 519 lbs. each; and if we call the ration 13 lbs. of hay, it gives 2½ per cent. of their live weight as an average ration. If we estimate the cost of this ration, we shall find the cost of putting a pound live weight upon a foal under full feeding,

| | | |
|---|---|---|
| 22 lbs. of | hay, at ½ cent | 11 cts. |
| 6 " | oats, at 1¼ cents | 7½ " |
| 3 " | bran, at ¾ cent | 2¼ " |
| 2 " | oil-meal, at 2 cents | 4 " |
| | Cost of 3.79 lbs. of gain | 24¾ cts. |

This makes a pound live weight put on a colt during the second six months cost 6½ cents. If we can raise good colts at this price for food, then horse-raising must be profitable. It is not claimed that this experiment establishes this cost accurately, but, in connection with the French experiments, it may be considered an approximation. It is quite reasonable to suppose, from present indications, that the farmers of the United States are to find as profitable a market for horses in Europe as for cattle; and thus this subject becomes one of great importance.

The foal will be affected favorably or unfavorably by the liberal or illiberal treatment of the dam before parturition, as well as the treatment of the dam and foal after the birth of the latter. The summer pasture furnished mares and foals should contain shelter against sun and rain. Open sheds are best, although trees with thick foliage will answer every purpose. But care must be taken that these wood pastures are not covered with logs upon which the foals may be injured. An open wood, by its cool shade, is favorable as a pasture, but it should be so cleaned up as to obviate all danger of injury to foals. The young foal is easily injured and an unsoundness inflicted. A prudent foresight should guard at least against probable dangers. When the dam and foal are kept in stable it should not only be warm and comfortable, but well lighted. Light is most important to young animals, and, in fact, to all animals. If the dam be fed generously during pregnancy and whilst nursing the foal, and the foal be fed as we have directed, it will be, in development and weight, equal to an ordinary three-year-old at twenty-four months.

### Exercise for Colts.

These young things are inclined to be playful and exercise their muscles liberally, and this, under proper precautions, should be encouraged. Muscles become developed, and acquire strength and endurance by exercise. These tender things will of course only lay the foundation for this development of muscle at this early age. This playful exercise consumes food which must be supplied with a liberal hand, for this exercise is necessary to the value of the future horse. The young eagle takes frequent short circles around its home-nest, preparatory to those longer flights with pinions nerved against the fierce, rude blasts over mountain and valley. Nature's process of educating colt and eaglet is very similar. Muscular development, great endurance come of frequent exercise. The foal is allowed to travel a few miles with the dam each day, after a month or two old, to give gentle exercise. In all cases care is taken not to heat the blood of the dam, and the moderate exercise of the foal in following her is a benefit.

## Food for Horses.

The horse is one of the most important of our domestic animals, being the principal draft animal on the farm, in cities, for commercial transshipment, and upon public roads. We have twelve millions of horses to feed and care for; and a knowledge of all the economies in their maintenance is of the highest consideration. Unfortunately, science has not made many accurate experiments to determine the proper feeding standards for horses under the various purposes for which they are kept.

Youatt gives the proportion of the ration usually employed in England for agricultural cart-horses as 8 pounds of oats and 2 of beans, added to 20 pounds of chaff; and then 34 or 36 pounds of the mixture is given as a day's ration to moderate-sized horses (probably of about 1,400 pounds' weight), on hard work. This chaff is hay and straw—half and half—cut together. And in this case they give no long hay at night. This observing author says of this mixed feed (grain and chaff together): "By this means the animal is compelled to chew his food; he cannot waste the straw or hay; the chaff is too hard and too sharp to be swallowed without sufficient mastication; and, while he is forced to grind that down, the oats and beans are ground with it, and yield more nourishment; the stomach is more slowly filled, and, therefore, acts better on its contents, and is not so likely to be overloaded. The increased quantity of saliva thrown out in the lengthened maceration of the food softens it and makes it fit for digestion."

He recommends, however, that the oats and beans should be ground and mixed with the chaff after slightly moistening it, so that the meal will not separate from it, but must be masticated with the chaff. This practice is quite generally followed by the English farmers. This last method is what they call manger feeding, and they give, as among the advantages of this system, that horses can completely masticate their food in a much shorter time, and leave so much longer time for rest.

The author has often urged the economy of this system of cutting the fodder of the horse and mingling the ground grain with it; and this has become the basis of the system in operation for feeding large numbers of horses on stage, omnibus and railroad lines, both in this country and in Europe.

## German Experiments.

Some recent experiments have been made, under the direction of Dr. Wolff, at Hohenheim, to test the comparative digestibility of foods by the horse and sheep; and, incidentally, they show the amount of food required by the horse experimented upon. Unfortunately the experiments were all made upon the same horse. The criticism to which German experiments are most liable is that they are generally tried on too limited a scale, and for too short periods, to fully accomplish the purpose intended; and yet these experiments have much interest on account of the great care in their execution; they throw much light upon the comparative economy of digestion in the horse and sheep, or between the ruminating and non-ruminating animals. Dr. Armsby translates the conclusions arrived at by Wolff, as follows:

1. Meadow hay is less fully digested by the horse than the sheep, the difference amounting to 11 or 12 per cent. of the dry substance.

2. The crude albuminoids of the hay is nearly as digestible by the horse as by sheep. In the better qualities of hay experimented upon, the difference amounted to from 4 to 6 per cent. of the total amount; while, in some of the poorer sorts, more was digested by the horse than by the sheep.

3. Of the non-nitrogenous constituents of hay, the nitrogen-free extract is slightly, and the crude fibre considerably better digested by the sheep than by the horse. As a result, the nutritive ratio of the portion of the hay digested is narrower in the case of the horse than in that of sheep. As regards fat, all the experiments gave very low results for this nutrient, owing to the presence of a considerable quantity of biliary products, etc., in the excrements.

4. In two kinds of lucerne hay the nitrogenous and nitrogen-free extract were equally well digested by the horse and by sheep, while the crude fibre appeared to be relatively better digested than that of meadow hay.

5. The digestibility of winter wheat straw was found to depend somewhat on the amount of mastication it received; but in general to be small. Under ordinary circumstances it seems to be hardly half as well digested by the horse as by ruminants.

6. Concentrated feeding stuffs (oats, beans and maize, the two latter soaked with water) are digested to the same extent by the horse and by sheep.

The result of the experiments on concentrated foods and coarse fodders seems to be borne out fully by practical experience in this country, in feeding the large numbers of horses used for hard labor on street railroads and omnibus lines, and with the practice of all livery men in cities and towns. It is found to be most profitable to feed only from 9 to 12 pounds of hay per day to each horse, and the rest of the ration in grain, either ground or whole. The tendency for the last twenty years has been to lessen the quantity of hay or other coarse fodder, while the oats or ground feed has been increased.

These experiments of Wolff show pretty clearly why the practice has taken this form. The concentrated food is better digested than the coarse fodder, after a certain amount is given. It requires a proportion of fibrous food to keep horses healthy; and from 25 to 40 per cent. of the whole weight of the ration for a work horse may be hay, and this will be economically digested. The light livery horse usually gets 8 to 10 pounds of hay and 12 pounds of oats; but the work horse gets 12 pounds of hay and 16 pounds of grain, often corn and oats ground together. It is well settled in practice that concentrated food is cheapest for the largest proportion of the ration for horses. And this appears to be scientifically explained in these German experiments. But we must not fail to gain what information these experiments afford in relation to the

## Standard Ration

required by a horse of given weight. The horse experimented upon had a weight varying from 1,100 to 1,200 lbs., and, when fed on hay exclusively, ate from 22 to 27½ lbs. per day. This was equal to from 19.4 to 24 lbs. of dry food, and when grain was also fed, the largest amount of dry matter was 25 lbs.

The experiments upon this one horse would indicate that 20 to 25 lbs. of dry matter is a full ration for a horse of 1,200 lbs. weight. Dr. Wolff found, during these experiments, that sheep consumed, per 1,000 lbs. live weight, 31.25 lbs. of hay, having 27.2 lbs. of dry matter. Some have interpreted this to mean that ruminants consume much more per weight than non-ruminants—as the sheep have consumed 30.7 per cent. more, per weight, than the horse—but this is probably an erroneous conclusion, for a proper consideration of the difference in the size of the animals may account for a large part of this greater consumption by the sheep. It would take six large or eight moderate-sized sheep to equal this horse in weight. Experiment has very clearly shown that large animals eat less, per weight, than smaller ones of the same species; that is, a horse weighing 1,600 lbs. will eat less than two horses of 800 lbs. weight; or two cows of 1,200 lbs. weight, each will eat less than three of 800 lbs. weight each. This is accounted for by greater surface for radiation of heat in the smaller animals, causing a greater consumption of respiratory food. But it is also probable that this horse was individually peculiar in the small consumption of food. And the following table, containing a summary of these experiments, shows that this horse often took insufficient nutrition to keep his normal weight. This table is instructive, as showing the amount of food digested, the work performed, and the changes in live weight. The work performed by the horse is represented in kilogramme-metres; an ordinary day's work being estimated at 1,500,000 kilogramme-metres.

LIGHT WORK.

| Work per day, kilogramme-metres. | Length of experiment. | Live weight. | Dry food per day. | Digested Per Day. | | | | Nutritive ratio 1: | Change in live weight per day. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Albuminoids. | Fat. | Carbo-hydrates | Total nutrients | | |
| | days. | lbs. | lbs. | lbs. | lbs. | lbs. | lbs. | | lbs. |
| 475,000 | 62 | 1,078 | 18.6 | 1.3 | 0.4 | 7.9 | 9.6 | 6 9 | —1 0 |
| 475,000 | 28 | 1,157 | 24 0 | 1 8 | 0.4 | 10.5 | 12.7 | 6.4 | 0 0 |
| 600,000 | 14 | 1,197 | 18.5 | 1.4 | 0.1 | 7.2 | 8.7 | 5 6 | —2.0 |
| 600,000 | 14 | 1,151 | 16.7 | 2.0 | 0.1 | 6 7 | 8 8 | 3.4 | —3 3 |
| 600,000 | 56 | 1,093 | 21.3 | 3 1 | 0.1 | 8.8 | 12.0 | 3.0 | 0.0 |
| 600,000 | 25 | 1,034 | 24 7 | 4 0 | 0.1 | 10 9 | 15 0 | 2.8 | +1.1 |
| 600,000 | 30 | 1,065 | 25 0 | 3 3 | 0 2 | 12 3 | 15.8 | 3.9 | +1 0 |
| 600,000 | 39 | 1,146 | 24.9 | 2.2 | 0.4 | 13.4 | 16.0 | 6.5 | +2.1 |
| *Ordinary Work.* | | | | | | | | | |
| 1,108,000 | 40 | 1,120 | 24.0 | 1.8 | 0 4 | 10.8 | 13 0 | 6.7 | —1.4 |
| 1,800,000 | 30 | 1,010 | 21.4 | 3 9 | 0 1 | 8.7 | 11.8 | 3.0 | —2.8 |

The experiments with light work show the amount of food required to sustain a horse of this weight under such circumstances, showing a loss in weight when the amount of dry food digested fell under 12 lbs., and when it exceeded 13 lbs. there was a gain in weight. But when the horse was put at ordinary work he lost 1.4 lbs. per day on 13 lbs. of nutriments utilized, and under heavier work, with slightly less food, lost 2.8 lbs. per day. The great omission here is that a full ration for heavy work, or even average work, was not given, and therefore it does not appear what ration would have been sufficient to keep his normal weight under full work. It is probable, that under the 7th and 8th rations for light work, with which he gained from 1 to 2 lbs. per day, would have sustained him under heavy work. These experiments seem to have been tried, primarily, to determine the digestibility of the foods, but they might have been made equally valuable also in the determining the proper standard for work.

Dr. Wolff recommends the following:

FEEDING STANDARDS FOR HORSES,

*Per 1,000 lbs. Live Weight.*

| | Total dry matter. | Digestible. Albuminoids. | Digestible. Carbo-hydrates. | Fat. | Nutritive ratio 1: |
|---|---|---|---|---|---|
| | lbs. | lbs. | lbs. | lbs. | |
| Light work | 21.0 | 1.5 | 9.1 | 0.3 | 6.5 |
| Ordinary work | 22.5 | 1.8 | 11.2 | 0.6 | 7.0 |
| Heavy work | 25.5 | 2.8 | 13.4 | 0.8 | 5.5 |

It is to be regretted that these experiments could not have been tested upon at least five horses, so that their teaching could have been given a confident, general application.

## PRACTICAL RATIONS.

We shall now consider the practical rations established in this country, as applied to large numbers of horses devoted to special work. The establishment of street railroads in cities has given steady and exacting employment to many thousands of horses. The cost of feeding so many animals has been the large item which has called for careful study to determine the most economical ration consistent with highest efficiency of service. Many experiments were made with various kinds of grain, and various methods of preparing the ration. Hay was fed long, and the grain, ground or whole, fed alone; but it was soon found that much more long hay was required than when cut into short lengths, and the ground grain fed upon the hay. Their experience was similar to that of the London Omnibus Company, many years ago. This company had 6,000 horses, and determined to test the relative value of cut and uncut hay, as well as ground and unground grain. To this end, 3,000 horses were fed ground oats, cut hay, and straw; and 3,000 were fed upon uncut hay and unground oats. The allowance to the first was—ground oats, 16 lbs.; cut hay, 7½ lbs.; cut straw, 2½ lbs. To the second was allowed—unground oats, 19 lbs.; uncut hay, 13 lbs. The horses which had 26 lbs. of ground oats, cut straw, and hay, did the same work as well, and kept in as good condition, as those that had 32 lbs. of unground oats and uncut hay. This was a saving of 6 lbs. per day on the feed of each horse, and was estimated at 5 cents per day, per horse, or $300 per day upon the 6,000 horses. This was demonstrating the economy of machinery over horse muscle in the mastication of food. These figures have a significance that would not attach to an experiment with a few horses. The result of a ration applied to 3,000 horses must be accepted as an unquestionable fact. In this it is a great contrast to the German experiments upon a single animal. The real advantage was not all in saving animal muscle in cutting and grinding; but the grinding reduced the grain to finer particles than the horse would masticate it; and, besides this, it assisted the hard-worked animal in eating its meals in so much less time; and this, giving so much more time to rest, would have a favorable effect upon its condition.

The ration of thousands of horses on street railroads in this country has, finally, been fixed upon the same principles. The ration for summer is half oats and half corn, ground together, 16 lbs. to each horse, with 12 lbs. of cut hay. In winter, 16 lbs. of corn-meal, with the same amount of hay, forms the ration. Corn-meal alone, in summer is too heating; but, in winter, the corn-meal seems well adapted to keeping up animal heat and condition, and, being cheaper than oats, is generally adopted in New York City; but in many other cities half oats is used the year round. If these companies would substitute clover hay for timothy, corn-meal would make a well-balanced ration. The clover would make up for the deficiency of the corn-meal in muscle-sustaining food. Clover is rejected because it is liable to be dusty, which may develop heaves; but this fear is groundless under the plan now adopted of moistening the cut hay and mixing the meal with it. It is fed in a damp condition, and, therefore, no dust can be present to affect the lung. Clover hay is not properly appreciated as a food for horses. It has a higher value than timothy, and is usually sold $2 to $3 per ton lower in market.

There are, probably, fifty thousand horses fed in our cities, for railroad and omnibus lines, on a ration very similar to these described. And if we go back forty years, we find that the Germans and Hungarians fed a ration very similar.

Mr. C. L. Fleischman gives the ration used upon the manor of Alcsuth, in Hungary, about 1840. Horses at labor were fed 12 quarts of heavy oats, 6 lbs. of hay, 4 lbs. of oat-straw, and 5 lbs. of steamed chaff. This is very similar to the London Omnibus Company's ration, being about the same weight as the ground oats, but less valuable, because unground; yet the steamed chaff would compensate for this.

The ration of all corn-meal and hay is not to be approved, except in winter, and not wholly then. The horse is used simply for his muscle, and corn is especially a fattening food, and not the best to replace wasted muscle. It is most admirably adapted as a respiratory food—producing animal heat and fat—and requires to be combined with more nitrogenous food. And a careful examination of the facts relating to the health and durability of horses, where corn-meal is fed almost wholly for grain, will show that they do not last so long as where oats are fed for the whole or half of the ration. The heating nature of corn will cause horses to perspire more easily, and thus subject them to the dangers of many diseases. This heating food is also a fruitful cause of diseases of the feet, which soon disable horses upon city pavements. The New York and Brooklyn car companies say that the average usefulness of a horse to them is four years. This is quite too short a time, if all the proper conditions of food and care are observed. These companies feed principally upon corn-meal, and sometimes the year round wholly upon corn as the grain food. There are other cities, employing 300 or more car horses, that feed half oats and half corn, ground together, upon 12 lbs. of hay, the average usefulness of whose horses is six years. It is also found that horses which have been raised largely upon corn are too tender-footed to stand city pavement. It is for this reason that Canada horses are preferred for street-car service; they having been raised upon grass, oats, roots and peas. Corn is the standard food for beef raising; but not for building up the best horse muscle and bone in rearing colts, or as an exclusive grain diet for hard work. Western horse raisers should study this question of the effect of an excessive corn ration upon the stamina of their young horses. Oats and barley should furnish the grain food for their colts. Corn may properly enter into every ration for work; and we shall soon consider the various combinations that may be made with corn as the basis of the ration.

As has been seen horses digest concentrated food, such as grain, when that forms part of the ration, better than coarse fodder, when that forms the whole ration. And it is at this point that we wish to give a short discussion of the necessity for

### Bulky Food

as part of the ration for the horse. We have incidentally referred to this before, but it requires a separate and special consideration, as it does not seem to be clearly understood even by some veterinarians of high standing. For instance, Dr. Spooner, of England, in discussing rations for horses, in Morton's "Cyclopedia of Agriculture," after speaking of the small comparative size of the stomach of the horse, says: "It seems evident that he was intended by nature to consume concentrated food, such as grain; and the formation of the molar teeth strongly corroborates this view of the matter. These molar teeth, or grinders, as they are very expressively termed, are broader and less cutting than those of the ox, but decidedly better adapted for grinding corn, as in a mill; for the teeth of the upper and lower jaw do not exactly correspond, but the teeth of the latter are narrower, as well as the jaw itself, so that the lower jaw is moved from side to side, and the grain is thus triturated and ground as between two millstones."

From this he concludes that "such poor, bulky food as straw or roots is unwholesome and innutritious as a diet for working horses, as unwholesome as for man to live entirely upon potatoes."

This view is certainly reasonable; and then he goes on to speak of good hay being the cheapest food for horses, considering its nutriment, but that it is too bulky as a complete ration for labor. Oats, he finds dearer, but containing just the nutriment to sustain and replace muscle wasted in labor. Beans are still more concentrated than oats, and contain a larger proportion of muscle-sustaining food, and are cheaper; but if given freely are too heating and stimulating, and are apt to produce inflammatory swellings of the limbs. Beans may be given in combination with oats—one-third beans and two-thirds oats. He says it has been proposed to overcome the too concentrated and heating nature of beans by feeding with bran: that beans are astringent and bran laxative, so far as they supply each other's deficiencies, but closely resemble each other in abundance of albuminous elements; and both are deficient in starch, etc. He tried the experiment of substituting a bushel of beans and a bushel of bran for two bushels of oats, but he soon found that the horses did not do so well on this diet.

This is the substance of his explanation. It appears evident that he did not quite see that the bean-and-bran ration lacked husk or woody fibre to make a proportional bulk to the nutriment contained. Oats contain as much bulk of fibre as of concentrated meal when ground, and therefore, when masticated, the food goes into the stomach in a light, porous condition, and the gastric fluid can pass freely through it and act upon every part at once, while the bean-meal and bran would form a more compact mass, and the gastric fluid could not so completely act upon it, and the result is the inflammatory swellings which he mentions. The result was not caused by the defective nutrition contained in the food, but from its compact nature. The horse's digestive organs are adapted to a larger proportion of concentrated food than those of the ox, but cannot be healthy upon concentrated food alone. In a state of nature the horse is nourished upon the grasses, and it must have a proportion (at least one-half in bulk) of fibrous food; and this fibrous food must be mingled with the concentrated, so as to render the food as it goes into the stomach porous. This is the significance of bulk in food. It is quite true that the horse must have a ration well balanced in all the constituents required to keep up animal heat and to supply the natural waste of the system, but this ration must also be so made up, mechanically, that the digesting fluid can properly act upon it. Inattention to this point has been, perhaps, the most fruitful cause of all his ills. In the use of bean-meal as a grain ration, if Dr. Spooner had mixed this bean-meal with three times its bulk of cut hay, all danger from its concentrated nature would have been avoided. This is not theory; we have thoroughly tested pea-meal (a food almost exactly similar, chemically) by feeding horses under heavy work upon 16 lbs. of pea-meal, mixed and fed with one bushel of cut hay, the hay being moistened so that the pea-meal would adhere to the hay and all be eaten together. Long hay was given in addition, making about 12 lbs. of hay. Four horses were thus fed for four months, performing full daily labor. The average weight of the horses at the beginning of the experiment was 1,050 lbs., and at the end, 1,065 lbs. We carefully watched the condition and health of the horses, and found both quite satisfactory. There was no indication of a feverish state of the system, or any disturbance of the digestive functions, and the appetite remained very uniform with every appearance of content. We should have continued this ration indefinitely but for the higher price of peas than of corn and oats.

If we examine this ration of pea-meal and hay, we find it well adapted to heavy work—the digestible albuminoids being 3.82 lbs., carbo-hydrates 13.91 lbs., and fat .44 lbs.—the entire digestible nutrients amounting to 18.17 lbs., with a nutritive ratio of 1:4. This is slightly deficient in fat, with an excess of muscle-forming matter; but we regard it as better than Wolff's ration for heavy work, given on page 377. The fact that the horses made a slight gain in weight proved that the extra muscle-forming food was well applied. But the principal object was to determine the effect of mixing this concentrated food with hay to give bulk and a porous condition to the food in the stomach. This effect was emphasized from an opposite experiment, tried at the same time, by a neighbor who did not think it made any difference whether the pea-meal was mixed with the hay or fed separately, with the hay given uncut. He also fed four horses, of about the same weight as those in my experiment. His were engaged in lumbering, and often hauled heavy loads. He fed 16 lbs. of pea-meal per horse, in three feeds. Within six weeks two of his horses had severe attacks of colic, and both of the others had to be treated for constipation. The writer then prevailed upon him to feed the pea-meal with one bushel of cut hay, in the manner above stated, and in a few weeks they were all in apparent health and able to do efficient work. The effect was so favorable, that he continued to feed meal—whether of peas, corn or other grain, mixed with cut hay—and told the author that he never had a case of colic afterwards.

### Corn-meal for Horses.

Corn-meal has long been a staple food for horses, as well as other stock in the United States, and is now largely purchased in England and Europe as a part of the ration for work-horses. It is quite as concentrated as bean-meal, and more heating in its nature, because it has a larger proportion of carbo-hydrates than beans, peas, oats or barley, and is comparatively deficient in muscle-forming elements. Corn, when ground into fine meal (the best condition for feeding) and moistened, becomes very plastic and adheres into a solid mass, not easily penetrated by any liquid. When corn-meal is masticated by a horse it becomes saturated with saliva and takes the form of a plastic adhesive mass, and in this form goes into the stomach of the horse. It is obvious that the muscular movements of the stomach can only move or roll this mass about, but cannot separate or loosen its particles so as to render it sufficiently porous for the circulation and operation of the gastric juice. It is for this reason that whole corn, or that coarsely ground, may be fed alone to a horse with less danger of colic or other diseases induced by a fevered stomach, because in the form of cracked kernels it cannot adhere into such a solid, plastic mass, and what is not digested will be passed in the droppings. But as the object of grinding is to reduce the grain to such fine particles that the digesting fluid may saturate and completely act upon it in the shortest time, the value of grinding is in proportion to the fineness of division. And when this finely-ground corn-meal is mixed with a little more than half its weight, but several times its bulk, of cut hay, as above described, this fibrous hay so completely separates the particles of meal as to form a spongy, porous mass, that fluids will pass through freely. When the horse masticates the meal he also masticates the hay, and the whole goes into the stomach together. This seems to be in imitation of nature, for when the horse eats grain or ripened grass in its natural state, he eats the stalk with the seed. When man, therefore, separates the grain for the purpose of grinding or making a more economical use of, he should again mix it with fibrous food, that the horse may not suffer from too concentrated a food.

And, as we have seen, the street railroad companies and omnibus lines have discovered the necessity of remingling the grain with coarse fodder. These great practical examples are sufficient authority for the practice, but we thought it important to give the reasons on which the practice is founded.

Indian corn is the great food crop for animals in this country, and is produced in nearly every county of every State, and probably more cases of horse colic arise from feeding corn-meal than from all other foods combined; and this especially occurs among farm horses, because farmers study the philosophy of foods very little, or the effect of condition in foods upon animal health. They feed what is most convenient and cheapest, without considering that any good food can be other than healthy. We have known of the death of at least a dozen horses which, on examination, proved to be caused by feeding corn-meal alone. Some feed wet and others dry. But, when fed alone, it is more dangerous wet than dry, because the wet meal may be swallowed with very little mastication, while the dry meal must be masticated till the saliva saturates it before it can be swallowed, and the saliva assists digestion. It is, therefore, in better condition for digestion when fed dry than wet. But four of those who had lost horses by feeding meal alone, when they changed the system and fed the meal upon cut hay, moistened, so that both must be eaten together, had no further losses or even illness of their horses.

In our experience of about thirty years in feeding work horses, no ill effects have arisen from feeding corn-meal, ground as fine as burr millstones can properly do it, when mixed with cut hay or straw. We have had cases of colic, but it was always traced to carelessness of the feeder and violation of orders in not mixing the meal with cut hay. We have fed horses, from four years old to twenty, upon various concentrated grains, ground into fine meal, and they were always in good health when the rule of mixing fine meal with cut hay or straw was strictly adhered to.

The following fatal case occurred: In our absence an acquaintance called, on his return from a pleasant drive of a hundred miles west, in June. Putting his fine, sixteen-hand, iron-gray horse into the barn, piloted only by a little boy of seven, he was proceeding to give his horse a good, round measure of fine corn-meal, when the boy warned him that it would make his horse sick if he did not mix it with cut hay; and he replied, "I will risk it." Starting an hour later to drive eight miles, he was scarcely able to get his horse that distance, and he died before morning. Speaking of it afterwards, he said: "The boy warned me, but I was not humble enough to learn wisdom from babes, and I lost my horse." But he consoled himself with the reflection that this experience saved him other horses afterwards.

The universality of corn everywhere, and its excellent quality as a fattening food and for keeping horses with light work, it becomes a matter of great importance that horse owners should study the best use of this food, and how to combine it with other foods. As we have often said, Indian corn is deficient in muscle-sustaining food, and the skill of the feeder consists in combining this with other grains or feeding stuffs that are rich in the elements in which corn is deficient. We can better point out these combinations after giving a table of the analyses of the different grains and by-products used in different parts of the country as food for horses, to which we add the different grasses used as hay, and some straw.

| Foods. | Water. | Digestible Nutrients. | | | Nutritive ratio. | Value. | |
|---|---|---|---|---|---|---|---|
| | | Albuminoids. | Carbo-hydrates. | Fat. | | Dollars, per 100 pounds. | Compared with meadow hay=1. |
| Meadow hay, average | 14.3 | 5.4 | 41.0 | 1.0 | 8 0 | 0.64 | 1.00 |
| Clover, red, average | 16.0 | 7.0 | 38.1 | 1.2 | 5.9 | 0.69 | 1.08 |
| Timothy, average | 14.3 | 5.8 | 43.4 | 1.4 | 8.1 | 0.69 | 1.09 |
| Hungarian, average | 13.4 | 6.1 | 41.0 | 0.9 | 7.1 | 0.66 | 1.04 |
| Alsike clover | 16.7 | 8.4 | 32.1 | 1.9 | 4.2 | 0.73 | 1.14 |
| Pea-hay, in blossom | 16.7 | 8.7 | 35.6 | 1.8 | 4.6 | 0.77 | 1.20 |
| Early meadow (*Poa annua*) | 14.3 | 6.0 | 42.5 | 2.1 | 7.9 | 0.74 | 1.16 |
| Orchard grass, in blossom | 14.3 | 6.9 | 40.3 | 1.9 | 6.5 | 0 94 | 1.16 |
| Blue grass (*Poa pratensis*) | 14.3 | 5.9 | 40.0 | 1.6 | 7.5 | 0.68 | 1.06 |
| Corn-fodder, good | 27.3 | 3.2 | 43.4 | 1.0 | 14.4 | 0.57 | 0.91 |
| Rye-straw | 14.3 | 0.8 | 36.5 | 0.4 | 46.9 | 0.35 | 0.55 |
| Oat-straw | 14.3 | 1.4 | 41.1 | 0.7 | 29.9 | 0.44 | 0.69 |
| Barley-straw | 14.3 | 1.3 | 40.6 | 0.5 | 32 2 | 0.44 | 0.68 |
| Wheat-straw | 14.3 | 0.8 | 36.0 | 0.4 | 46.3 | 0.37 | 0.58 |
| Corn (Western yellow) | 13.0 | 7.5 | 67.3 | 3.1 | 10.0 | 1.04 | 1.62 |
| Corn (Southern white) | 12.7 | 8.2 | 68.8 | 3.1 | 9.2 | 1.09 | 1.67 |
| Corn-sugar meal | 72.2 | 3.2 | 19.3 | 1.8 | 7.4 | 0.39 | 0.60 |
| Wheat middlings | 11.4 | 10.0 | 48.5 | 3.1 | 5.6 | 1.01 | 1.58 |
| Rye-bran | 12.9 | 10.6 | 50.0 | 2.3 | 5.3 | 1.00 | 1.56 |
| Malt sprouts | 11.6 | 20.8 | 43.7 | 0.9 | 2.2 | 1.23 | 2.08 |
| Linseed-cake | 9.1 | 27.6 | 27.0 | 6 0 | 2.0 | 1.89 | 2.98 |
| Linseed-meal (new process) | 10.7 | 27.8 | 33.9 | 2.56 | 1 2 | 1.69 | 2.64 |
| Cotton-seed meal, decorticated | 7.2 | 33.2 | 17.6 | 6.0 | 1 8 | 2.30 | 3.60 |
| Linseed (flax-seed) | 12.3 | 17.2 | 18.9 | 35 2 | 6.0 | 2.44 | 3.81 |
| Cotton-seed (decorticated) | 7.7 | 17.1 | 14.7 | 27.3 | 4.6 | 2.06 | 3.21 |
| Rye | 14.3 | 9.9 | 65.4 | 1.6 | 7.0 | 1.08 | 1.68 |
| Barley | 14.3 | 8.0 | 58.9 | 1.7 | 7.9 | 0.95 | 1.47 |
| Oats | 14.3 | 9.0 | 43.3 | 4.7 | 6.1 | 0.98 | 1.53 |
| Millet | 14.0 | 9.5 | 45.0 | 2.6 | 5.4 | 0.93 | 1.45 |
| Buckwheat | 14.0 | 6.8 | 47.0 | 1.2 | 7.4 | 0.77 | 1.19 |
| Peas | 14.3 | 20.2 | 55.4 | 1.7 | 2.9 | 1.44 | 2.25 |
| Beans | 14.5 | 23.0 | 50.2 | 1.4 | 2.3 | 1.51 | 2.26 |
| Vetch | 14.3 | 24.0 | 48.2 | 2.5 | 2.2 | 1.63 | 2.53 |

We give in the above table only the amount of digestible constituents, as these constitute the value of a food. This table contains nearly everything fed to horses. Malt sprouts are not often used as horse feed; but there is no reason why they should not be. They are usually in a dusty condition, and this may be the reason why horse feeders have not made use of them; but as it is customary to soak malt-sprouts before feeding them to cattle, they are then in a proper condition to feed horses. Malt sprouts are also somewhat bulky, and when mixed with corn-meal will make that less concentrated. If malt sprouts are used, the proportion may be 11 lbs. corn-meal, 5 lbs. sprouts, and 12 lbs. timothy hay. The corn-meal and sprouts may be soaked for six or more hours, and then mixed with one bushel of cut hay. Cut hay weighs 7 to 9 lbs. per bushel. The other 3 lbs. of hay may be given uncut. Even poor hay or straw may be used in this ration, because of the large proportion of muscle-forming matter. The vetch, of which an analysis is given, is not much raised in this country, but is in portions of Canada, and the future is likely to see it extensively cultivated over large portions of the Western States, to which it is well adapted, and is important as a food to balance the deficiencies of corn. We will now give several practical rations in which corn forms a part, and give the rations in detail, so as to show our readers how to make up rations from the table.

These rations represent a few only of the almost endless combinations of foods that may be made for horses when subjected to hard work. The albuminoids should amount to from 2½ lbs. to 3½ lbs. per day. No. 2 is apparently deficient in this element; but we have used this ration with good results for three or more months. It will also be seen that good clover hay, 12 lbs., and 16 lbs. corn-meal, will give 2.24 lbs. of muscle-forming matter, and make a very good ration to work on; but it would be much improved to give 14 lbs. of corn-meal and 2 lbs. of oil-meal. This renders it less heating, and the oil has the effect of cleansing the stomach and intestines, and preventing all danger of a constipated condition of the system.

RATIONS FOR HORSES, PER 1,000 LBS. WEIGHT.

| | Cost. | Dry organic substance. | Digestible. Albuminoids. | Digestible. Carbo-hydrates. | Digestible. Fat. |
|---|---|---|---|---|---|
| **No. 1.** | cents. | lbs. | lbs. | lbs. | lbs. |
| 12 lbs. timothy hay | 06 | 10.29 | 0.69 | 5.20 | 0.17 |
| 11 lbs. corn-meal | 11 | 9.57 | 0.92 | 6.66 | 0.52 |
| 5 lbs. malt sprouts | 03 | 4.42 | 1.04 | 2.19 | 0.05 |
| | 20 | 24.28 | 2.65 | 14.05 | 0.74 |
| **No. 2.** | | | | | |
| 8 lbs. red clover | 4 | 6.72 | 0.56 | 3.05 | 0.10 |
| 6 lbs. oat-straw | 1½ | 5.14 | 0.08 | 2.47 | 0.04 |
| 12 lbs. corn-meal | 12 | 10.44 | 1.01 | 8.07 | 0.57 |
| 6 lbs. wheat middlings | 3½ | 5.32 | 0.60 | 2.91 | 0.19 |
| | 21 | 27.62 | 2.25 | 16.50 | 0.90 |
| **No. 3.** | | | | | |
| 8 lbs. alsike clover | 4 | 6.72 | 0.67 | 2.57 | 0.15 |
| 6 lbs. corn-fodder | 2 | 4.37 | 0 20 | 2.60 | 0.06 |
| 10 lbs. corn-meal | 10 | 8.70 | 0.84 | 6.60 | 0.48 |
| 6 lbs. rye-bran | 3 | 5.23 | 0.64 | 3.00 | 0.14 |
| 2 lbs. linseed-meal | 2½ | 1.79 | 0.55 | 0.67 | 0.05 |
| | 21½ | 26.81 | 2.90 | 15.44 | 0.88 |
| **No. 4.** | | | | | |
| 12 lbs. blue-grass hay | 6 | 10.29 | 0.71 | 4.80 | 0.20 |
| 8 lbs. corn-meal | 8 | 6.96 | 0.67 | 4.84 | 0.35 |
| 3 lbs. linseed-cake | 4½ | 1.73 | 0.83 | 0.82 | 0.18 |
| 6 lbs. wheat middlings | 3½ | 5.32 | 0.60 | 2.91 | 0.19 |
| | 22 | 24.30 | 2.81 | 13.37 | 0.92 |
| **No. 5.** | | | | | |
| 6 lbs. meadow hay | 3 | 5.14 | 0.33 | 2.46 | 0.06 |
| 8 lbs. wheat-straw | 2 | 6.86 | 0.07 | 2.88 | 0.03 |
| 8 lbs. corn-meal | 8 | 6.96 | 0.67 | 4.84 | 0.35 |
| 6 lbs. pea-meal | 7 | 5.14 | 1.21 | 3.26 | 0.10 |
| 2 lbs. cotton-seed meal | 2½ | 1.95 | 0.66 | 0.[illegible]5 | 0.12 |
| | 22½ | 27.95 | 2.94 | 13.79 | 0.66 |

But let us call attention to that grain ration which is easily obtained in all parts of the country—equal weight of oats and corn ground together—16 lbs. of the composition fed with one bushel of cut hay, or half hay and half straw, will enable a team horse to do good work. But a better ration still is, 950 lbs. of oats, 950 lbs. of corn, and 100 lbs. of flax-seed, all ground together. The 20th part of flax-seed improves the ration in albuminoids, and very much in oil—35 lbs., or 1¾ per cent. to the 2,000 lbs. We have fed this for long periods—sometimes two years continuously—and have found no ration that surpasses it. It is well balanced as a working ration, and just laxative enough for health. It keeps the coat fine and glossy; and, as I think, by its aperient quality, prevents colds and other diseases following them. It is probable that decorticated cotton-seed would do as well as flax-seed, and would be a valuable addition to the ration for Southern horses. Decorticated cotton-seed meal may also be profitably used in the ration for horses, but it should seldom exceed 1½ to 2 lbs. per day.

The American Institute Farmers' Club appointed a committee to make a thorough examination of the method of feeding in omnibus and railroad stables of New York City, where the number of horses is so large that a useful lesson could be learned. This was in 1855. (See transactions of that year.) We give the important part of the report, and our readers can study it with profit:

"It is the object of the stage proprietors to get all the work out of their teams possible, without injury to the animals. Where the routes are shorter, the horses consequently make more trips, so the different amounts and proportions of food consumed are not so apparent when the comparison is made between the different lines, as when it is made also with the railroad and livery horses. The stage horses consume the most and the livery horses least.

The stage horses are fed on cut hay and corn-meal, wet, and mixed in the proportion of about one lb. of hay to two lbs. of meal, a ratio adopted rather for mechanical than physiological reasons, as this is all the meal that can be made to adhere to the hay. The animals eat this mixture from a deep manger. The New York Consolidated Stage Company use a very small quantity of salt. They think it causes horses to urinate too freely. They find horses do not eat so much when worked too hard. The large horses eat more than the small ones. Prefer a horse of 1,000 to 1,100 pounds weight. If too small, they get poor, and cannot draw a stage; if too large, they ruin their feet, and their shoulders grow stiff and shrink. The principal objection to large horses is not so much the increased amount of food required, as the fact they are soon used up by wear. They would prefer for feed a mixture of half corn and half oats, if it were not more expensive. Horses do not keep fat as well on oats alone, if at hard labor, as on corn-meal, or a mixture of the two.

"Straw is best for bedding. If salt hay is used, horses eat it, as not more than a bag of 200 pounds of salt is used in 3 months. Glauber salt is allowed occasionally as a laxative in the spring of the year, and the animals eat it voraciously. If corn is too new, it is mixed with an equal weight of rye bran, which prevents scouring. Jersey yellow corn is best, and horses like it best. The hay is all cut, mixed with meal, and fed moist. No difference is made between day and night work. The travel is continuous, except in warm weather, when it is sometimes divided, and an interval of rest allowed. In cold weather the horses are watered four times a day, in the stable, and not at all on the road. In warm weather, four times a day in the stables, and are allowed to sip on the middle of the route.

"The amount that the company exact from each horse is all that he can do. In the worst of the traveling, they fed 450 bags per week, of meal, of 100 lbs. each. They now feed 400. The horses are not allowed to drink when warm. If allowed to do so, it founders them. In warm weather a bed of sawdust is prepared for them to roll in. Number of horses, 335. Speed varies, but is about four miles an hour. Horses eat more in cold weather than in warm, but the difference has not been exactly determined."

| STAGE LINES. | No. of animals. | Miles of daily travel. | Pounds of cut hay daily fed. | Lbs. of corn-meal daily. | Lbs. of salt per month. | Increase of meal for recent severe term of traveling. |
|---|---|---|---|---|---|---|
| Red Bird Stage Line | 116 | 17 | 14 | 18 | 1½ | 3½ |
| Spring Street Stage Line | 105 | 21 | 14 | 20 | 4 | 3½ |
| Seventh Avenue Stage Line | 227 | 22 | 10 | 18½ | 1 | 2½ |
| Sixth Avenue Railroad, horses | 117 | 17 | 10 | 14 | 2 | .... |
| Sixth Avenue Railroad, mules | 211 | 17 | 10 | 7 | 2 | .... |
| N. Y. Consolidated Stage Co., | 335 | 21½ | 8 | 17 | 2.9 | 2½ |
| Washington Stables, six livery horses, | .... | .... | 12 | 7½* | .... | .... |

* And six quarts of oats at noon.

From this report it appears:

1. That it is possible to keep horses in good condition with hard work when fed on cut hay and corn-meal alone. (We proved this thoroughly in our own experience, but found they did better if the hay was clover.)

2. A mixture of oats were found to benefit the horses, but to increase the expense of keep. Corn-meal keeps horses fat better than oats.

3. Rye bran is found to prevent scouring.

4. Ten pounds of hay is found sufficient for work horses.

The following table, giving detailed information of the practice of many horse-feeders in England, is taken from *London Agricultural Gazette*, for Nov. 25, 1865.

## Stable Feeding During Winter.

| No. | Name and Address. | Hay, per week. | Oats, per week. | Beans, per week. | Roots, per week. | Sundries, per week. | Straw, per week. | Weekly cost. |
|---|---|---|---|---|---|---|---|---|
| | | lbs. | lbs. | lbs. | lbs. | lbs. | lbs. | |
| 1 | Professor Low—Elements of Agriculture.......... | 56* | 56* | .... | Potatoes 56† | ......... | 56* | $1.56 |
| 2 | H. Stephens—Book of the Farm.................. | 112 | 35 | .... | Turnips 112 | ......... | ......... | 1.44 |
| 3 | J. Gibson, Woolmet—H. Soc., 1850.............. | ......... | 84 | .... | 217† | Potatoes 217† | 112 | 2.16 |
| 4 | Binnie, Seaton ........... | ......... | 70* | 28* | 243† | Barley 42† | ad lib. | 2.76 |
| 5 | Thompson, Hanging Side. | ......... | 84 | 14 | 336 | 14 | ad lib. | 2.28 |
| 6 | W. C. Spooner—Ag. Soc. Journal, vol. ix... ..... | ... ..... | 63 | .... | 42 | ......... | 196 | 1.14 |
| 7 | T. Aitken, Spalding, Lincolnshire.............. | ad lib. (⅔) | 37 | .... | ..... ... | ad lib. (⅓) | ......... | 2.16 |
| 8 | G. W. Baker, Woburn, Bedfordshire.............. | ......... | 60* | 20* | ........ | ......... | ......... | 2.32 |
| 9 | R. Baker, Writtle, Essex.. | 70 | 42 | .... | ..... ... | ......... | 140 | 1.20 |
| 10 | J. Coleman, Cirencester... | ......... | 84 | 16 | ........ | ......... | ad lib. | 1.74 |
| 11 | T. P. Dods, Hexham...... | ......... | 95 | .... | 56 | ........ | ad lib. | 1.92 |
| 12 | J. Cobban, Whitfield ..... | 84* | 60* | .... | ........ | Linseed 3½ | ad lib.* | 1.74 |
| 13 | S. Druce, Jr., Ensham.... | 112 | 52 | .... | Swedes 70 | ......... | 2 bush.* | 1.68 |
| 14 | C. Howard, Biddenham. | ad lib. (⅔) | 52 | 17 | 84 | ......... | ad lib. (⅓)* | 2.04? |
| 15 | J. J. Mechi, Tiptree ..... | 49* | 70* | ... | M. Wurzel 210 | ......... | ad lib.* | 1.80 |
| 16 | W. J. Pope, Bridport... | 2* | 84 | .... | ........ | ......... | ad lib. | 2 16? |
| 17 | S. Rich, Didmarton, Gloucestershire ............ | 168 | 63 | ... | ........ | Grains 2 bush. | ad lib. | 2.56 |
| 18 | H. E. Sadler, Lavant, Sussex........... ........ | 140 | 84 | .... | .... .... | ......... | ......... | 2.24 |
| 19 | J. Morton, Whitfield Farm | ......... | 126 | .... | Carrots 350 | ..... ... . | ad lib. | 2.58 |
| 20 | E. H. Sanford, Dover..... | 56 | 42 | ... | ........ | Bran 12 | ad lib. | 1.32 |
| 21 | A. Simpson, Beauly, N. B. | ......... | 49 | 7 | 105 | Tail corn 21 | ad lib.* | 1.32 |
| 22 | H. J. Wilson, Mansfield .. | 42 | 52½ | .... | ........ | Bran 21 | ad lib. | 1.56? |
| 23 | F. Sowerby, Aylesby, N'th Lincolnshire... ........ | 112 | 28 | cut oat sheaf | | ......... | ad lib.* | 1.92? |

Where an asterisk (*) is attached to any item, it is to be understood that the corn has been bruised or ground, or the hay or straw has been cut into chaff. Where a dagger (†) is appended, the article so marked has been boiled or steamed. A mark of interrogation (?) indicates that the result so marked is uncertain, owing to some indefiniteness in the account given.

Mr. Slater, of Western Colville, Cambridgeshire, speaking of his feeding pulped roots, says: "I give all my cart horses a bushel per day of pulped mangel, mixed with straw and chaff. I begin in September, and continue using them all winter and until late in the summer, or nearly all the year round, beginning with smaller quantity, about a peck, and then a half bushel, for the first week or two, as too many of the young-growing mangel would injure the horses. I believe pulped mangels, with chaff, are the best, cheapest, and most healthy food horses can eat. I always find my horses miss them when gone, late in summer. Young store-horses, colts, etc., do well with them."

Farmers, who preserve green corn in silos, may produce the same effect with ensilage, as Mr. Slater does with pulped mangel. There is no doubt that the pulped mangel have a very beneficial effect upon the digestive organs, but we much doubt the propriety of feeding to working horses as much as a bushel of pulped mangel. This would be equal to 60 pounds of corn ensilage or green corn, whilst 30 to 40 lbs. would be quite sufficient. Clover and the grasses ensilaged, could, properly, form one-half to three-fourths of the ration for horses with slow work, for the clover and grass ensilage would contain the requisite muscle-forming food for work.

The table last given shows the variety of food given by English farmers to their horses—that oats form the principal concentrated food of the ration, beans being fed sparingly, probably because of greater cost. Hay is fed much less liberally there than by farmers in this country, who, no doubt, feed too much hay and too little grain. It will also be noted that English farmers, very generally cut the hay and straw fed to horses, and, where this is done, the ground feed is given with the chaffed hay and straw. This, as we have before shown, is promotive of easier and more complete digestion of the food and of the health of the horse.

## Feeding for Fast Work.

It may be expected that we should speak of the rearing and feeding of horses used for speed. Our remarks on the foal and colt will mostly apply to the finest racing or trotting blood. We are aware that few horsemen have been accustomed to use, as we have recommended, cow's milk after weaning. But a moment's consideration of milk shows its distinguishing characteristics to be its casein and albumen—an admirable combination with nitrogen for the formation of muscle. This nitrogenous compound in milk is in solution, and easily appropriated by the digestive organs. A moderate allowance of sweet skimmed milk is exactly adapted to the continuance of the muscular growth of the foal after weaning. There is no objection to fresh milk from the cow, as it will have the cream in addition to the other good qualities, but sweet skimmed milk will meet all the necessities of the case at considerable less expense. Suppose the foal at and after weaning be allowed ten pounds of skimmed milk—this will contain $\frac{4}{10}$ pounds of digestible albuminoids or muscle-forming material; and it would take five quarts of oats to yield as much digestible nutriment for the muscular system. If we estimate the milk at ¼ cent per pound or 2½ cents (a price farmers would like to realize), it will be seen how much cheaper it is than oats.

We do not mean that ten pounds of skimmed milk contain as much of all the elements of food as five pounds or quarts of oats, but that it contains as much for the muscles, just what is needed most at this period in the growth of the foal. Besides, the milk-sugar or small amount of fat is excellent carbonaceous food, and the ash contains the mineral elements of bones. For a short time after weaning there should be a tablespoonful of boiled flax-seed mixed in the milk to prevent all tendency to constipation. The foal should be learned also to eat a quart of oats or finished wheat middlings. There should be no forcing in the feeding—aim to keep a keen appetite for food, which assures a better digestion.

If easily obtained this milk should be continued three or more months after weaning; and after this, one quart of oats and one to two quarts of wheat middlings should be continued till grass affords a good living.

For all constipation, rely upon small quantity of boiled flax-seed instead of oil, for that is dangerous from possible adulteration.

In rearing this colt, designed for fast work, a parsimonious policy should have no place. Scanty feeding must, in the nature of the case, defeat the purpose in view. Complete development cannot result except from generous feeding. The feeder may indeed choose among various combinations of food. Some may cost less than others, and yet be equally good for the purpose. But he must not lose sight of the fact that there must always be a proper combination of concentrated and bulky food. Horses are, perhaps, fonder of oats than any other grain, yet when fed too freely upon oats they will eat, with great relish, even the bedding in their stalls. However good a single food may be, an animal must not be confined to it. A combination of foods, given together in the same ration, will be relished much longer, and, for working horses, such combined ration will be satisfactory for many months together, but for the horse, devoted to fast work, his taste must be studied and humored by a frequent change of food, each selected, however, for its quality of nourishing the muscles.

The English farmer raises the horse-bean as a specialty for horses, but that species does not succeed in this country. Our grains, which may be considered especially appropriate in larger or smaller quantity for the healthy development of horse muscle, are: Oats, barley, rye, millet, peas, vetch, and the oil-bearing flax-seed, and, perhaps, cotton-seed. Cotton-seed, when decorticated, would be excellent to mix 1-20 with oats, barley, rye, etc., before grinding. When the tough rind is taken off it is a healthy food, in small quantity. Its large per cent. of oil would prevent its being fed as more than a fifteenth part of the ration. But the oil in that small part of the ration would be sufficient to keep the digestive organs in an open, healthy condition. All this may be more strongly said of the good effects of flax-seed, when used in this small proportion. The husk of flax-seed is not objectionable like that of cotton-seed, and the oil is extremely mild and soothing.

The author has used flax-seed, in the small proportion mentioned, in feeding colts, intended for fast work, with the most satisfactory results—keeping their coats in fine condition, the skin clean, the bowels free, and by this giving an even development to the muscles of the limbs and whole body. When thus using flax-seed in the ration, never had a case of staring coat or feverish condition of the system.

We have given these various grains, which are easily produced in most parts of the country, and will afford a good variety of food to promote the health and growth of the young, and the health and capacity for work in the mature horse.

*Oats*, by common consent, stand at the head. But it is highly probable, that the real reason for this general preference for oats, rests upon the fact that about ⅓ of oats consists of husk, which must be eaten with the meat of the grain, and thus gives bulk in the masticated food, and a loose texture through its substance, permitting a freer circulation and more complete digestive action of the gastric juice.

*Barley* is an excellent food for horses, but is not generally used because of its greater value for malting. Its husk is some 25 per cent. less than oats, and is, therefore, not quite so healthy a food to be given alone and unground, but when ground and mixed with cut and moistened clover-hay, makes a desirable ration for young or mature horses.

*Rye* is of greater weight per bushel, has 60 per cent. less husk than oats, but has also a less percentage of albuminoids than the latter, and also more carbo-hydrates and a slightly lower nutritive ratio, but when ground and mixed with cut hay makes a healthy and appropriate ration. Rye is not now so largely used as horse food as formerly, owing to its extra price for distilling.

*Millet-meal* is a highly appropriate food for young or mature horses. It has a higher proportion of albuminoids and a higher nutritive ratio than oats, but having less oil. It is found, when well ground (and it cannot properly be fed without grinding), to be one of the best rations for horses, being particularly adapted to the development of muscular strength.

*Peas* contain more than double the digestible albuminoids of oats and more than a hundred per cent. higher nutritive ratio. Like English bean-meal, our pea-meal is considered the strongest horse food. It has a somewhat constipating effect upon the digestive organs; and it is therefore advisable to mix 8 bushels of peas with 8 bushels of Indian corn and one bushel of flax-seed, and grind all together. The flax-seed counteracts the constipating effect of the peas; and the mixture has a slightly higher nutritive ratio than oats. The author has fed this ration with much satisfaction. The combination of food elements is admirable, and the flavor is well relished by horses.

*The Vetch* is very similar in chemical constitution to peas, and it may be used in about the same combination as a ration. This crop has not been raised as much in this country as its importance demands. It is probably as sure a crop in the Northern and Western States as peas.

The rule in feeding should be to use as many of these different foods as can be easily obtained. Where three of these different foods are in stock—one may be fed one week, another the next, alternating regularly. If the feeder has never tried it, he will be surprised to find how eager the horse is for the change. Some regard it better to give one food two days, and another the next two, and so on. This latter is probably the best way. Another way is to grind the three foods together, and then each will enter into every ration. But this is not quite so tempting to the appetite, as the flavor is the same at every meal. We have dwelt, at some length, upon this matter of change of food, but it is a vital point in the practice of the skillful feeder, and cannot be too closely studied.

The colt, whether intended for fast or heavy work, should be handled at frequent intervals through all the period of growth. The old theory, so insisted upon by some, is that the colt will have more spirit if it is allowed to run wild, without handling, till three or four years old. It will evidently be more difficult to break, and, for a long time, if not always, less obedient to the will of man, than if handled, as it should be, from two weeks old. Is an animal less able to exert his power at the will of man that has learned to have implicit confidence in him, than if he has run wild, and having little or no confidence in man? There is no foundation in the theory whatever, but the exact opposite is the fact. There is much to be gained by controlling the colt through all stages of its growth. But there should be no roughness in handling him. The colt should be accustomed to grooming from an early age, and it should learn to depend upon man for the supply of its wants and to regard him as its best friend.

# CHAPTER XI.

## SHEEP.

Sheep husbandry is destined to assume very great importance in this country. It appears to be the industry which cannot produce a supply equal to the demand. There is no probability of our ever growing much wool for export. The wants of our population in clothing will even more than keep pace with our wool production. But it is to be hoped that, with our constantly expanding territory suited to the production of wool and mutton, we may, within a short period, be able to supply most of the wool now imported. It is the one home market never yet supplied, and thus has the advantage of most other agricultural industries, of a customer unsought. In dairying, beef-growing, wheat-growing, and cultivating swine products, we sedulously stimulate the foreign demand; but in wool-growing our last fleece is sought at our own door. We are improving so rapidly the machinery for manufacturing the best cassimeres, broadcloths, and Brussels, Wilton and Axminster carpets, that our wools bring better prices to the grower than those of any other country. We have cheaper lands, cheaper foods, and as good a climate for sheep-growing, as can be found; and all we need beyond these to compete with all the world in wool production is a knowledge of the business equal to our facilities. Here, as elsewhere, we must study the whole business, understand and utilize all its details. Simple wool-growing cannot be maintained in any country where land has any considerable value. To breed and feed sheep simply for the wool is little better than raising wheat for the straw—the more valuable half goes to waste. As civilization has advanced, and the processes of agriculture have been improved, one country after another has ceased to grow wool for itself alone—mutton has become the principal, and wool the incident of the business. This transition was accomplished in England first; but France is moving on steadily to the same point. England did it by improving the Leicester, Cotswold and Southdown mutton sheep. France has been gradually doing it by transforming the Merino into a mutton breed, by an improved system of feeding. This was based upon the true physiological principles of animal growth. At the breeding establishment of Rambouillet, the last century has witnessed an almost complete transformation of the Merino—from the small-bodied, short-fibered, thin-fleshed, slow-maturing animal of the past, has come a larger size, a little coarser and longer fibre, a heavier carcass, and a heavier fleece; one more ready to take on flesh, and much earlier in maturing. The best-fed American Merinos are tending in the same direction. They are animals of much better formed bodies, longer staple, heavier fleece, earlier maturity, and better flavored flesh than the originals imported. The French are also testing the English Leicester and Cotswold cross upon the Merino, to hasten the transformation to a mutton carcass. The tendency everywhere is to utilize the flesh in the best possible way. It must not be supposed that this transformation has reduced the quantity or, materially, the quality of the wool. The quantity has been very materially increased, as well as its aggregate value; so that the wool interest is not injured by this new zeal in favor of the mutton. Good feeding improves the coat, whether it be hair or wool—note the favorable effect upon the hair of well-fed cattle, compared to those poorly fed, and also upon the wool of well-fed and poorly-fed sheep.

Profit in sheep husbandry means the most generous and judicious feeding and care, carried out in every part of the system. When this is done, so far from sheep being unprofitable upon our higher-priced lands, it is doubtful if any other animal pays so well. In England, it has been said that, on lands worth three to five hundred dollars per acre, fertility can be more profitably kept up with sheep than any other stock. Dairy stock, for instance, carry off much more in the milk alone than sheep in all ways, besides taking as much to build the bones and grow their bodies. The waste of phosphates is much more rapid in dairying than sheep husbandry. If, then, sheep may be fed to profit in England on land worth four hundred dollars per acre, we should not be deterred from sheep-feeding on lands worth $50 to $150 per acre. England is considered peculiarly a beef-eating country; but yet the best mutton brings a higher price than beef. Our large cities and manufacturing towns are constantly increasing their demand for good mutton, and this demand is likely to increase as fast as the production. If we should feed as large a number of sheep per hundred acres in the Middle and Eastern States as does Great Britain, the desire for emigration from these States to more fertile lands of the West would soon cease.

## Sheep Feeding in New Jersey.

New Jersey, lying nearly equally distant between the two largest cities of the country, where populations of over two millions are fed, has accomplished more in feeding for mutton than any other State. Yet all feeding stuffs are perhaps higher in this State than any other. The fact, therefore, that sheep may here be fed at a profit, shows how the same system might be very widely extended to other States in the vicinity, as the cost of feeding and transportation, combined, would be even less. On farms that need renovation, sheep feeding is most desirable, because, properly conducted, it will pay for purchased grain, and in this way the manure will be made very rich, and the refertilization progress rapidly.

The method of procedure in New Jersey has largely been as follows: The flock of ewes are changed yearly. They are selected in August or September, for their thrifty breeding condition, from flocks reaching that State or New York City from Ohio or Pennsylvania, and some from Canada. They are purchased at a wide range, from $3 to $6 per head; are placed upon fresh pastures in the early fall, and if thin, furnished cooling wheat middlings to start thrift during mild weather. They are served by Southdown rams, and fed well during winter, usually upon corn, oats and middlings. It is not attempted to fatten them, as that would heat their blood unfavorably; yet they must be kept in fine thrifty condition, that their lambs may come strong, and the ewes yield abundance of milk. These lambs are pushed, and sold off in May and June. The fleeces of the mothers are sold early, and they fed heavily, and fattened for sale early in summer. So the transaction of the August previous in the purchase of the flock is closed out about the 1st of July, and all completed before the end of the year. The best feeders reckon that from $6 to $10 are received per head for feed and care, and a large amount of valuable manure obtained for the growth of grain crops. These ewes are usually grade Merinos; and the lambs produced by a cross of Southdown are found to feed much better, and bring extra prices in the early market. This system has some important points to recommend it—that the food used is all made active in producing an immediate result, and nothing wasted on keeping up the vital organism during a storing period. It is all used either to fatten the lambs or fatten the mothers, and the sheep are passed into market, and the cash realized, before disease brings its hazards.

This system is also followed, to some extent, in portions of Southern New York, and the adjacent parts of Pennsylvania; and when a good lot of ewes can be obtained, the best management is generally successful. But this, however, is the mere factitious part of sheep husbandry. It is making the best of a bad system carried on by others, who do not know how properly to dispose of the sheep they raise. These ewes are raised under a very defective system of feeding, and are not so thrifty and disposed to early maturity as they would be if reared under a better system; and it is only by a Southdown cross (or perhaps a Cotswold) that good early lambs can be raised for market. Yet these ewes are benefited by raising these lambs under a better system of feeding, and make very fair carcasses of mutton themselves after this preparation. They have been fed so sparingly all their previous lives, that it takes a few months, under good feeding, to induce a thrifty and healthy state of the secretions preparatory to fattening. This state of sheep-feeding is in the same condition that cattle-feeding was a few years ago, when the store cattle were raised by one class of farmers, and fattened for beef by another; and this is still the practice in many parts of the country; but it is quite different from that complete system of sheep-feeding to be established in the future, in which the lambs will never pass from the hands of the feeder until sold to the butcher or shipper. Then uniformity of practice may be established, and the animal receive such food and care every day of its life as to produce the best result under the system adopted.

The old system of slow growth and late maturity has been abandoned by the most progressive feeders of all classes of animals intended for food, and the better one of full-feeding, rapid growth, and early maturity adopted instead. There is no class of animals to which this improved system may be applied with greater profit than sheep.

## The Double Income.

It is important in all branches of industry to consider the sources of income, and their availability at short periods. Sheep afford two annual incomes—lambs and wool—and they are usually about equal in value. The experiments of Sir J. B. Lawes, in reference to the percentage of food utilized or stored up by different animals, presented the sheep in a very favorable light. Of the dry food consumed, he found that sheep stored up in increased weight 12 per cent., while cattle only laid up in increased weight 8 per cent.; that is 8½ lbs. of dry food increased the live weight of sheep as much as 12½ lbs. the live weight of cattle. So that, relying upon these experiments, sheep must be considered as excellent utilizers of food, as producing as many pounds of mutton, besides the wool, from a given quantity of food, as can be produced of beef; and as the best mutton brings as high a price as the best beef, it would appear, on this basis, that sheep would give the fleece as extra profit over cattle. If this is not too favorable a view, then sheep on suitable lands must be considered among the most profitable of farm stock. It is true the dairy cow brings her profitable flow of milk to offset the yield of wool; but the dairy cow does not lay on flesh while producing milk, as does the sheep, while producing wool. A fleece of five pounds of wool, grown in a year, requires only a daily growth of 1-5 of an ounce, which can take but a small portion of food to produce. The mineral matter taken from the soil by the fleece is only 1.6 ounces per year; and if six half-mutton sheep represent a cow, the whole mineral constituents taken by the six fleeces would only be 9.6 oz., and about 1.9 lbs. of nitrogen; whilst the ordinary cow, yielding 4,000 lbs. of milk, would take 26 lbs. of mineral matter or ash, and 25 lbs. of nitrogen, or 43 times as much mineral matter, and 13 times as much nitrogen as the fleeces of the sheep. But this is not considering all the elements of waste in feeding sheep. Let us suppose the six ewe sheep will carry off in growing bone and muscle, or in supplying the waste of bone and muscle, as much as in growing the fleece; and besides this, let us suppose that these six ewes raise five lambs, of 40 lbs. live weight each. This 200 lbs. live weight of fat lambs would contain of dry matter 87.4 lbs., containing 3.9 lbs. of nitrogen and 5.9 lbs. of mineral matter. This would give an aggregate of 7.2 lbs. of mineral matter, and 7.7 lbs. of nitrogen, as the waste from six ewes and their five lambs, which is less than one-third of the waste of mineral matter and nitrogen from the milk of a cow. The six ewes and five lambs will consume more food than a cow; but all that is stored up and carried off is less than one-third as much as in the milk. This, then, explains the Spanish proverb, "the sheep's foot is golden"; that it brings improvement, and not depletion of the soil.

This double income from the fleece and the lambs may be certainly respectable without counting high figures. The fleeces, at a moderate average price, would bring $13.50, and the lambs, at a low figure, $20, or $33.50 as the income of the six ewes.

## Early Maturity.

When the production of lambs, mutton, and wool is carried on under a regular system, and the breeding ewes are reared by an experienced breeder, whether they be of a fixed type—such as the Southdown, Shropshire Down, Cotswold, Leicester, etc., or a cross of one of these upon grade Merinos, or a mixture of common blood—the breeder knows that the best care and feeding for a few generations will greatly influence their early maturity, and consequently the profit to be derived from them. There is probably no animal more plastic in the hands of a skillful feeder than the sheep. By the cross of a thoroughbred male upon selected common ewes, and the best of feeding, even the first generation will show a decided change in the period of maturity, making a larger growth, and showing a fuller development in 12 months than the dams had shown in 18 months. The next cross will show also a great improvement on the first. And here time is the great element of success. As we have seen in the growth of animals, if the gain in weight can be doubled in a given time, the cost is not doubled, for, after the food of support, all the extra food digested and assimilated is laid up in increase. If it requires two-thirds of an ordinary ration to support the animal without gain, and if a certain ration would increase the weight of a sheep 1½ lbs. per week, then if one-third addition to this ration was equally well-digested and assimilated, the sheep would gain three pounds per week—a saving of two-thirds of the cost in the increased growth. Then, to double the growth in a given time, reduces the cost of the whole growth one-third, and this one-third gain in profit is a good margin.

Let us illustrate this in the growth of early lambs. Under scanty feeding—that is, the ewe being insufficiently fed to yield a good flow of milk—the lamb would make a slow growth of about 1½ lbs. per week, and would weigh about 21 lbs. at three months old. If, on the other hand, the ewe is a fair milker, and is fed one-third extra food adapted to produce milk, the extra milk will double the weight of the lamb, reaching 40 lbs. at three months. The significance of this double growth is not measured by doubling the value of the lamb, however; for the 40-lb. lamb often brings, in April and May, $10 in our best markets, while the 20-lb. lamb would scarcely bring $3. Doubling the weight often trebles the value, or more. The yearling wether that weighs 150 lbs. will sell for more than double the price of the one that weighs 80 to 100 lbs.; so that the more rapid growth means not only one-third less cost, but double the value. This is a decided encouragement both ways for good feeding. Early maturity—that is, the even, healthy, rapid development of the young animal, is the great thing to be striven for in sheep feeding, as in every other department of feeding which is to fit animals for human food. This holds good in both the vegetable and animal world. It is the tender, juicy, crisp radish and asparagus that tempt the appetite, and these must be grown rapidly to reach this degree of excellence. It is also the tender, juicy, high-flavored meat that fills our desires for that food; and this, like the vegetable, must be grown or matured rapidly. This matter of early maturity is of the highest consideration in any system of profitable meat production.

We must consider the present stage of sheep-feeding when conducted for the production of mutton, as in a transition state—the feeders simply endeavoring to graft upon the old system of wool-raising, a better system of fattening. But we wish to discuss a system of sheep husbandry adapted to our older States, which shall be complete and harmonious in all its parts, and conducted as a regular business from year to year; the flock being bred and handled by the farmer through all its stages, until the carcass goes to the butcher and the wool to the manufacturer. It should be carried on as systematically as the best dairying, every part of the business being carefully considered.

## Selection of Sheep for Breeding.

The plan of our work does not include a discussion of the philosophy of breeding, but it is necessary to consider the style of sheep to feed for a particular purpose. As we endeavored to show, the wool alone does not afford an adequate object for feeding sheep in States where land has any considerable value, and it therefore follows that a system of sheep husbandry adapted to the older States must deal with sheep fitted for the production of mutton—that mutton must be the first consideration and wool the second.

With this object in view, some one of the mutton breeds must be selected, either for pure breeding or to cross upon the Merino or grade sheep. The latter must, of necessity, be the plan adopted, since there are not pure-bred sheep enough to be had within any practicable limit of price to set up any large number of flocks. It is therefore evident that we must breed our mutton sheep from the materials at our command, and we certainly have a pretty extensive variety of material upon which to engraft the Down, Leicester, or Cotswold blood.

If our breeders will follow the wise example of Bakewell, in reference to the style of sheep to be improved, it will much hasten their progress. In Bakewell's time, Leicester sheep were long-legged, rough-boned sheep, greatly wanting in symmetry of form. He started out with the sound principle that the largest proportion of the value of the sheep was in its mutton, and he had also observed that the medium-sized, compact, and symmetrically-formed sheep took on flesh much more readily than the larger and rougher specimens. He therefore selected from various flocks the most evenly and symmetrically-developed animals he could find, that showed the greatest aptitude to fatten, and that he thought would produce the largest proportion of valuable meat, and the least amount of offal. Having made his selections, he carefully studied the peculiarities of the individual animals from which he bred, and never hesitated to discard those that did not come up to his ideal. It is true he selected all his animals from the old Leicester blood, and that he did not scruple to breed those together that were related, but the animals bred were selected for their strong points of adaptation to each other.

Breeders of to-day may select on the same principle as did Bakewell, choosing the medium-sized ewes and those having the most even development, from the grade Merinos or the common bloods, and crossing upon these a good

Down, Leicester or Cotswold ram. But, as in Bakewell's case, the selection of the best must continue, and the defective be constantly weeded out. In-and-in breeding produced no evil effects in his case, because he constantly coupled such males and females as tended to remedy the defects that existed on either side. This mode of selection resulted in the most remarkable improvement in the Leicester sheep as a meat-producing animal that has ever occurred in the history of breeding. The change in external appearance of the old and new Leicesters was so great as to be regarded by some as a new variety of sheep, and led many to suppose that Bakewell had crossed different breeds in producing the result; but this is clearly disproved. There can, however, be no doubt that if our sheep-breeders will make such selections of ewes as we have indicated, and proceed to cross one of these fixed breeds of mutton-sheep upon them, continuing with males from the same strain of blood, the result, in a few generations, will be an extremely uniform animal; and then males may be selected from the same flock. Our readers must not suppose this to be an expensive plan of improving a flock. The ewes may be selected at a mere trifle above ordinary price. A Leicester, Southdown, or Cotswold ram can be purchased or leased at a small sum.

The outlay above purchasing an ordinary flock need not exceed $50 to $100, if a start is made with from 25 to 50 ewes. If such a system of breeding should be multiplied to any considerable extent, it would also produce a class of ram-breeders, as it has in England; and the system of ram-letting would also be here introduced, which has many advantages, for this would enable the breeder to select a ram from a considerable number, and he could change the ram as often as he found advantageous. The result of crossing the Southdown and Cotswold rams upon grade Merinos has been so well tested in this country as to be no longer regarded as an experiment. The progeny are found to feed nearly as well as the full blood, and the improvement on the first generation is considered a full return for the expense. The next generation approximates still closer to the type of the male, and, of course, the cost of this system of breeding becomes less and less the longer it is continued. There is no loss upon those discarded as breeders, for they pay their full cost when sent to the butcher. The temptation to keep defective animals for breeding will not exist in this case as in the case of pure breeding, for the value of the animal will be measured by its value for mutton and wool. There is nothing sacrificed here, either in carcass or fleece, for the mode of improving the one will also improve the other. The Merino blood will improve the wool, and the Cotswold blood will improve the meat.

## Summer Feeding of Small Flocks.

There has been a great deal of speculation as to all the minutiæ of Bakewell's methods of breeding, and many contrary opinions entertained, but little has ever been said or curiosity manifested as to Bakewell's mode of feeding. All his success was attributed to some occult system of breeding, and they neglected to inquire into one of the principal causes of his success—his system of feeding. His principles of breeding brought him a symmetrical animal, but improved feeding was absolutely necessary to develop it. This point seems to be well established in regard to his system. He sought to develop a sheep that should produce the largest amount of meat for a given amount of food. This hint shows that the question of food, or economy of production, was the point he sought to solve, which shows, further, that his system was complete, and not a mere half system, as it must have been had he provided merely for improved breeding, treating with indifference the question of developing the animal when bred.

It is unfortunate that Bakewell, with all his philosophical ideas upon breeding and growing animals, was not large-hearted and philanthropic enough to desire that his improvements should be perpetuated for the benefit of his countrymen. But so far from this, he neither put pen to paper, nor did he disclose his system in conversation with his most intimate friends. They could see the result of his work, and from this infer his system, but he kept his methods and the details of his experiments wholly to himself. Perhaps we should not judge him harshly because his countrymen, who have conjectured as to his system and lauded the result, have never criticised his selfish secretiveness, but treated it as a natural thing to expect. This grows out of the different social education of the people of England and the United States. Here a citizen feels that he owes something to the public welfare, and takes a pride in promoting it; but the hereditary government appears to prevent the development of public spirit, and leaves the individual to think only of his private welfare.

A thorough exposition of Bakewell's practical system, and the careful details of all his experiments, would have been worth millions to his countrymen, as well as to the breeders of other countries. But the world must be content with the great good that has resulted from the distribution of the improved Leicester sheep, and the stimulus given by these to the improvement of other breeds.

We desire to show, somewhat in detail, the application of sheep husbandry to the wants of agriculture in our oldest settled States. Here, under the principles discussed, the sheep will bring the recuperation of the soil, renew its capacity for grain crops, and bring back the old-time thrift to the owners of half a million of farms. If we suppose New York, with its 20,000,000 of acres in grass or cultivated crops, to maintain one sheep to four acres, it would give her 5,000,000 of sheep—a very moderate number to be carried upon her acres, yet 3.3 times the number she now keeps. This would give her an average of 25 sheep to each 100 acres of improved land—a number that might easily be kept without disturbing her other industries. A small flock of sheep will bring into use neglected spots and fence corners, will turn to account the gleanings of grain fields, and consume many things not so well relished by cattle.

## Hurdle-Feeding.

The question of fences, which has come to involve a very large expense, and would be an insuperable obstacle to sheep-keeping, if farms were to be fenced into small fields in order to use all the neglected forage, is solved by the use of hurdles. Movable hurdle fence is quite necessary to the proper use of all the fields upon a farm for any class of stock, and especially for sheep. Fifty to 100 rods of movable fence will be of the greatest service upon all farms. By using the hurdle, any piece of aftergrowth or stubble may be inclosed in a few minutes, and the sheep or other animals confined, and the hurdles may be moved over the field till every part of it is eaten and turned into flesh and wool. This will have a double advantage—turning the green food into money and killing weeds. The portable or rolling hurdle is most convenient, as it is placed so quickly, and rolled along day by day to supply fresh herbage; and its additional cost is but slight. The celebrated Mechi used an iron hurdle, placed upon wheels, which he recommended highly because of its great durability, having been in use upon his farm for more than thirty years. His hurdle was too expensive for our ideas of economy, being $6.50 per rod. Yet he seemed to regard it as cheap, considering its great utility. We invented a hurdle, made of wrought iron, well adapted to the needs of small flocks in this country, and which we do not describe, because we were unable to reduce its price below $5 per rod. But as yet the ordinary wooden hurdle is the only one obtainable. Such a movable hurdle would remove the most formidable obstacle to keeping small flocks upon almost every farm. Let us here note the important results which might follow from the introduction of such small flocks of sheep upon the so-called worn-out farms of the older States. It often becomes very difficult to seed down these long-cultivated fields without a very large application of manure, which cannot be had. With an easy means of confining sheep upon any such field or portion of field, the fertilizer required for its renovation could cheaply be manufactured upon the spot. By plowing this field and sowing thickly with oats to be fed off by sheep, and placing a few racks on one side of the field, into which green food grown elsewhere upon the farm can be placed, and then also feeding a small grain ration, which will be repaid twice over in the growth of the sheep, the field becomes fertilized by the droppings of the sheep evenly distributed over the field. This experiment has often been tried, keeping an accurate account of purchased grain; and the increased value of the sheep has not only paid for the grain, but amply for the labor, leaving the fertilization of the field as a clear profit. It should always be a prime consideration in feeding sheep for market to do as much as possible of it in warm weather. And, if they are kept till January or February, still the feed should be very generous in the fall, that they may be fat enough for the butcher at the beginning of cold weather. It will then cost but little to carry them to the later period in fine mutton condition, so that this grain ration, given upon the poor fields, will be profitable, considered only in reference to the progress of the sheep. A small grain ration in September and October, on green food, will push them faster than a large one in cold weather.

When sheep are fed upon land needing such fertilization there is the greatest inducement to be liberal in the ration, as an important result is obtained without any real expense. It is also important that such extra food should be chosen as will leave the most valuable fertilizer upon the land. And in this connection it will be well for the American farmer to become better acquainted with linseed oil-cake and decorticated cotton-seed cake. These foods contain a large proportion of oil for fattening, and also a very large proportion of nitrogen, as well as the important mineral constituents of phosphate of lime, potash, etc. By feeding these cakes the animals not only progress rapidly, but the droppings are much more valuable than when on corn alone. For summer feeding, as here mentioned, ¼ lb. of oil-cake and ¼ lb. of corn (or, better, wheat bran) to each sheep will be the most valuable ration.

As I am now illustrating sheep-feeding as adapted to the long-cultivated lands of the older States that have become less fertile for want of proper stock husbandry, it will be necessary to a full discussion that we should consider somewhat accurately the

## Compensation for Food in Manure.

It is important that the feeder should understand the quantity of manure produced for a given quantity of food consumed by the stock he feeds, so that he may be able to know the return to be expected from this source. The amount of manure produced from a given quantity of food is greater for the sheep than the pig ; but this arises mostly from the greater digestibility of the food of the pig than that of the sheep.

In estimating the value of the manure made by animals, only the nitrogenous and ash constituents of the food are considered, as the carbonaceous elements are supplied by the atmosphere. We must also have some basis for determining the proportion or amount of food elements to be found in the manure. If there is no growth nor increase in the live weight of the animal, and no milk produced, then the amount of nitrogen and ash constituents passed into the manure must be equal to these elements contained in the food; because the albuminoids and mineral elements of the food used to build up the waste of the system, or for the renovation of tissue, must be equal to these elements broken down and passed off by the degradation of the tissue; so that the same amount of valuable elements contained in the food will be found in the manure. But when the body is increasing in weight, or milk is produced, then the albuminoids and mineral elements required to form this increase of body or the milk, must be deducted from these elements in the food consumed. A part of the nitrogenous and mineral elements of the food is left undigested in passing through the alimentary canal, and this is found in the solid excrement. What is digested of the nitrogenous and ash constituents passes into the blood, and is converted into animal increase, or milk, if the animal is increasing in weight, or yielding milk, and the balance of these constituents are separated from the blood by the kidneys, and are passed in the form of urine. These albuminoids are oxydized into urea before they are expelled from the system. Hippuric acid is also found in the urine of herbivorous animals.

We find the proportion of albuminoids that will appear in the solid excrement by deducting the percentage of digestible albuminoids from the whole amount. Dr. Wolff's late experiments with sheep and other animals, show that sheep digest of the various elements of certain foods as given in the following table:

### Experiments with Sheep.

*Table No. 1.*

| Food. | Proportion or Percentage of Each Constituent Digested. | | | | |
|---|---|---|---|---|---|
| | Total organic matter per 100 lbs. | Albuminoids. | Fat. | Soluble carbo-hydrates. | Fibre. |
| Pasture grass | 75 8 | 73.3 | 65.4 | 75.7 | 79.5 |
| Meadow hay (very good) | 64.7 | 66.6 | 54.5 | 65 6 | 63.5 |
| Meadow hay (ordinary) | 58.7 | 57.2 | 44.3 | 58.7 | 59.8 |
| Lucerne hay | 59.1 | 72.8 | 29.7 | 67.9 | 43.6 |
| Oats | 72.9 | 85.5 | 84.8 | 77.7 | 26.1 |
| Beans | 89.6 | 87.1 | 84.2 | 91.2 | 78.5 |
| Indian corn | 88.5 | 78 5 | 81.6 | 91.3 | 61.9 |
| Grass cut at different dates— | | | | | |
| May 14th | 75.8 | 73.3 | 65.4 | 75.7 | 79.5 |
| June 9th | 64.3 | 72.1 | 51.6 | 61.9 | 65.7 |
| June 26th | 57.5 | 55.5 | 43.3 | 55.7 | 61.1 |
| Clover-hay | 59.0 | 55.0 | 56.0 | 56.0 | 44.0 |
| Oat-straw | 51.0 | 38.0 | 30.0 | 43.0 | 61.0 |
| Wheat-straw | 46.0 | 20.0 | 36.0 | 39.0 | 56.0 |
| Bean-straw | 50.0 | 51.0 | 55.0 | 60.0 | 36.0 |
| Linseed-cake | 80.0 | 84.0 | 90 0 | 78.0 | .... |

It will be seen that there is a steady change in the digestibility of grass cut at different periods. The grass cut May 14th had 75.8 per cent. digestible matter; while the same grass cut June 26th had only 57.5 per cent. digestible. Other experiments have shown the same difference in the digestibility of clover cut before blossoming, while in blossom, and after blossoming. This table should be well studied, as a lesson on the proper time to cut grass for hay. The percentage digestible of any constituent is called by Dr. Wolff its "digestion co-efficient." From this it is easy to determine what proportion of nitrogen passes into the solid and liquid excrement.

Suppose we take oats: 85.5 is its "digestion co-efficient"; that is, this is the percentage of the albuminoids of oats that is digestible by sheep, and therefore the indigestible

14.5 per cent. of the albuminods of oats will pass into the solid excrement. The digestible part will pass into the blood; and if the sheep are not increasing in weight, or suckling lambs, 85.5 per cent. of the albuminoids will pass in the urine, so that all the nitrogen received in the food will be voided in the solid and liquid excrement. But if the animals are full-fed and are increasing in weight, then the increase will reduce the quantity of manurial constituents in the excrement. From the German tables of experiments, it is estimated that the following percentages are stored up and voided as excrements when fed on barley-meal.

NITROGEN STORED UP AND VOIDED FOR 100 CONSUMED.

*Table No. 2.*

| ANIMALS. | Stored up as increase. | Voided as solid excrement. | Voided as liquid excrement. | In total excrement. |
|---|---|---|---|---|
| Sheep | 4.3 | 16.7 | 79.0 | 95.7 |
| Oxen | 3.9 | 22.6 | 73.5 | 96.1 |
| Pigs | 14.7 | 21.0 | 64.3 | 85.3 |

ASH CONSTITUENTS STORED UP AND VOIDED FOR 100 CONSUMED.

*Table No. 3.*

| ANIMALS. | Stored up as increase. | Voided in total excrement. |
|---|---|---|
| Sheep | 3.8 | 96.2 |
| Oxen | 2.3 | 97.7 |
| Pigs | 4.5 | 95.5 |

An examination of these tables will show, in the case of fattening sheep, what proportion of the valuable elements of the food are returned to the soil, or may be returned, to prevent exhaustion. Over 95 per cent. of the nitrogen and ash constituents are voided in the excrement in the cases of sheep and oxen. This shows a very small waste of the fertilizing matter of food in fattening sheep.

The following table will show the composition of solid and liquid excrement of sheep fed on hay:

*Table No. 4.*

| | SOLID EXCREMENT. | | URINE. | |
|---|---|---|---|---|
| | Fresh. | Dry. | Fresh. | Dry. |
| Water | 66.2 | .... | 85.7 | .... |
| Organic matter | 30.3 | 89.6 | 8 7 | 61.0 |
| Ash | 3.5 | 10.4 | 5.6 | 39 0 |
| Nitrogen | 0.7 | 2.0 | 1.4 | 9.6 |

It will be seen that the solid and liquid excrements, even when the sheep are fed upon hay, are rich in both nitrogen and ash constituents, as a ton of the solid would contain 14 lbs. of nitrogen, and a ton of liquid 28 lbs. of nitrogen; at 18 cents per lb., the first would be worth $2.52, and the second $5.04 per 2,000 lbs., in the ordinary wet state.

That the reader may see the relative value of various foods, and how much they differ, depending on the proportion of nitrogen and the ash constituents, we give Table No. 5, containing many of the most common foods, and giving the nitrogen, potash, and phosphoric acid in 1,000 parts.

This table shows how much of each valuable constituent is contained in each of these different foods; and anyone can calculate the value of a ton, by multiplying the pounds of nitrogen, potash, and phosphoric acid by the price of each in the market. Nitrogen is usually estimated at 18 cents per pound, potash at 8 cents, and phosphoric acid at 12 cents per pound. The figures in this table give the amounts of these elements in 1,000 pounds of each food, when of good quality, and all is saved. If 90 to 95 per cent. of these fertilizing constituents of food could be actually saved by farmers and returned to the soil, then it is easy to see the effect that must be produced by judicious stock-feeding upon the depleted soils of the New England and Middle States.

*Table No. 5.*

| Foods. | Dry matter. | Nitrogen. | Potash. | Phosphoric Acid. |
|---|---|---|---|---|
| | lbs. | lbs. | lbs. | lbs. |
| Cotton-seed cake (decorticated) | 900 | 66.0 | 21.0 ? | 31.2 |
| Cotton-seed cake (undecorticated) | 885 | 39.0 | 20.1 | 22.9 |
| Rape-cake | 900 | 48 0 | 13.2 | 24.6 |
| Linseed-cake | 880 | 45.0 | 14.7 | 19.6 |
| Linseed (flax-seed) | 905 | 36.0 | 12.3 | 15.4 |
| Palm-meal | 930 | 25 0 | 5.5 | 12.2 |
| Linseed-meal (extracted) | 903 | 59.8 | 17.0 | 25.6 |
| Poppy-seed cake | 885 | 47 8 | 22.0 | 40 0 |
| Hemp-seed cake | 901 | 44.7 | 27.6 | 37.6 |
| Walnut-cake | 863 | 52.2 | 17.7 | 23.4 |
| Sunflower-seed cake | 897 | 55.9 | 26 8 | 35.4 |
| Beans | 855 | 41.0 | 12.0 | 11.6 |
| Peas | 857 | 36.0 | 9.8 | 8.8 |
| Malt sprouts | 905 | 38.0 | 19.5 | 17.2 |
| Wheat-bran | 865 | 22 0 | 14.8 | 32.3 |
| Oats | 870 | 20.6 | 4.5 | 6.2 |
| Wheat | 856 | 18.8 | 5.4 | 8.0 |
| Barley | 860 | 17.0 | 4.9 | 7.3 |
| Maize | 886 | 16.6 | 3.6 | 6.1 |
| Clover-hay | 840 | 19 7 | 19.5 | 5.6 |
| Meadow hay | 857 | 15.5 | 16 8 | 3.8 |
| Bean-straw | 840 | 10.0 | 25.9 | 4.1 |
| Wheat-straw | 857 | 4.8 | 5.8 | 2.6 |
| Barley-straw | 850 | 5.0 | 9.7 | 2.0 |
| Oat-straw | 830 | 5 0 | 10.4 | 2.5 |
| Potatoes | 250 | 3.4 | 5.6 | 1.8 |
| Mangolds | 115 | 1.9 | 3.9 | 0 7 |
| Swedes | 107 | 2.4 | 2 0 | 0.6 |
| Carrots | 142 | 1.6 | 3.2 | 1.0 |
| Turnips | 83 | 1.8 | 2.9 | 0.6 |

It will be noted that clover-hay is more valuable than any of the cereals as manure; and common meadow hay has a value above corn-meal. If the nitrogen, potash and phosphoric acid are estimated at the usual commercial value, then wheat bran, malt sprouts, linseed-meal, and many of the richer feeding stuffs, are worth all they cost as fertilizers. Wheat bran figures at $18 per ton; malt sprouts at $20.80; linseed-meal at $30.48; cotton seed (decorticated) at $33.64. These prices may be beyond the real money value; but it shows the intelligent feeder what foods he may buy with safety, expecting to get back the cost of them in growth, and increased weight in fattening, besides getting a large return in the manure.

## Value of Solid and Liquid Excrement.

We must study most carefully the proportionate value of the solid and liquid manure. Table 4 shows the proportionate amount of nitrogen found in the solid and liquid excrement, and the amount is seen to be three to four times as much in the urine as in the solid excrement. The amount voided in the urine will depend very much upon the digestibility of the food, for only what is digestible and soluble can pass in the urine. But when the farmer becomes aware that considerably more than half of the fertilizing matter of manure is to be found in the urine, he will begin to consider his means of saving this most important part of the excrement. Not only is more than half of all the fertilizing matter of animal excrement found in the urine, but this is much the more valuable, according to quantity, as this is all soluble, and becomes immediate and active plant food; while much of that in the solid excrement requires time for decomposition before becoming food for plants. The solubility of the fertilizing matter in urine renders it so much more difficult to preserve from loss. It is liable to be exhaled or evaporated in the sun, washed away by rains, absorbed by the earth under the manure pile, and temporarily lost in a great variety of ways when the manure is kept in the ordinary careless manner.

The great effect of the proper application and saving of all the liquid excrement is seen in the English custom of feeding off crops with sheep. It appears quite evident that this mode of application greatly increases the effect over that of applying the manure made from the same amount of food in yard or stall, when the manure is thrown into the yard. When a crop is thus fed off upon the land, or when other food is brought and fed upon a field, during cool or damp weather, all droppings are saved, and all urine is at once absorbed by the soil, and stored as plant food—nothing is lost. It is in such applications of manure that we may see an effect to warrant the prices mentioned for the fertilizing constituents of foods.

Sheep are the best animals for making an even distribution over the soil of the fertilizing ingredients of excrement.

## An Experiment.

To test the comparative effect of feeding a definite quantity of food to sheep upon the land, or applying the manure made by sheep in winter under a shed, from the same kind of food, the author confined 50 large sheep between hurdles, upon 25 rods of ground, for three days, commencing early in June, and feeding each sheep 20 lbs. per day of green clover, cut before blossoming, in racks; and the parts of stalks not eaten at first were fed each day in troughs, with ¾ lb. of corn-meal and a pinch of salt, to each sheep, spread over them. Thus treated, the clover was all eaten. At the end of three days, they were moved along upon an equal space adjoining; so that each rod of land received the droppings from 120 lbs. of green clover and 4½ lbs. of corn-meal in six days. This was equal to 4.06 lbs. of dry food to each sheep per day—the clover having 83 per cent. of water—each rod thus receiving the excrement from 24.36 lbs. of dry food; or an acre received 3,264 lbs. of dry clover, and 633 lbs. of dry substance of corn-meal. This would yield, approximately, in the excrement 90 lbs. of nitrogen, 84 lbs. of potash, and 22 lbs. of phosphoric acid to the acre. The sheep were moved until one acre had been gone over. The land had been in oats the previous year, without manure, and not seeded. Fifty sheep, of about the same weight, had been fed under a close shed for 30 days of the previous winter upon clover cut and cured in good order, before blossoming, with one pound of corn per head, per day. 200 lbs. of clover-hay were fed each day, or 4 lbs. per head. The shed was bedded four inches deep with cut straw before the feeding began. The clover was eaten up closely. Here were fed 6,000 lbs. of clover-hay, or 5,160 lbs. of dry clover, and 1,500 lbs. of corn, or 1,296 lbs., deducting water. Placing this upon one acre, it gives the excrement of 40.34 lbs. of dry substance of food to the rod; or it will give to the acre 130 lbs. of nitrogen, 119 lbs. of potash, and 40 lbs. of phosphoric acid, not counting the cut straw used for bedding. It is proper to state, that the sheep fed upon the green clover gained 3¼ lbs. per head, per week, while those in the shed only gained 2½ lbs. per week.

The experiment to show the effect of the manure was conducted thus: When the acre was fed over with sheep to clover and corn-meal, this acre was plowed, June 21st, five inches deep, preparatory for winter wheat; and the manure from the shed was hauled upon the adjoining acre, and this was plowed to the same depth. About the 20th of July each acre was plowed again six inches deep, and afterwards thoroughly worked with cultivator and harrow, and wheat drilled in August 25th. Grass-seed was sown with the wheat. Result: The acre fertilized by feeding clover and corn-meal upon it yielded 30 bushels of wheat, the acre with the shed manure 25 bushels. The grass crops which followed were considerably better upon the former acre for two successive years, after which the difference was not perceptible.

This experiment showed very strongly in favor of feeding the animals upon the land to be fertilized. We may say, however, that when applying fresh the excrement of animals taken from a water-tight receptacle, where both solid and liquid were completely preserved, we found the effect quite equal to feeding upon the land. We have, therefore, adopted a water-tight receptacle under the platform on which our cattle stand in winter, and cows, during night, in summer, and the excrement is hauled fresh to the field, thereby preserving all its fertilizing elements.

## Sheep on Worn-out Lands.

We have illustrated this matter of the return for the food in the value of the manure at considerable length, because it has a strong bearing upon the profits of sheep husbandry in the older States. At most of the agricultural discussions in Massachusetts, Connecticut, Vermont, New Hampshire, and in some of the Middle States, the great complaint is that their agriculture is in a state of decay, their farms are deteriorating—the product being less year by year. In the first two States named, many of the farms, once profitable, are abandoned, as having no agricultural value, although these farms are near the best markets of the country. These farms are mostly upland, that had a fair natural fertility; but by long cropping, and little return of the drafts made upon them, have ceased to respond to labor so improvidently bestowed. There must be reciprocity in agriculture as in other matters. The great law of equivalence is here enforced—something for something.

It is evident that a regular system of mutton and wool-growing upon such lands would very soon produce an improvement, and that these lands might profitably be brought back to their original fertility, and to a much higher market value than they have ever held. Sheep-husbandry takes the preference of dairy-husbandry for this purpose: First, because the competition in the latter is much greater; in fact, there is properly no competition in sheep-husbandry in this country; for the whole product of wool is much less than the home demand, and good mutton is far from an overstocked market; secondly, because mutton and wool-growing, as we have seen, make a much smaller draft upon the soil than dairy husbandry, and may return to the soil, under a proper system, 95 per cent. of the fertilizing matter of all the feeding stuffs used.

These deteriorated lands may, therefore, be rapidly improved by feeding to sheep the richer foods mentioned in our tables, with a return in growth and fattening of sheep equal to the cost of the food, and, at least, 80 per cent. of its cost returned in effective fertilizers to the soil. Nitrogen, potash, and phosphoric acid can be furnished to the soil in this way at fifty per cent. of the commercial cost of these fertilizers. And another important point is seen in the fact that the standard of quality in these foods can much more easily be determined than that in commercial fertilizers. When one ton or ten tons of decorticated cotton-seed meal, linseed meal, malt sprouts, wheat bran, corn-meal, or other food, is fed to sheep upon the land, you may determine, quite accurately, the amount of each of these important food elements added to the soil; but when you apply a ton of commercial fertilizer, purchased at the full value of a proper standard, the ordinary farmer knows very little of what he really adds to the soil. Under a proper system of feeding, the sheep farmer can scarcely err in applying fertilizers to his soil which are obtained by passing rich foods through the digestive system of his sheep. This will be a chemical analysis and determination which he may rely upon for accuracy.

## Feeding Green Crops on the Land.

This return made by sheep for their food, in manure, based as it is upon reliable German experiments, is most encouraging to those who would feed sheep for the recovery of fertility. This result follows in feeding off large crops grown upon the land, such as turnip, or other root crop, clover, vetches, rye, oats and peas, peas alone, the different varieties of millet, and many other green crops. The clover, vetches, rye, oats, peas, millet, etc., may be fed over several times in a season; as, if fed off when a few inches high, each of these crops will spring up again, on good land, like pasture grasses. This point is worthy of close consideration in feeding for the renovation of worn-out lands in the Eastern States; for some of these crops may be raised upon most lands, and thus furnish green pasturage for sheep; and if fed off within hurdles, in a manner to confine the sheep upon small spaces, the extra grain food will produce an immediate result in improving the second or future growth of the green crop. These portable hurdles are easily moved, and the sheep may be passed on to fresh ground each day, not allowing them to eat the green crop too close. In this way the land may be made to furnish the green food for summer, to be cropped off the ground, saving all labor of feeding, except that of moving the hurdles, and distributing a certain quantity of linseed meal, corn or other grain in troughs, daily, for each sheep. This labor could not exceed one-half hour per day for fifty sheep. Let us now consider the crops that may be fed off green by sheep.

### Winter Rye.

A crop of winter rye would succeed for this purpose probably better than most other crops, and might be fed off, successively, for the whole season, and then furnish pasture, or mature a crop, the second season. It does better for pasturing than cutting for soiling, for which it is often used; because in pasturing it will be kept cropped off too low for the seed panicle to start, and thus keep up a constant growth, whilst in soiling it is seldom cut before some of the seed-heads are formed, and these plants will not grow again, and, therefore, the second cutting will be small, compared to the first. Rye furnishes a good pasturing crop, also;

because, being sown in the fall, it gets well-rooted, and when pastured early in the spring, starts up again at once. If the soil is in such heart as to grow a good crop of rye, it will furnish a large amount of sheep pasturage—six acres may be fed over continually by 50 sheep during the whole season. As soon as they have passed over the field between hurdles, they may be brought back to the starting point, and go over it again. It is evident that, if each of the sheep are given four ounces of linseed-meal, and the same amount of Indian corn, per day, during the season, although light feed, this six acres will be qualified for raising a good grain-crop the following season, and that the gain in the sheep will pay for this extra food, with a good margin for other expenses. Liebig has stated that rye, when cut often during the first year, will mature a crop the following year, and it is reasonable to suppose that, if properly pastured, it will also continue through the following seasons, which must render it a favorite crop for feeding off on the land, as it must give pasture one-third longer than a spring crop.

## Winter Vetch.

The vetch has not been so thoroughly tried in the United States as it deserves, as, where it succeeds, it has many qualities to recommend it; but having been raised in Canada, north of Montreal, at latitude 46, over a belt of territory from Lake Erie of more than two hundred miles, it is reasonable to infer that it is suitable for the territory of this country from New York to Oregon—that it has probably nearly as wide a range as clover; in fact, Nuttall enumerates some five species of the vetch as natives of the United States, some being identical with those found in Europe—as the *Vicia sylvatica*, growing on the borders of woods, and banks of the Missouri river; the *Vicia crocea*, growing in a wild state in bushy meadows, and sometimes troublesome in gardens in Pennsylvania and other Middle

States. He also enumerates *Vicia sativa*, the most valuable species grown by English farmers. So that there can be little doubt that the vetch, or tare, can be profitably grown in all the Eastern, Middle and Western States.

English farmers regard the vetch as only second to clover, because of its nutritiousness, and the relish with which all kinds of stock eat it, as well as because of its easy cultivation. It is the favorite crop of the sheep-farmer for feeding off on the land; and, like clover, will furnish pasturage upon which sheep may be folded, at successive periods, during the whole season.

For this purpose the winter vetch is chosen, because, being established over winter, the roots ramify more extensively, and produce a larger amount of fodder than the spring vetch, and it has been found, on several tests, to be more nutritious per weight. This winter vetch would be even better for bringing forward sheep and lambs in summer than winter rye, because it is much richer in albuminoids. Dr. Voelcker found the green food to contain 82.16 per cent. water; 3.56 albuminoids; 12.74 carbo-hydrates and fat, and 1.54 per cent. ash; and, when deprived of water, it contained 20 per cent. albuminoids—thus being richer than clover. It possesses all the elements, in due proportion, for growing lambs and fattening sheep. This food, being so rich in nitrogen, it might be fed with Indian corn to better effect in bringing up a worn soil than rye or millet. It is often grown upon the heavy clay loams in England; and a rich clay loam will produce maximum crops.

It will readily be seen what an important agency this crop may become, when fed off by sheep, in recovering the worn farms of New England and the Middle States. It is not better, with the same weight of crop, than clover for this purpose; but can be grown upon land where it is difficult to seed to clover, and this crop may be the means of fitting the land for the growth of clover. Rye is the easiest crop to begin with, which, being fed off by sheep, with the addition of linseed-meal and oats, corn, or some nitrogenous food, the land would be well-prepared for the winter vetch, and the winter vetch would prepare it for clover, and clover would prepare it for any crop. The land need not be plowed more than 4½ to 5 inches deep for vetches; but should be worked into a very fine tilth before the seed is drilled in, at the rate of two bushels per acre. The time for seeding is the same as for wheat.

The spring vetch is also much grown in Europe, and may be grown in this country where spring grain succeeds better than winter; but the spring vetch should be planted as early as the condition of the soil will permit. A frost occurring after the seed is sown will not injure the plant any more than it does the pea. On early land, the spring vetch may be brought forward so as to furnish pasture early in June; but care must be taken not to feed it close, as this will much retard its future growth.

### Peas as a Pasture Crop.

As we are considering what crops may be grown for feeding sheep in summer, and at the same time result in the improvement of the soil, we must not omit the common field pea. This crop has not been adequately appreciated as a renovator of the soil. It has been little used as a green pasture crop, either in this country or in Europe, most of our farmers thinking it only adapted for being cut at maturity. But when sown thickly upon properly-prepared land, and fed off at six to eight inches high, it starts again immediately, and makes a vigorous new growth, the ground being more closely covered the second than the first time. This has been our experience on several trials. But the sheep must not be permitted to feed it closely, and should, therefore, be passed over the ground before they have time to do this. If the season is favorable, peas may be fed over three times, and thus yield a large amount of green food. If the season is likely to be too dry, the second feeding should be commenced when the peas are in blossom. It has then the largest amount of nutriment, and of the best quality. The nutritive ratio of peas, vetches, and the clovers, each at the first blossom, is nearly the same; they all stand in the first rank of fodder plants, especially for growing young animals, as they are all rich in the elements to grow the muscles, bones, and nervous system. Peas will flourish upon a variety of soils, either light or heavy; dry clay soils bring large crops. The land does not require to be rich; but a soil containing abundance of lime and potash succeeds best. The pea plant is a large appropriator of lime and potash, and the seeds of potash and phosphoric acid. Land highly manured grows more vine than grain; but lime, wood ashes, and bones are quite appropriate fertilizers. The land should be in fine tilth and smooth, and peas are best planted with a drill which will deposit the seed at an even depth of 2½ inches, at the rate of 2½ bushels per acre. If further practice should discourage feeding the pea crop off upon the land, then it should be grown and cut green at the time of first blossom, and fed to sheep between hurdles on parts of the same field which have been cut. This will require little carriage, and all the valuable manure will be saved; but we think that it will be found practically as safe to feed off peas as winter rye. The pea may be planted as early as the land can be tilled in spring, as it is not injured by frost; and heavy lands should be plowed in the fall, so as to be ready to work as soon as a few inches of the surface is dry enough to be made mellow. Peas will furnish pasturage for sheep in dry weather the last of May or first of June in latitude 40° to 43°. A variation of this pea crop is to sow one-third oats with the peas—that is, two bushels of peas and one bushel of oats per acre. This will generally produce a larger yield of green food than peas alone or oats alone, and the combined crop may be pastured as early as peas alone.

OATS are an important crop for pasturing when sown alone. The oat is also frost-proof in the spring, and may be drilled in the first moment that the land is fitted for it, and, on warm, early soil, will be six inches high and strong by May 20th; and, on being eaten off by the sheep, will start anew at once. If left till the seed head is formed, there will be no second growth. The struggle in all plants is to perfect the seed; and most of our annual plants, if cut when small, will grow again, and when having a strong and vigorous root will push on the second growth very rapidly.

The second feeding of the green oat crop should be when the plant has reached the flowering stage; and if the crop be rank, sheep may waste too much of it when fed off upon the land. If mown and fed to them in racks, it will have the largest amount of nutriment when the seed is in the milk. But the sheep, at that stage, are not inclined to eat the whole stalk unless tempted by a small allowance of meal upon the left stems. As we have seen, this extra grain food will be refunded by extra growth, and the land will get the benefit of the enriched manure. This is the end towards which sheep-feeding on worn lands should point. The oat has the advantage of being adapted to nearly all soils, and it may be the best crop with which to begin the improvement.

## MILLET FOR PASTURE.

Millet is grown in all parts of the country, more or less, both for the seed and fodder. It requires dry, warm land to produce the best crop, and the soil must be made very fine, or the seed, which is small, will not grow. In a fine, rich loam millet produces a very large growth of excellent fodder. When the land is appropriate, it springs up rapidly, and soon covers the ground. When it reaches the height of eight inches, and its root has become well established, sheep may be folded upon it, and crop off four or five inches. The hurdles should be moved each day, to prevent its being eaten too close. It will spring up anew, and more completely cover the ground than before. If care is taken it may be folded over three or four times in a season, at from 14 to 20 days apart. This food is highly relished by sheep, because the leaves and stems, at that stage of growth, are very tender and succulent. Small pieces may be sown at different times, so as to be ready for feeding one after the other. A good crop will produce, at three or four feedings, ten tons of green food on an acre, and pasture 50 sheep 25 to 30 days. There are several varieties of millet, but the common (*Panicum milliaceum*), Hungarian grass (*Panicum Germanicum*), and golden millet are the kinds most grown. The latter produces the largest growth, and for pasturing may be found the most profitable.

We have given these numerous annuals which may be cultivated as pasture plants for sheep, to show the resources of sheep feeders in providing green food which may be eaten off by the sheep during the summer; but we do not mean to set these annuals up as preferable to the perennial grasses and the biennial clovers. These annuals are only to be used to assist in fitting the land for growing profitable crops of the perennial grasses and clovers. The perennial grasses and the clovers are the sheet-anchor of successful stock-feeding, for they yield successive crops without annual labor. But the annual grasses are often necessary in the preparation of the soil for the permanent ones.

## Roots for Sheep-Feeding.

The question of economy in the production of root crops for stock-feeding in this country has never been settled beyond grave doubts in the minds of judicious farmers. The rigor of our northern winter climate is not favorable to out-door feeding of roots; but the modern improvement of warm, well-ventilated stables has done much to obviate this objection, so far as temperature of stable-feeding is concerned. But we cannot adopt the English practice of feeding off turnips and beets on the land; yet many of the most intelligent English farmers think it much better for the sheep to receive their roots in sheds, and that their better thrift will pay for lifting and carting the roots. We think, for sheep feeding in our northern climate, the most profitable use to make of roots is to feed them off on the land during October and November, before the weather becomes too cold. The turnip and beet may be so matured as to be quite ready for feeding in October; and sheep may then be folded upon them, with a little late-growth clover, and thus continue succulent food of the best quality to the beginning of winter. The comparatively high price of labor has usually been regarded as fatal to the profitable production of roots here; but Hon. Harris Lewis, and many others, have declared that beets or turnips can be raised, lifted, and stored for six cents per bushel; and at this cost of labor they must be profitable food for sheep, especially as a small ration of green food in winter. But there is a plant, belonging to the same class as turnips and cabbages, which is extensively raised in Germany and France as a food for stock and as an oil plant. It is a biennial, and has a spindle-shaped, stringy root, running deep, instead of being bulbous, like the turnips, and the value of the crop is in its succulent stalks, leaves, and seed. This is

RAPE (*Brassica napus*),

and is grown upon the same sort of land as turnips, beets, etc. Rape has both a winter and spring variety. If the winter variety can be cultivated here, it will furnish excellent and abundant food for sheep and other stock in May, June and July. It is so hardy as not to be injured in the coldest parts of Germany. Professor Brewer, who examined this crop with care in Germany, believed it well adapted to the United States, and highly recommends it. It seems to have a great superiority over the turnip in fattening qualities. It is exceedingly succulent, having, in its green state, 87 per cent. water; albuminoids 3.13, carbohydrates 8.20, ash 1.60 per cent. When deprived of water, it contains 24.19 per cent. of albuminoids; being richer in this important element than clover, and twice as rich as the Swede turnip. The American edition of Johnson's "Encyclopædia" states that this crop has been tried in New York and New England, and found to stand the winters well. Mr. Samuel Thorne, of Dutchess County, N. Y., writes that, in 1863, he folded lambs upon it very late in the fall, and that frost did not injure this plant. It produces, under good tillage, extraordinary crops. Mr. Blackie, an English writer upon the "Improvement of Small Farms," says that, when well manured, the stalks are juicy, and grow to the height of from five to six feet; and that he believes an acre, with the addition of some straw to counteract its great succulence, will keep 30 head of milch cows in full milk for a month. It is, no doubt, an overestimate, as it would be equivalent to keeping a cow 900 days on the crop of 160 rods of land, or 180 sheep 30 days on an acre, or 33¾ sheep one day upon one rod of land. If we can estimate its capacity to feed cows and sheep at one-half these figures, it is an exceedingly desirable crop. It is generally regarded in Germany, and in all parts of England, as one of the very best crops for fattening sheep; and as it is ready for feeding June and July, or if fed earlier in spring would give its largest crop later in the season —say September—it must prove to be one of the most profitable green crop that can be raised, and especially adapted to the improvement of the land. Its seed has long been used for the production of rape oil; and the rape cake, so much used by English feeders, is the refuse of the seed after the oil has been expressed. Many estimate the labor in producing a crop of rape as about the same as that required for a crop of wheat. There can be no doubt of its success on the deep rich prairie soils of the West; and when stock-feeding on these lands shall be conducted for the purpose of preserving their fertility, as well as for profit, this is likely to become one of the most important crops. It has greatly the advantage of the turnip, beet, or carrot, on account of its richness in albuminoids, thus supplementing this deficiency in the corn crop, and on account of its easier cultivation. Being a deep-rooted plant, it will recover very quickly after feeding off by sheep, and soon furnish a second growth of stalks and leaves for the same purpose. It is certainly worthy of a careful trial.

## Ensilage for Winter Feeding.

Sheep are extremely fond of succulent food, and one of the difficulties encountered by the sheep-feeders during our long winters is the want of a due proportion of green food. The recent invention of the improved silo, for the preservation of green, succulent food for winter use, will wholly remedy this defect in winter sheep-feeding. Every description of green crops may be preserved in silo, for winter use; and as the sheep is particularly fond of variety in its food, and will travel over a large field, most industriously selecting the greatest variety within its reach, the silo enables the feeder to gratify this appetite of the sheep. If a large variety of grasses is sown upon our meadows, they may all go into the silo together; thus not only gratifying the appetite, but greatly adding to the thrift of the sheep. All the crops we have mentioned as appropriate for feeding off upon the land are also appropriate for preserving in silo for winter use. This green food in winter will enable the sheep-farmer of the older States to make as good progress in winter-feeding as the sheep-farmers of Europe with the aid of succulent roots. The great advantage of turnips for sheep in winter is, that they counteract the effect of the dry food given.

A most important consideration in favor of the silo is, that the feeder may not only give variety in the ration, but he may give a ration containing the proper proportion of food elements. The silo has been discussed in this country almost wholly as a means of preserving fodder-corn; but as fodder-corn is only a partial food, and must be fed with some more nitrogenous food to produce a satisfactory result, the silo could only be a very partial success if it only preserved this one green food. Its great result must be looked for in enabling the feeder to mingle in the silo several different green foods which unitedly contain the food elements in the proper proportion for growing or fattening animals. As sheep will fatten very fast upon a good pasture which contains a variety of the best grasses, so they should gain as rapidly when fed from a silo upon green fodder-corn, clover, millet, rape, peas, oats, etc., containing a combination of the same food element in as digestible a condition. It is a common opinion among farmers (which we do not wholly share), that grain is the most expensive food, and that sheep are kept much cheaper upon pasture or hay than upon hay and grain. It is only necessary to feed grain because hay is less digestible than grass. Now, the silo, if successful, will enable sheep to be fed upon grass in as succulent a state in winter as in summer. This may render the older States, which have reached a diminished capacity for grain raising, independent of Western grain in the production of meat. These States are still well adapted to the production of the grasses and every green food required for winter feeding, when preserved in silo;

and as green, succulent food goes much farther than the same food dried into hay, so the capacity of these States for the production of mutton and other meat will be vastly increased.

Ensilage being nearly as succulent as the fresh green food itself, root crops will become much less important. When the silo shall come into full use, sheep will really be fed the same winter and summer ; and progress in fattening will be nearly the same, a little extra food being given in the winter, to keep up the animal heat. This succulent winter food will have an important effect in improving early lambs, causing the ewe to yield more milk; and the lambs may make as good progress as if their dams were upon pasture.

## Managing a Flock.

The mode of conducting a breeding flock for profit will vary according to locality and cost of food. Near the large Eastern markets, and on land upon which sheep are kept as the best compensation for the food consumed, the ram lambs of the flock will principally be disposed of at a few months old, as affording better profit at this than at any subsequent period. The forty-pound fat lamb costs less in food than any forty pounds of growth added afterwards, and brings about three prices per pound. If, then, a flock of common ewes is being crossed with a pure-blood South-down or Cotswold ram, for the purpose of laying the foundation and building up an improved breeding flock, it will be profitable to keep only the ewe lambs—grade rams should never be kept for breeding, but grade ewes will be a great improvement over common ones when bred to a ram of the same blood as their sire. So, in grading up a flock towards a pure-blood mutton breed, about half of the lambs each year may be sold for the early market. Each generation will approximate nearer and nearer to the pure blood until they are practically equal for mutton or wool.

It will be seen that the expense of grading up this flock over that of common breeding is hardly worth considering; that, in fact, the ram or wether lambs marketed each year will be enhanced in value much more than the cost of the pure-blood ram over a common one. But while these ewe lambs are growing up to breeding age, the defective ones must be weeded out, and not permitted to breed. Only those of good form and prime feeders should be kept for breeding. The first requisite of a profitable animal is a good appetite and active digestion. A habitually mincing eater should always be discarded, whatever beauty of external form it may possess. No profit ever comes from a slow feeder. The breeding ewe, if she raises good lambs, must secrete a liberal quantity of milk, and this can only be done by a large consumption and digestion of food. The young ewes should not be bred before 14 to 16 months old; earlier breeding is not conducive to vigor of constitution. As the flock increases in numbers, greater care can constantly be given to selection of the ewes to be bred—breeding always from the best. The third cross will give ewes of $\frac{7}{8}$ pure blood, and this can be accomplished in four years; two years more would give $\frac{15}{16}$ blood; so that six years would grade up common ewes to fifteen-sixteenths blood Southdown, Cotswold, or other pure blood. It is not, therefore, long to wait for a thoroughly-improved flock, which will practically give all the profit of the highest blood. Even the half and three-fourths blood usually feed about as well as the higher blood. After the fifth cross with pure-blood rams, or thirty-one-thirty-second part of the pure blood, the rams of this cross may be considered prepotent, and may be used for breeding—often even the cross below this will be found prepotent as males. The English Short-horn Herd Book admits four crosses to record as Short-horns; and the same rule would hold with sheep. But we think breeding together grades of low degree tends to bring pure blood into discredit, and is unprofitable.

### Regularity in Feeding.

All feeders who have studied the habits of the animals they feed, have discerned that they take special note of time, and are disappointed if the time is delayed only a few minutes. It is a cardinal point to observe great regularity in time and quantity for feeding sheep. It has been observed that a careful and regular feeder will produce a better result with inferior food, given at equal times and in even quantity, than an irregular feeder as to time and quantity with the best quality of food. It is said that "the master's eye is worth two pair of hands," and it may as truly be said that "the shepherd's eye, which takes note of the individual wants of his flock, is worth a large amount of carelessly-given food."

The late John Johnston, of Geneva, N. Y., to whom we have before alluded as a successful cattle-feeder, has also been, under the old system, a successful sheep-feeder. In a letter to the Hon. H. S. Randall, in 1862, he describes his common mode of winter feeding. Mr. Johnston was a very successful wheat and barley raiser upon a 300-acre clay-loam farm, completely tile drained. He had large quantities of straw, and studied how to turn this into the largest quantity of manure. He says:

"I generally buy my sheep in October. Then I have a pasture to put them on, and they gain a good deal before winter sets in. I have generally put them in the yards about the 1st of December. For the last 23 years I have fed straw the first two or two and a half months, a pound of oil-cake, meal, or grain, to each sheep. When I commence feeding hay, if it is good, early-cut clover, I generally reduce the cake, meal, or grain one-half; but that depends on the condition of the sheep. If they are not pretty fat, I continue the full-feed of cake, meal, or grain, with their clover, and on both they fatten wonderfully fast. This year (1862–63) I fed buckwheat, a pound to each per day—half in the morning and half at 4 P. M.—with wheat and barley straw. I found the sheep gained a little over one pound each per week. It never was profitable for me to commence fattening lean sheep. Sheep should be tolerably fair mutton when yarded. I keep their yards and sheds well littered with straw.

"Last year I only fed straw one month. I fed each sheep one pound of buckwheat. From the 20th of October to the 1st of March they gained 1⅓ lbs. each per week. They were Merinos—but not those with the large *cravats* around their necks. I have fed sheep for the Eastern markets for more than 30 years, and I always made a profit on them, except in 1841–42; I then fed at a loss; and it was a tight squeeze in 1860–61 to get their manure for profit. Some years I have made largely. Taking all together, it has been a good business for me."

This account of sheep-feeding is on a different plan from the one we have been considering, of making it a systematic business—the feeder breeding his own sheep. But we give it to show what a careful feeder may do on a grain farm to keep up its fertility. Mr. Johnston's gains per week are small besides those we shall give of feeding the mutton breeds; but his results are remarkable, considering the fact that the sheep he bought were those of slow growth and late maturity. His success in winter-feeding on that plan was largely owing to his custom of buying in October, and giving them good pasture for some two months. His straw-feeding would also have been much less successful had he not fed oil-cake with it. The very nitrogenous oil-cake balanced the carbonaceous straw, and this oil-cake greatly enriched the manure.

## ENGLISH SHEEP-FEEDING.

Sheep husbandry has become so important an element of our agriculture, that the American shepherd should make a careful study of the methods of feeding adopted in other countries where this branch of husbandry is successfully carried on. In growing mutton and wool together, England has been pre-eminently successful, and her method of feeding must be well considered. It is hardly to be expected that the American feeder can use precisely the same crops as the English farmer to feed his flocks; but he may, at least, find substitutes which are better suited to our soil and climate, and have the same nutritive value. We shall give some of the best-authenticated experiments of English feeders, that may serve to give a clear idea of their plan of winter feeding—a period attended with more obstacles than any other, as the summer produces Nature's best ration for sheep—the grasses.

## EXPERIMENTS WITH ROOTS, GRAIN AND GRASS.

The experiments recorded in Mr. Robert Smith's essay on "The Management of Sheep"—for which the Royal Agricultural Society granted him a prize in 1847—are full and carefully made, and represent the effect of the most commonly adopted ration, and many important variations of it.

*Experiment* 1.—Eight lambs were weighed on the 20th December, 1842, and placed upon turnip land to consume the turnips on the field where they grew; and being supplied with all the cut swedes they would eat, were found to consume, on an average, 23½ lbs. per head, per day. They were again weighed April 3d (15 weeks), and gained 25½ lbs. each.

*Ex.* 2.—Same day, eight lambs were placed in a grass paddock, under same regulations, and found to consume

19 lbs. of turnips per day, and gained, in 15 weeks, 26¾ lbs. each.

*Ex.* 3.—Same day, eight lambs were placed alongside No. 2, and allowed to run in and out of an open shed during the day, but were shut up at night. They had half a pound of mixed oil-cake and peas per day, and ate besides 20½ lbs. of turnips, and gained 33½ lbs. each.

*Ex.* 4.—Same day, eight lambs were placed under same conditions as No. 3, but supplied with one pound of mixed grain (oats, barley, beans) per day. They consumed, during the ten following weeks, 20 lbs. turnips per day; were weighed February 28th, and had gained 26½ lbs., average.

*Ex.* 5.—Eight lambs were placed in a warm paddock, with a shed, during the day, but were shut up during 18 hours, and fed upon 1¼ lbs. of mixed grain per day. They consumed 18½ lbs. of turnips each, and in ten weeks gained 33½ lbs. each.

*Ex.* 6.—January 5, 1843, sixteen shearlings were equally divided—eight placed in a grass paddock, and given each one pound of mixed grain per day, ate 24 lbs. of Swedish turnips, and gained, in eight weeks, 21½ lbs. each.

*Ex.* 7.—The other eight shearlings were placed alongside No. 6, were allowed an open shed during the day, and were shut in at night, had one pound of mixed grain, consumed 20½ lbs. of turnips, and gained, in eight weeks, 24 lbs. each.

*Ex.* 8.—On the 3d of April, eight lambs (No. 3) were weighed and placed upon young clover, and supplied with half a pound of mixed grain, as before. They ate also 12 lbs. of turnips per day; and, on the 1st day of May, had gained 11¾ lbs. each—having had a shed during the day, and being shut up at night.

*Ex.* 9.—On the 29th of May, the eight lambs (No. 8) were again weighed, having been allowed, as before, half a pound of mixed grain upon the clover, but no turnips, with shed to run under at will. They gained 16 lbs. each during the month.

To prove the effect of less heating food in hot weather, he placed the two lots of shearlings (Nos. 6 and 7) upon moderate growth of clover, July 1, 1843.

*Ex.* 10.—The eight shearlings (No. 6), being weighed, were allowed one pint of peas per day, and again weighed at the end of 21 days; had gained 9¼ lbs. each.

*Ex.* 11.—The eight shearlings (No. 7) being also weighed, were given one pint of old beans, and, at the end of 21 days, had gained 6 lbs. each; the beans proving to be a too heating food, and the sheep eating them being found to be getting humors, even in this short time, while those fed upon peas were looking very healthy. This is a very doubtful criticism upon the heating qualities of beans and peas, since, as the percentage of carbo-hydrates and oil is about the same in both, the heating qualities must be the same.

Desiring to test the qualities of the various vegetables in the fall, he divided 30 lambs into equal lots of 10 each, on the 2d of October, 1843, and placed them upon overeaten stubble fields (which the English call "seeds"). To each were fed different vegetables by an experienced shepherd.

*Ex.* 12.—Ten lambs, fed upon cut, white turnips, were weighed again November 13th (six weeks), and had gained an average of 11 lbs. each.

*Ex.* 13.—Ten lambs, fed on cut swedes, gained, during the six weeks, 11 lbs. each.

*Ex.* 14.—Ten lambs, fed on cut cabbage, gained, during the time, 16½ lbs. each; showing that, at this season, cabbage is superior to turnips; but as cold weather came on, he found the value of the white turnip and the cabbage grew less, and the swedes improved. This is owing, no doubt, to the larger percentage of water in cabbage and white turnips, which is unfavorable in cold weather.

To test grass land, in comparison with cole-seed (a species of rape or cabbage) and cabbage, in the autumn of 1844 he put ten lambs upon each, on the 14th of October.

*Ex.* 15.—Ten lambs penned upon green cole-seed (rape), with cut clover chaff, gained, in one month, 12½ lbs. each.

*Ex.* 16.—Ten lambs, penned on drum-head cabbage, with cut clover chaff, gained 10½ lbs. each in one month.

*Ex.* 17.—Ten lambs, upon grass, and fed upon cut swedes and cabbage, in equal quantities, with clover chaff, gained 9¾ pounds each.

*Ex.* 18.—Ten lambs upon grass, and fed upon cut white turnips and cabbage, in equal parts, with clover chaff, gained 11 lbs. each.

To test carrots, as against swedes, he fed No. 16 all the swedes they would eat, and No. 17 all the carrots they would eat.

*Ex.* 19.—Ten lambs, fed upon cut swedes and clover chaff, were found to have gained, in one month, 10 lbs. each, and had eaten 22 lbs. of turnips per day.

*Ex.* 20.—Ten lambs, fed upon cut carrots and clover chaff, gained, in the month, 9¼ lbs. each, and had eaten 22½ lbs. of carrots per day.

It will be noted that the ten lambs upon green rape gained more than those upon swedes and cabbages. This series of experiments very well represents the feeding of lambs with roots, grain, grass, etc.; but it has not gone much into the use of oil-cake, and has not given the results in feeding older sheep.

## Feeding Young Lambs.

We will now give a series of somewhat different experiments, representing the lambs at an earlier age with their dams. This is from Mr. T. E. Pawlett's essay, which was highly commended by the Royal Agricultural Society of England. His views are based upon a long-continued habit of weighing his sheep and lambs every month, alive, so that his statements are based upon actual figures, like those just given.

He gives, preliminarily, the average gain he has had in lambs during the year commencing soon after birth. In small lots he has found the gain as follows:

Young lambs in month of

| | |
|---|---|
| April | 9 lbs. |
| May | 16 " |
| June | 18 " |
| July | 15 " |
| August | 12 " |
| September | 12 " |
| October | 12 " |
| November | 8 " |
| December | 6 " |
| January | 5 " |
| February | 7 " |
| March | 10 " |
| In 12 months, gain in live weight | 130 " |

Mr. P. fed, altogether, Leicesters, and he says the above weights were often very much exceeded.

American feeders may not have a very clear idea of the weight of swede turnips that lambs and other sheep will eat per day. Mr. P. says an ewe lamb-hog (one unshorn) will eat of cut swedes, in the month of February:

| | |
|---|---|
| Per day | 18 lbs. |
| A wether lamb-hog | 20 " |
| A ram lamb-hog | 22 " |
| A shearling wether | 22 " |
| A feeding or breeding ewe | 24 " |
| A sucking ewe | 28 " |
| A ram above two years old | 30 " |

if no other food but cut swedes is given them; but warm weather will reduce the amount about one-fourth. If grain or oil-cake, or any other dry food is given, they will consume less turnips in proportion to the amount given.

*Experiment* 1.—In March, 1845, he selected 12 ewes and lambs from the flock, and divided into lots of equal quality and weight. Six were fed entirely on clover-hay chaff, of which each ate 24½ lbs. per week, at a cost of 21 cts.; and the other six were fed each 163⅓ lbs. of swedes, costing 17 cts., and 2⅛ pecks of beans, worth 14 cts., amounting to 31 cts. per week each. At the end of a month the lambs of the ewes fed on clover chaff alone looked the most thriving.

*Ex.* 2.—Twelve ewes and lambs were again selected and divided, and fed for two weeks, the lambs being weighed. Six were fed on 9 lbs. of bran daily and 15 lbs. of clover chaff, costing for each sheep 26 cts. per week; and the other six were fed upon clover chaff alone, as before, costing 21 cts.—the lambs of the former gained, in 14 days, 6 lbs. and those of the latter 4¾ lbs. This difference of 1¼ lbs. live weight Mr. P. regards as costing all it comes to in the 5 cts. extra for bran.

To test the comparative value of clover and trefoil, as against vetches or tares, he selected 14 lambs with their dams, weighed the lambs and divided them equally by weight and number.

*Ex.* 3.—Seven of these dams and lambs were placed upon clover and trefoil, and the other seven upon vetches. The seven on clover and trefoil gained 20 lbs. each. Those on vetches, 16½ lbs. each.

*Ex.* 4.—He selected ewes and lambs, weighed and divided them on the middle of May, folded one-half in the clover field, and fed with cut mangold-wurzel and a little hay chaff; their lambs ran through the hurdles on a good pasture of red clover. The other lot were left at large on white clover and trefoil, their lambs also ran on a good piece of red clover, and both lots of lambs had a small quantity of peas. At the end of 28 days the lambs of the ewes fed on mangolds had gained 21 lbs., the other lot, 18 lbs.

Here is a most remarkable gain shown of 21 lbs. in 28 days, or over 5 lbs. per lamb per week.

*Ex.* 5.—June 10th, 10 lambs were weaned and weighed alive, put on red clover, with some vetches and beans. On the same day 10 lambs were weighed, remaining with their dams on white clover and trefoil, but allowed to run through the hurdles upon good red clover.

At the end of 33 days the unweaned lambs had gained 17 lbs., and the weaned, 16½ lbs. each. Another experiment with 12 lambs weaned and 12 unweaned, showed the former to have gained in a month 21 lbs., and the latter 20¾ lbs., showing the gain about equal; but Mr. P. remarks that those weaned early wintered best.

*Ex.* 7.—Two lots of lambs were weighed November 19th. To the one was given cut swedes with clover-hay chaff and malt sprouts mixed; and the other lot, cut swedes only. In two months the former gained 14½ lbs., and the latter 8 lbs. each, making 6½ lbs. in favor of dry food.

*Ex.* 8.—Another experiment of a similar character was tried with eight lambs each, February 18th. The one was fed with cut swedes and 2 lbs. of clover chaff and 2 lbs. of bran, the others on swedes alone. At the end of one month the former had gained 7¼ lbs. and the latter 3¾ lbs. each.

Here the gain is nearly double with the dry food, and this is no doubt owing to the temperature.

*Ex.* 9.—Eight lambs were fed upon cabbages and white turnips in October, with a half-pint of linseed to each, and a like number were fed upon cabbages, white turnips and clover chaff, as much as they would eat. The former gained, in one month, 16 lbs., and the latter 16 lbs.

Here the clover chaff balances the half-pint of linseed. One of its most important offices is to absorb the extra amount of water in the cabbage and turnips. Mr. P. appears to be opposed to feeding sheep in yards; but he thought he would try it again, and on the 4th of December he put some of his best lambs into a warm, well-sheltered yard, with a high shed to feed under, well littered with fresh straw, and fed them, as usual, on swedes and grain.

These were weighed as against a like number fed eight weeks in a turnip field :

| | |
|---|---|
| Those in field gained each | 13 lbs. |
| Those in yard only gained each | 3 " |
| Apparent balance against yard feeding | 10 " |

He remarks: "These lambs did not appear to like the confinement, and took every opportunity of getting out if they could." The reader will compare this with experiments three, five, and seven of the first series, where the shed appeared to increase the gain decidedly. The explanation is probably to be found in the strict confinement, which so changed the habits of the lambs as to unfavorably affect their health.

The American feeder, in looking over these experiments, will note the favorable effect of a little grain with the turnip ration. The turnip is a very watery plant; and although a moderate amount of succulence is very conducive to health and animal growth, yet to compel lambs to take their entire food diluted with 87 to 90 per cent. water is not appropriate, except in the warm season ; and even then dry food as a part of the ration is an improvement. In experiment No. 5, on 1¼ lbs. of mixed grain with 18½ lbs. turnips, the lambs gained as much in 10 weeks as those in experiment 3 did in 15 weeks on ½ lb. of oil-cake and peas with 20½ lbs. of turnips; and in these two experiments the shelter was the same and only proportions of the food changed.

It has always been our strong belief that English feeders are in error in feeding more than 10 lbs. of turnips to a lamb, and the balance of the ration should be made up of early cut and cured clover-hay, tares, rape, or fine grasses, and grain, or oil-cake, or a mixture. Experiments 8 and 9 prove that 12 lbs of turnips on very young and succulent clover (No. 8), with ½ lb. of grain, produced less gain per month (11¾ lbs.) than when omitted (No. 9, where the clover and grain produced 16 lbs. gain). The actual nutriment in 20 to 23 pounds of turnips is only equal to 3 lbs. of Indian corn. And when we take into consideration the amount of extra water that must be exhaled and evaporated from the body in the excessive use of turnips as a food in moderately cold weather, it is highly probable that 23 lbs. of turnips scarcely represents in heat and fat-forming power, 3 lbs. of corn. This would make a bushel of corn balance 429 pounds of turnips, or an acre of corn, at 40 bushels per acre, would equal 8½ tons of 2,000 pounds of turnips; and, counting the corn at 25 cents per bushel, as it averages over large districts of the West, it would give but $1.18 per ton for the turnips, and $2.36 when corn is 50 cts. per bushel. This last price would equal 6 cents per bushel—a price for which some American farmers say turnips or beets can be raised. But this comparison will show that turnips cannot compete with Indian corn when the latter can be purchased at 25 cts. per bushel. Yet the real value of turnips, as a food preservative of animal health and growth, is higher than that given here. Ten pounds of turnips with 1½ lbs. of corn will fatten a young sheep or lamb faster than 3 lbs. of corn alone. The English ration of turnips or other roots for both sheep and cattle is quite excessive, and would be more profitable if divided and the same value in grain fed for the other half. The succulent root crop, fed in moderate quantity, is the basis of successful winter-feeding of sheep in England, and may yet be widely adopted in this country, unless the silo shall preserve better green food at a less price, where the price of corn ranges from 40 to 75 cts. per bushel.

## German Experiments in Sheep-Feeding.

We will now give some German experiments—the first conducted by Dr. Wolff in feeding two common lambs for 9 months, from 5 to 14 months old. These lambs were fed upon hay, oats, and oil-cake. The hay during the first two periods was early-cut and nicely-cured meadow hay, and during the other periods was aftermath. The following table gives the amount of food, gain, etc.:

| Period. | Age, months. | Average live weight. | Total fodder. | Digested. Albuminoids. | Digested. Fat. | Digested. Carbo-hydrates. | Nutritive ratio 1: | Gain per day. |
|---|---|---|---|---|---|---|---|---|
| | | lbs. | lbs. | lbs. | lbs. | lbs. | | lbs. |
| 1 | 5–6 | 59 7 | 1.99 | 0.21 | 0.08 | 0.97 | 5.6 | 0.26 |
| 2 | 6–8 | 70.7 | 2.02 | 0.24 | 0.08 | 1.02 | 5.1 | 0.24 |
| 3 | 8–9 | 78.9 | 1.91 | 0.21 | 0.10 | 0.92 | 5.6 | 0.07 |
| 4 | 9–12 | 84.8 | 1.82 | 0.19 | 0.06 | 0.91 | 5.6 | 0.12 |
| 5 | 12–14 | 95.8 | 1.76 | 0.19 | 0.08 | 0.89 | 5.7 | 0.19 |

It appears from the above table that the daily gain in the first two periods was very uniform, in the third period fell off 72 per cent., in the fourth period was 50 per cent. of the second, and in the fifth period increased 50 per cent. over the fourth. This experiment, although it illustrates the law of growth—that the younger the animal the greater the gain from a given amount of food—yet there are such irregularities visible as to deprive it of much authoritative value. The number of animals is quite too small.

The following experiments by Stohmann were upon lambs seven to eight months old, fed upon straw, potatoes, clover-hay, and oil-cake. These were combined into rations for the four different lots of lambs, each slightly varying from the others. These lambs were fed four months before shearing and one month after shearing. The nitrogenous and non-nitrogenous elements of the ration per day per head, gain per day, etc., are shown in the following table:

BEFORE SHEARING.

| | Lot 1. | Lot 2. | Lot 3 | Lot 4. |
|---|---|---|---|---|
| Digestible albuminoids, lbs. | 0.38 | 0.28 | 0.28 | 0.38 |
| Digestible carbo-hydrates and fat, lbs. | 1.54 | 1.56 | 1.36 | 1.41 |
| Nutritive ratio | 1.41 | 1.56 | 1.49 | 1.37 |
| Gain per day, lbs. | 0.25 | 0.21 | 0.17 | 0.21 |
| AFTER SHEARING. | | | | |
| Digestible albuminoids, lbs. | 0.48 | 0.35 | 0.33 | 0.46 |
| Digestible carbo-hydrates and fat, lbs. | 2.04 | 2.02 | 1.76 | 1.80 |
| Nutritive ratio | 1:4 3 | 1:5 8 | 1:5.3 | 1:3.9 |
| Gain per day, lbs. | 0.28 | 0.25 | 0.23 | 0 24 |
| Average live weight, lbs. | 95.00 | 92.00 | 86.00 | 92.00 |
| Dressed in per cent. of live weight | 58.10 | 57.40 | 56 20 | 53.10 |

This experiment of Stohmann's shows the effect of higher feeding over that of Wolff's, but neither shows a gain equal to the English experiments given above; and this may be explained from the fact that the English mutton sheep are better bred than the German, mature earlier, and eat larger rations. Take No. 19 of Mr. Smith's experiments, where the 10 lambs average 22 lbs. of swedes per day. This would be equal to .29 lb. digestible albuminoids, 2.40 lbs. carbo-hydrates, .022 lb. fat; and they averaged a gain of .33 lb. per day, and this is only about an average gain per day of the lambs in Smith's and Pawlett's experiments, and yet the proportions of the rations do not greatly differ.

We will add to these experiments those of Weiske, of recent date, on feeding lambs. He carried two lambs through nine periods of about five weeks each, beginning at the age of four months. At the end of the ninth period the lambs were put into the flock for some nine months, and then fed another period. The ration consisted of hay and peas at first, but gradually the hay was increased and the peas diminished until in the last three periods the ration was composed wholly of hay. In each period analyses were made of the fodder, of the excrement—solid and liquid—and live weight taken for some eight days. It was said also these lambs gained weight faster than lambs of the same age on good pasturage. We are indebted for these tables to Prof. Armsby's recent "Manual on Cattle-Feeding":

PER HEAD.

| Period. | Age, months. | Weight of lambs. | Digested, per day. | | | Nutritive ratio, 1: | Gain, per day. | |
|---|---|---|---|---|---|---|---|---|
| | | | Albuminoids. | Fat. | Carbo-hydrates. | | Live weight. | Flesh. |
| | | lbs. | lbs. | lbs. | lbs. | | lbs. | lbs. |
| 1.......... | 4 — 5¼ | 45.0 | 0.17 | 0.03 | 0.74 | 4.8 | 0.28 | 0.17 |
| 2.......... | 5¼— 6½ | 56.2 | 0.18 | 0.04 | 0.92 | 5.7 | 0.27 | 0.17 |
| 3.......... | 6½— 7¾ | 63.5 | 0.18 | 0.04 | 0.90 | 5.6 | 0.23 | 0.15 |
| 4.......... | 7¾— 9 | 71.7 | 0.20 | 0.04 | 0.98 | 5.4 | 0.20 | 0.18 |
| 5.......... | 9 —10¼ | 77.0 | 0.18 | 0.04 | 0.95 | 5.8 | 0.13 | 0.15 |
| 6.......... | 10¼—11½ | 77.6 | 0.18 | 0.04 | 0.94 | 5.8 | 0.09 | 0.13 |
| 7.......... | 11½—12¾ | 83.6 | 0.18 | 0.05 | 0.96 | 6.0 | 0.13 | 0.19 |
| 8.......... | 12¾—14 | 89.1 | 0.17 | 0.05 | 0.99 | 6.6 | 0.16 | 0.16 |
| 9.......... | 14 —15 | 85.8 | 0.16 | 0.04 | 0.98 | 6.8 | .... | ... |
| 10.......... | 24 | 126.5 | 0.15 | 0.06 | 1.18 | 8.9 | .... | 0.14 |

This experiment shows very clearly the effect of age and weight upon the growth of the lamb—each period a steady decrease in gain per day, although the food is slightly increased, and especially in proportion to the gain. Had there been a larger number of lambs—say ten—so as to have eliminated the peculiarities of the individual, this series of experiments would have possessed great value; and this is the fault of most of the feeding experiments at the German stations—that they have been performed upon individuals and upon too small a number of animals. But if this table is calculated per 100 lbs. live weight, instead of per head, the result more clearly appears.

PER 100 LBS. LIVE WEIGHT.

| PERIOD. | DIGESTED, PER DAY. | | Carbo-hydrates. | Gain of weight per day. | Albuminoid consumption, per day. | Gain of Albuminoids, per day. | Gain, per cent. of albuminoids digested. |
|---|---|---|---|---|---|---|---|
| | Albuminoids. | Fat. | | | | | |
| | lbs. | lbs. | lbs. | lbs. | lbs. | lbs. | |
| 1 | 0.38 | 0.07 | 1.67 | 0.73 | 0.29 | 0.09 | 23.7 |
| 2 | 0.33 | 0.07 | 1.66 | 0.54 | 0 26 | 0 07 | 21.2 |
| 3 | 0.28 | 0.06 | 1.41 | 0.41 | 0.23 | 0.05 | 17.9 |
| 4 | 0.28 | 0.06 | 1.36 | 0.31 | 0.22 | 0.06 | 24 4 |
| 5 | 0.24 | 0.05 | 1.23 | 0.17 | 0.20 | 0.04 | 16.7 |
| 6 | 0.23 | 0.06 | 1.22 | 0.13 | 0.19 | 0.04 | 17.4 |
| 7 | 0 22 | 0 05 | 1.15 | 0.17 | 0.17 | 0.05 | 22.7 |
| 8 | 0.20 | 0.05 | 1.11 | 0.19 | 0 16 | 0.04 | 20.0 |
| 9 | 0.19 | 0.06 | 1.09 | .... | ... | .... | .... |
| 10 | 0.12 | 0.05 | 0.93 | .... | 0 10 | 0.02 | 16.7 |

This table shows most clearly the extra cost of putting on live weight as the animal grows older and heavier. If we take an average of the first three periods, we find that 3½ lbs. of digestible food produced one pound gain in live weight; but if we take an average of the 6th, 7th and 8th periods, it required $8\frac{7}{10}$ lbs. of digestible food to make one pound gain in live weight—about two and a half times as much food to produce the same result. This shows in striking light the advantage of early maturity. If our readers will carefully study these experiments and tables, they will never more doubt the economy of full-feeding from birth to commercial maturity.

## CUTTING AND COOKING FODDER FOR SHEEP.

The preparation of the winter food for sheep is an important matter to be considered. The sheep's grinding or masticating apparatus has often been so strongly commended as to lead most feeders to suppose that the artificial preparation of their food is labor lost. This, however, is far from being borne out by the facts. The author, on theory, has regarded the cutting of hay and other coarse fodder for sheep as good economy; and to test this point by an

### Experiment,

we fed 25 medium-sized grade Merino sheep 50 lbs. of long, early-cut timothy-hay per day for one week, and, on gathering up the fragments each day, found that the average was 12 lbs. per day left uneaten. We found, also, that this hay was not left because of over-feeding, for when fed 75 lbs. per day they ate the same proportion of it.

They were then given 50 lbs. of the same hay per day cut $\frac{3}{8}$ inch long, for one week, and, on carefully gathering up what was left, found less than 2 lbs. average per day uneaten. On increasing this cut hay to 60 lbs. per day, this was found to be all they would eat. This was continued till we came to the conclusion that 60 lbs. of cut hay equaled, for sheep, 75 lbs. of the same hay uncut. We also found, in the case of good fodder corn, that twice as much of it was eaten by sheep, when cut $\frac{3}{16}$ inch in length, as when uncut. In short, our experiments proved that sheep pay as well for fine chaffing of coarse fodder as any class of farm stock. The experiment was intended simply to test the effect of cutting the hay and fodder corn when feeding store sheep.

In fattening sheep we have experimented on the effect of cooking hay and grain together. For this purpose we mixed 100 lbs. corn-meal, 100 lbs. of wheat middlings and 50 lbs. of linseed oil-meal (old style). One hundred pounds of this mixture was mixed with 200 lbs. of cut hay, the hay being first moistened; and then 600 lbs. of this mixture were placed in a steam-box and cooked with live steam for one hour and a half. The sheep, of about 100 lbs. weight, consumed 3 lbs. per head per day in two feeds, morning and evening, with ½ lb. of dry hay at noon. Upon this ration the gain was 3 lbs. per head per week. The same ration uncooked produced a gain of 2 to 2¼ lbs. per head per week.. Upon this cooked ration the sheep seemed as contented as on grass.

A cooked ration is more laxative than a dry one, and the small proportion of oil-meal also assisted in keeping the digestive organs in a healthy condition. The small lock of dry hay at noon was relished and corrected any tendency to relaxation. Having fed sheep upon steamed food for several winters, and always with satisfaction, we came to regard this way of feeding as most profitable with a large stock and the proper facilities.

### Another Experiment.

Under this head we will give a condensed statement of the experiments of the late Arvine C. Wales, of Massillon, Ohio, in feeding sheep on a large scale upon cooked food. In 1874 he divided a lot of 300 sheep into two flocks of 150 each. The one lot was placed under a shed and fed liberally on clover hay and sheaf oats; the other lot was placed in another shed and fed on cut fodder corn and wheat bran. Seventy-five pounds of bran were mixed with one day's feed of fodder corn and all wet down with boiling water. Both lots of sheep were weighed before the feeding began and frequently during the experiment, of eight weeks. He does not give the figures of the weighings, but says: "They were interesting to me and so satisfactory as to seem to warrant the purchase of an engine and boiler, and the putting up of tanks and conveniences on a scale adequate to the wants of the flock. Since then I have fed cooked food almost exclusively. Last winter, owing to the failure of the hay crop, I kept over my entire stock, consisting of 20 horses, 20 head of cattle, and between 1,600 and 1,700 sheep, without a pound of hay, and they came into spring in better condition than they have ever done on dry feed." He then gives his mode of raising fodder corn, which was to sow two bushels of seed with a drill, all the tubes working, and cut it with a reaper, setting it up in large shocks. He figures his corn at six tons of cured stalks per acre, at a cost of seed, labor, all told, including shocking, at $1.30 per ton. He gives the following statement of

## Cost of Steaming.

"The stock now being fed requires about three tons of dry feed per day. The cutting is done by a No. 6 Cummins cutter, and it is so arranged that the cut feed as it falls from the cutting machine is carried to and placed in the tanks, wet up with the necessary quantity of water, and mixed with bran or meal by machinery—so that when the cutting is done the feed is ready for the steam. Three men in an hour and a half can cut the three tons. With the present boiler capacity it takes one man four hours more to steam it. The cost of fuel for cutting, mixing, steaming, pumping water, etc., is about five cents per ton of dry feed. The cut feed is much more easily and rapidly distributed to the animals than long feed. It is shoveled from the tanks down into wagons with side boards, that stand below the bottoms of the tanks, and carried to the sheep-folds. The racks are made to accommodate twenty sheep, and this number is found to need about two bushels of cut feed. The feeder has two two-bushel baskets. While he is carrying one to the racks the boy fills the other. In this way a man and a boy can feed and care for 1,500 sheep. The fodder is eaten up clean, a few joints and soiled pieces only being left, but not one per cent. is wasted.

"All the advantages claimed for feeding steamed food to cattle and horses—the economy of feed, the increased health, thrift and comfort of the animals—are found in an equal degree in the feeding of sheep. The effect is shown in the wool, which is of a length, clearness, *style,* and particularly *strength* of staple rarely found on sheep wintered on dry feed. There is no *jar,* or tender place in the wool indicating the point in the growth of the fibre where the sheep changed from green to dry feed. All the wool buyers observed this; and the wool, it is believed, commanded a higher price than any other clip bought from first hands in this or any of the adjoining counties.

"It is not claimed that the steaming of feed adds to its nutritive elements. But as the pulverization and stirring of the soil promote the growth of plants by making the plant food more accessible to the plants, so the steaming of feed makes it at once more palatable and more readily digested and assimilated by the animals, and performs the same office for their food that cooking does for ours."

We have no doubt that Mr. Wales' views of the improvement of the food by steaming, for sheep, is correct. Our experiments, which long ante-dated his, gave us the fullest confidence in this mode of feeding. English farmers find great benefit from succulent roots for sheep-feeding, and cooking produces very much the same effect. We think it probable, however, that ensilage will take the place in sheep-feeding both of roots and cooking. The green corn, clover and grass, preserved in silo, may be expected to accomplish all that is to be desired in this respect.

# CHAPTER XII.

## SWINE.

WE discuss this class of stock last, but it is by no means least. The pig is often treated with contempt on account of its supposed filthy habits and diminutive size; but it occupies a most important position in our agriculture. It furnishes to the people a very large share of their flesh food; and in a commercial point of view it rises into grand proportions. We have been wont to glory over our export of dairy products, especially of cheese, and now we have great reason for encouragement in regard to our beef export, which may reasonably be expected to reach $50,000,000 in a few years; but a comparison of our exports of animal products for the fiscal year ending June 30, 1876, places the despised pig at the head. The products of the pig exported during that year were—

| | |
|---|---|
| Bacon and hams, valued at | $39,664,456 |
| Pork, " | 5,744,022 |
| Lard, " | 22,429,485 |
| Lard oil, " | 149.156 |
| Live hogs, " | 670,042 |
| Total value of pig exports, 1876 | $68,657,161 |
| Total, 1881 | $105,790,779 |

If we take the entire range of cattle products exported during 1876, we find the following items:

| | |
|---|---|
| Beef, valued at | $3,186,304 |
| Preserved meats, valued at | 998,052 |
| Butter, " | 1,109,496 |
| Cheese, " | 12,270,083 |
| Tallow, " | 6,734,378 |
| Hides and skins, " | 2,905,921 |
| Leather, " | 8,394,580 |
| Total cattle products exported, 1876 | $35,598,814 |
| Cattle products, 1881 | $68,711,300 |

By a comparison, we find the exported products of the pig at the former period to have been about double the value of those of cattle, and at the latter period more than 50 per cent. greater. The item of bacon has greatly increased within the last few years. In 1872 it was only $21,000,000, and previous to that only averaged about $6,000,000 per year, while in 1881 it reached over $61,000,000. This great increase has resulted from our study of the tastes of the English people. They require hams put up in a particular way, and we are only catering to that taste, and the increase is $30,000,000 in a few years. This export of meat instead of corn, concentrating that bulky cereal into the condensed product of pork, when it may be exported for one-eighth of the cost of exporting the raw food to make it, and the difference coming to gladden the heart of the meat producer.

We thus find that the pig grows in the estimation of the American farmer every year as, perhaps, the most economical machine for the manufacture of our coarse grain crops into meat. This animal is, therefore, worthy of the most careful study, as it is soon destined to represent one hundred and fifty millions in our cash exports.

The pig yields us more dollars in exports than any other single agricultural product except wheat and cotton. It is therefore entitled to be treated with great consideration. Another excellent point in its favor is, that no other animal utilizes a greater percentage of its food. It costs less food to grow a pound of pork than a pound of beef. Sir J. B. Lawes, of Rothamstead, in his experiments, a few years ago, found that the pig utilized 20 per cent. of its food, while cattle utilized but 8 per cent. of the dry substance of their food. It thus appears that the stock farmer has every reason to study the nature and management of the pig as one of his most fruitful sources of revenue.

If we examine the digestive apparatus of the pig, it will be plain why this animal produces a larger growth from the same amount of food than the ox or sheep. Messrs. Lawes and Gilbert's researches throw some light upon this point. They found, by accurate experiment, that the stomach and its contents amounted, in the pig, to only 1¼ per cent. of the whole weight of the animal, whilst in sheep it was 7½ per cent., and in oxen 11½ per cent. of the entire weight. But the proportion of the weight of the intestines and their contents is greatest in the pig, it being in that animal 6½ per cent., while in the sheep it is 3½, and in oxen only 2¾ per cent. See on this point page 63 *ante*.

The food of the ruminant consists of a large proportion of indigestible woody fibre, whilst the food of the pig consists more largely of starch, and the digestion of its food takes place largely in the intestinal canal. This explains why the pig is so great a digester of food, and why it consumes more food in proportion to the weight of its body than the ox. It also furnishes the basis for an explanation of the fact that the pig gains more in weight from a given amount of food than the ox. As we have seen, all animals require a certain amount of food to keep them alive, or in their present condition, called the food of support, and it is the food eaten and assimilated beyond this food of support that gives the increase, and this is called the food of production. This extra food all goes to increase the weight. Now if the pig digests and assimilates more in proportion to its weight than the ox or sheep, it must use a larger precentage of what it eats as the food of production, and, of course, a larger gain results from a given quantity of food. Large capacity for digestion is, therefore, a prime quality in animals reared for the production of meat, and in this respect the pig stands unrivaled among all our domestic animals. We shall therefore be justified in studying carefully all its wants with a view of supplying them.

## Care of Breeding Sows.

Having selected such young sow pigs as appear likely to make the best breeders (and this selection will be made by experienced breeders before the pig is two months old), such system of feeding should be adopted as will develop every part of the body evenly, and particularly the muscular and osseous systems. The young breeding sow should be fully fed, and made to develop as rapidly as good health will permit, for the feeding habit and constitution of the mother will be inherited by the offspring. The mother is supposed especially to impart to the young her own digestive system, and it is natural therefore to conclude that the thrifty, rapidly-growing young sow will impart these characteristics to her offspring. Early maturity, together with a vigorous constitution is now the desired end sought by all swine-breeders and feeders. But the young breeding sow needs to have length and depth of body, well-rounded ribs, and ten to twelve teats, well spread apart. In order to promote this conformation of body, the food of the young sow should be rich in muscle and bone-forming elements, not such as is best calculated to fatten. A short compact body in a sow will indicate a tendency to fatten, and not to bring large litters and furnish them with abundant milk. Food rich in oil, sugar and starch must be given very sparingly. In all Indian corn growing regions, the custom is to feed too much corn to young pigs, and especially to young breeding sows. Young clover and grass are always proper food for pigs; and in dairy districts, nothing is better than skim-milk. Containing so large a proportion of casein, or cheese, and phosphate of lime, it is admirably adapted to develop the muscular and osseous systems. But in the West, the great corn and pig-growing region, so little attention is given to the proper food of breeding sows, that they are often fed indiscriminately with the fattening herd, almost wholly upon corn. We have always regarded that frightful scourge, hog cholera, to be largely the result of feeding so indiscriminately with corn. As a proof of this, this disease is hardly known in Canada, where peas, oats and barley are fed in place of corn to young and growing pigs. There is also very little cholera in the Eastern and Middle States, except among hogs brought from the West.

The milk supplied by the brood sow to her young pigs is said to be even richer in casein, or nitrogenous food, than cow's milk ; and as we have said in former chapters, Nature furnishes in her food for the young the best combination of elements, and if we imitate the milk of the dam, we shall make no mistake in the food ration. Then, besides grass, we should give the young breeding sow food of similar composition to oats, peas, beans, oil-meal, bran or wheat middlings—all having a large proportion of albuminoids, and being also rich in phosphate of lime.

It is not well to couple the young sow before she is nine months old, as she should not farrow her first litter under thirteen months old. Sows are sometimes coupled at six or seven months, but this practice is likely to produce a puny offspring, and if it is persisted in for several generations, like planting small potatoes, the progeny will grow smaller and punier with each succeeding generation.

When the young sow is about to farrow, she should be put into a small clean pen, with a narrow board placed around the outside of the bed, about four inches from the wall and four inches above the floor, so as to prevent her from overlying her young, which will escape under these boards. From one to two bushels of cut straw only should be given her for bedding.

It is expected that these young sows have been petted and accustomed to being handled by the attendant. This kindness and gentleness may save a very valuable litter of pigs. If the sow is wild, it is quite useless to attempt to assist her, as it will only increase her excitement, and still more endanger the safety of the young pigs.

If the sow should produce less than eight pigs at the first litter, it may be considered unprofitable to keep her as a breeder; unless her blood is very valuable, she had better be fattened for pork.

## Weight of Pigs at Birth.

The sow having farrowed her litter in safety, let us examine the young things, and get an idea of their dimensions. What does the young pig ordinarily weigh at birth? We have never personally weighed them at birth, and know of only one record of such weighing. Boussingault says he was "curious to ascertain the weight of pigs at the moment of birth, so as to determine their rate of increase during the period of suckling." He weighed a litter of five pigs on the 5th September. They weighed from 2.20 lbs. to 3.30 lbs., the average being 2.75 lbs. each. This seems a very small beginning for an animal that has sometimes reached over 1,000 lbs. weight. Thirty-six days afterwards, October 11th, the litter had grown to 86.9 lbs.—an average of 17.3 lbs. per head; being an increase of 14.6 per head, or 0.41 lbs. per day. On the 15th November, they weighed 177 lbs.—an increase, in 35 days, of 90.2 lbs., or 18 lbs. per head, being 0.50 per day. In another case, he found that eight pigs that weighed at a month old 14.3 lbs. per head, at a year old weighed 165 lbs. per head; being a gain of 150 lbs. each in eleven months, or less than half a pound per day.

## Milk Yielded by Dam.

We have weighed many pigs at four to six weeks old, and found the weight to range from 12 to 18 lbs. Thus it will be seen that the pig increases in weight from birth to weaning about fivefold, and then only has a weight of about 15 lbs. This growth generally comes from the milk of the dam in the short time of four or five weeks. What an immense drain this must be on the mother, and how important is it that she should be well fed during the period of suckling. She has often to produce more food in her milk than is contained in the milk of an excellent cow, weighing three times as much. Dr. Miles, of the Michigan Agricultural College, found that Essex pigs three weeks old consumed 3⅓ lbs. of milk each, per day, the first week, and nearly 7 lbs. per day the second week. A litter of eight pigs at this age would drink some 24 quarts of cow's milk per day. To enable the mother to give this large quantity of food for her young, her diet must be rich and varied. We have found three gallons of skim-milk, two quarts of corn-meal, and four quarts of oats and peas ground together an excellent diet for a large sow with nine pigs. This barely keeps her from losing flesh. If you have not the milk, one quart of oil-meal may be substituted and the other food increased about two quarts, all given in a thin slop.

### Rations for Young Pigs.

Preparatory to weaning, pigs should be encouraged to eat food with the dam. They will learn to drink milk quite early, but do not take to eating solid food until some three weeks old. The great majority of farmers have skim-milk to feed young pigs; but in the absence of this best substitute for the milk of the dam, the solid food should be prepared by cooking. There are many rations which will be appropriate to young pigs without milk, such as wheat middlings, oats and corn-meal, in equal portions, cooked together: or 4 parts oats, 4 parts corn and 1 part oil-meal, cooked; or 6 parts peas, 5 parts corn and 1 part flax-seed, cooked; or oats and peas ground together and cooked; or potatoes, corn and oat-meal, cooked; or 4 parts corn, 2 parts oats and 1 part decorticated cotton-cake, and many other similar combinations of food. But corn-meal alone is a very unprofitable ration for young pigs. The food should contain all the elements necessary to growing the frame and muscular system. Corn or corn-meal is very inadequate for this purpose, it being 66 per cent. starch, 7 per cent. fat, and only about 10 per cent. nitrogenous food, with too small a portion of phosphate of lime to build the bones. We have seen the worst results from attempts to grow good pigs upon corn-meal alone. We saw one case of three pigs fed upon corn-meal, prepared in the best way, to induce them to eat largely of it with the expectation of producing a large growth at an early age. The result was, that, at 130 days old, these pigs were mere squabs of fat, almost spherical in form, and their bones and muscles so weak that two of them could not stand but a moment, and had to sit upon their haunches; yet these pigs only weighed 90 lbs. each—at least 40 lbs. less than if they had been fed a proper ration. It is very unskillful feeding that will not produce an average growth of one pound live weight per day. If the feeder has plenty of skim-milk, then cooked corn-meal mixed with the milk makes a very desirable ration—the skim-milk being rich in albuminoids and the mineral elements necessary to grow a muscular and rangy young animal. Length and breadth of body are necessary to build rapid growth upon. This development cannot be attained without the proper food; but with either of the rations above recommended, and especially the skim-milk and corn-meal ration, the best result may be reached. Skim-milk alone has too large a proportion of albuminoids to carbo-hydrates, being about four-ninths of muscle-forming food, or 1 of casein and albumen to 1.25 of milk, sugar and oil. The proportion should be, as in whole milk, 1 to 2.25. If, then, one quart of skim-milk is added to 1 lb. of cooked corn-meal, the starch and oil of the meal will make the proportion right; and, fed in this way, a quart of skim-milk is about equal, in food value, to a pound of corn-meal; or 112 lbs. of skim-milk fed with 56 lbs. of cooked corn-meal, is equal in growth of pork to two bushels of corn. But if the milk is fed alone, the nitrogenous elements are in excess, and not fully utilized. This illustrates the advantage of mingling a variety of elements in the food-ration, and these elements should be selected with reference to the proper balance of all the constituents.

The food of the young pig should be in liquid form, and cooked, to render it easier of digestion; and, as the suckling pig is accustomed to take nourishment from its dam many times a day, he should be fed, after weaning, five times per day for some weeks, and then gradually reduced to three feeds per day.

## Feeding Whey to Pigs.

Whey may also profitably be fed to pigs; but even greater care is required to supply the missing constituents of the whey than in feeding calves, especially if the pigs are young. See pages 242, 243. The young pigs cannot properly be grown upon whey alone, as they get less of other food than the calf. Pigs are usually kept in pen, and there is not food in the whey to grow the bones and muscle; and this explains the cause of disease among small pigs attempted to be raised at cheese factories upon whey alone. The only case where whey alone may sometimes be fed safely to hogs is, when the hogs are full grown, with well developed frame and muscle, but lean, requiring to be fattened. Such hogs will sometimes fatten very rapidly upon whey alone—the whey furnishing the materials to make fat, rounding out the body into fine proportions. This mode of feeding may be pursued for three months with such hogs, producing a good result. But when the young pig is to be grown upon whey, it must be mixed with other food, as directed for the calf. The pig should also have green grass given in pen every day. We have found whey to pay a fine profit when fed to shoats of 80 lbs. weight, somewhat lean at the start. To experiment, we put up 5 shoats of 80 lbs. weight on the average, costing 5 cents per pound, or $4 per head. These pigs were fed ½ lb. oil-meal, 2 lbs. wheat-bran, and 1½ lbs. of corn-meal each, per day, in 4 gallons of sweet whey. This was the average ration for six months, or 180 days, commencing on May 1st. The gain was 270 lbs. each, or 1½ lbs. per day. The cost was as follows: 90 lbs. of oil-meal, $1.35; 360 lbs. of wheat-bran, $2.70; 270 lbs. of corn-meal, $2.70—amounting to $6.75—add cost of pig, and we have $10.75. The pigs averaged in weight 350 lbs., and brought 6 cents, or $21 per head. Deducting the cost, leaves $10.25 to be credited to the whey. This is $1.42 per 100 gallons, or, the whey from a cow (500 gallons) worth $7.05 per year. In the West this extra food would cost less, and make the whey still more valuable. The sugar of milk in the whey is very soluble, and will lay on fat rapidly if the other constituents are added.

In growing the young pig upon whey, we do not use corn-meal until the pig has reached a weight of some 40 to 60 lbs.; before that the ration is very similar to that given for the calf. The small pig will increase in weight more, in proportion to the food eaten, than the older shoat, but it requires more care in feeding. It will be found that 2 lbs. can be put on the young pig with the same food that will produce 1½ lbs. on the older shoat; but, as the young pigs cost more per pound, there is not any more profit in feeding them when purchased. Shoats of 60 to 80 lbs. weight can be purchased in market for only a trifle more than a pig of 15 lbs.; so that it is more profitable to buy shoats than young pigs. It must be obvious from this discussion of whey that dairymen are far from making the best use of it generally. They want to grow an animal on whey alone, so that they may make something out of it; but the whey possesses only enough of some elements to keep the animal alive, without growing, and is likely to create disease; so that this penurious use of it is about equivalent to throwing it away. It must be remembered that whey is 93 per cent. water, and, if it were a well balanced food, the water is in too great proportion for the health of animals. If grass were 93 per cent. water it would be likely to produce disease. But the whey when mixed with dry food becomes a healthy ration. The study of the farmer should be to make the most of everything.

## Grass as a Part of the Ration.

We have before spoken of the pig as a grass-eating animal, and this part of its nature must not be overlooked. Great losses occur every year by confining pigs to concentrated food alone. It is doing no greater violence to the nature of the horse to feed him wholly upon grain than the pig. In a natural state both are supported upon grass. In the winter, hay is substituted for grass with the horse, and no one expects a horse to be healthy without a certain proportion of fibrous food; and we have no more reason to expect the pig to be healthy and vigorous in digestion and without a small percentage of bulky fibrous food. The rule, in feeding all animals, should be, to follow Nature as closely as possible. We have tried several experiments to test the natural system of feeding grass as a part of the ration, supplemented by grain, in connection with the system of pure grain-feeding. Some of these experiments have been published before, but they will bear repeating.

A litter of six pigs were weaned at five weeks old, and divided into two lots of three each and of equal weight. Each lot was put into a separate pen on the first day of June. One lot was fed wholly upon corn-meal soaked twelve hours in cold water, and given *ad libitum*. The other lot had a small portion of green clover, cut short with a straw-cutter, and mixed with corn-meal. Only one quart of this cut clover was given at first to each pig, with all the meal it would eat. This meal being mixed with clover, had its particles separated by the fibrous food, and, when eaten, went into the stomach in a spongy condition, so that the gastric juice could penetrate and circulate through the mass as water through a sponge. It will be noted that the digesting fluid comes in contact with every part of the mass of food at once, and the digestion must thus be accomplished evenly and rapidly. But, when the meal is fed alone, it necessarily goes into the stomach in the solid, plastic form of dough, and the gastric juice cannot readily penetrate the mass, but must mix with it, little by little, whilst it is slowly moved by the muscular contraction of the stomach. The lot of pigs with the clover and meal were always lively, always ready for their feed; whilst the other lot, with meal alone, ate greedily for a time, and then became mincing and dainty for a few days, indicating a feverish state of system, taking little but water for a few meals; and by fasting they appeared to recover the tone of the stomach and the appetite, and go on eating vigorously again. This was repeated many times during the five months the experiment continued. On weighing the two lots at the end, the one fed on meal alone averaged 150 lbs. each; the lot on clover and meal averaged 210 lbs. each, or 40 per cent. more for being treated according to their nature as grass-eating animals. Each lot consumed the same amount of meal. The clover was intended, principally, as a divisor for the meal, and amounted to not more than two quarts at a feed. We have often since followed this plan in summer, giving all the cut clover they would eat, mixed with the various kinds of grain used, and it is a most excellent system when inconvenient to give pasture. This may be considered the

### Soiling System for Swine,

and, when properly conducted, is capable of being carried on with a large herd, by simple subdivision into lots of twenty each. An acre of good clover will soil four times as many pigs as it will pasture, giving them a full ration of grass, with this great advantage over pasture, that you may mingle the grain ration with it so as to produce the most rapid growth with perfect health. Pigs in pasture, fed on grain at the same time, are apt to take mostly to either the grain or the grass, and thus not make as rapid progress as when the ration is properly combined. We have never seen a pig that did not relish green clover and grain mixed together. It may be mingled in any proportion the feeder chooses, and the animal thus be pushed slowly or rapidly, as circumstances require.

This system should become the prevailing one in the West—adopted as a matter of economy—producing greater results from the same capital and labor. A swine-herder, under this system, may prepare the ration and feed 500 pigs, looking after all their wants, and producing much more uniform growth than under the present system. The cost of labor per head will be very trivial.

A modification of this plan may be adopted in connection with pasture, by feeding the grain, mixed with a small portion of short-cut grass, in long troughs. Any green food may be used in lieu of clover; such as green rye, oats, millet, Hungarian grass, green peas, etc., but nothing, except the peas, is equal to the clover. This system will be considered more appropriate to Eastern farms, on account of their limited area, and is especially adapted to the great want of the Eastern farmer—more home-fertilizers. The pig-pen will become the great resource of better tillage.

## The Pig in Winter.

The great importance of this class of stock commercially, and the large extent to which its flesh is used for home consumption, demanded a thorough discussion of its management in all its phases.

The proper system of winter-feeding requires to be better settled. The old "storing" system, by which a pig is simply kept alive during winter, that it may be ready to grow the next summer, has not yet been wholly given up, but may be found in full operation in many parts of our country. It does seem as if every feeder should have discovered the utter improvidence of this practice. If pigs were like a wagon, a bin of grain, or a mow of hay, that might be kept over winter without expense, there would be some excuse for it; but when we reflect that two-thirds of a full ration is used merely as the food of support, without adding anything to the weight or value of the pig, this practice of keeping pigs through the winter, or at any other time, without constant growth, seems absolutely indefensible.

As we have shown in previous chapters, time is a most important factor in the problem of pig-feeding. Every week that a pig is kept without growth, the feed is worse than thrown away, because it takes time to overcome the unthrifty habit, and all the food is lost till growth begins again. It is thus evident that the skillful feeder must strive after continued and unremitting growth.

The winter season should be no exception to this steady growth, although it will require more food to put on a pound gain in winter than in summer, unless the temperature in the pig-pen is raised to near summer warmth. All animals must keep up their heat by the consumption of food, and it makes a great difference whether the surrounding air is at zero or sixty degrees above. It would seem, therefore, that while thrift is as necessary in winter as summer, the feeder way control the temperature and save a large percentage of the food in winter growth.

We have just discussed the importance of grass as a part of the ration of the pig. It might reasonably be supposed that the pig would require some fibrous food in winter as well as in summer; and if green clover is good in summer, why not nicely-cured clover hay in winter? Having established the necessity of grass, in its season, for the promotion of health, the writer experimented also on the use of clover hay in winter as an addition to the grain ration.

Having four pigs of the same age, and about the same weight, they were divided into two lots of two each. Each lot weighed 150 lbs. at the commencement of the experiment. One lot was fed corn-meal, wet up with hot water, and allowed to stand some ten or twelve hours. The other lot was fed about two quarts each of short-cut clover-hay, mixed with corn-meal, wet up with hot water, and allowed to stand the same length of time. Each lot was fed without stint upon its ration, and the experiment continued for 120 days. As in the experiment with grass, the lot on clover-hay and meal had the best appetite, ate the most steadily and showed greater thrift; but the lot on meal alone were apparently healthier than those on meal alone in the other experiment; but they were older, and, the weather being colder, were not so feverish. This latter lot gained 110 pounds per head; whilst the lot on clover, hay and meal gained 143 lbs. each, or 30 per cent. more. Since this we have often fed pigs upon fibrous food in winter, and always successfully. Feeding clover-hay in winter may be novel; but why should it not be considered as appropriate to feed pigs clover-hay in winter, as to feed cattle or horses clover-hay in winter? The pig eats green clover in summer, if he can get it, as profitably as the cow or horse; and when farmers understand the true system of feeding, clover-hay will generally make part of the winter ration of pigs.

### Cob-meal as Pig Food.

As bearing upon the necessity for coarse food in the ration, we will give some experiments made with the meal of corn and cob ground together.

There has been a great variety of opinions expressed upon the value of the cob-meal, many supposing it to be injurious to the coatings of the stomach, even in horses, and the pig's stomach has been thought by some as incapable of managing such hard material as the scales of cob; but we long since experimented with corn and cob-meal, and found all these adverse opinions merely imaginary. We have fed it largely both to swine and horses, and never saw any ill effects from it, but, on the contrary, found it a healthier feed than clear meal. The advantage of grinding the cob and corn together is not altogether in the nutriment of the cob, but because the cob, being a coarser and a spongy material, gives bulk, and divides and separates the fine meal, so as to allow a free circulation of the gastric juice through the mass in the stomach. Corn-meal, when wet into plastic dough, is very solid, and not easily penetrated by any liquid; and when pigs are fed wholly on corn-meal, they often suffer with fever in the stomach, because the meal lies there too long undigested.

We will here give the experiment of two farmers' clubs in Connecticut, to show the value of corn-meal, corn and cob-meal, and whole corn. We condense it to the essential facts.

A committee of the two farmers' clubs appointed to make the experiment, purchased nine thrifty shoats and divided them as evenly as possible into three lots, placing three in each of three separate pens. The experiment began the first of April, and ended the sixth of June.

Lot No. 1 was fed 1,332 pounds of corn ground into meal—clear meal, wet in pure water. Lot No. 2 was fed 1,361 pounds of corn and cob-meal, wet up in water. Lot No. 3 was fed 1,192 pounds of corn soaked in water.

Results: Lot No. 1 weighed at the beginning of the experiment, 453 pounds; at slaughtering, 760 pounds; gain in live weight, 307 pounds; dressed weight, 615½ pounds.

Lot No. 2 weighed at beginning, 467 pounds; at slaughtering, 761 pounds; gain in live weight, 294 pounds; dressed weight, 593 pounds. Lot No. 3, live weight at start, 456 pounds; at slaughtering, 689 pounds; gain in live weight, 233 pounds; dressed weight, 567 pounds.

Lot 1 gained in live weight for every bushel fed, 12.90 pounds; lot 2 gained 15.11 pounds; lot 3 gained 10.38 pounds per bushel. Lot 1 took 4.34 pounds of meal for 1 pound gain in live weight, and 5.37 pounds for 1 pound dressed weight. Lot 2 required 4.62 pounds to make 1 pound live weight, and 5.93 pounds for 1 pound dressed pork. Reducing this quantity of cob-meal to clear meal, it will be found that 3.70 pounds make 1 pound live weight, while 4.75 pounds make 1 pound of dressed pork. Lot 3 required 5.11 pounds of clear corn to make 1 pound live weight, and 6.21 pounds to make 1 of dressed pork.

This was a valuable experiment, and greatly surprised the committee appointed to carry it out. They say: "We have long been satisfied that a certain amount of coarse material fed to cattle with concentrated food was both judicious, economical and profitable, but on account of the peculiar construction of the pig's stomach, we were not prepared for the result, showing the desirability of feeding a coarse material in connection with corn-meal to pigs." This experiment shows that cob-meal is superior in feeding value to clear whole corn, and that it is nearly as valuable, cob and all, as clear meal. Cob-meal should always be ground very fine.

As we are treating of winter-feeding it will be appropriate to discuss the form and construction of the

### Swine House,

and preliminary to the description of a plan of our own, we will give an illustration and description of the breeding pens of a most intelligent practical breeder and feeder at

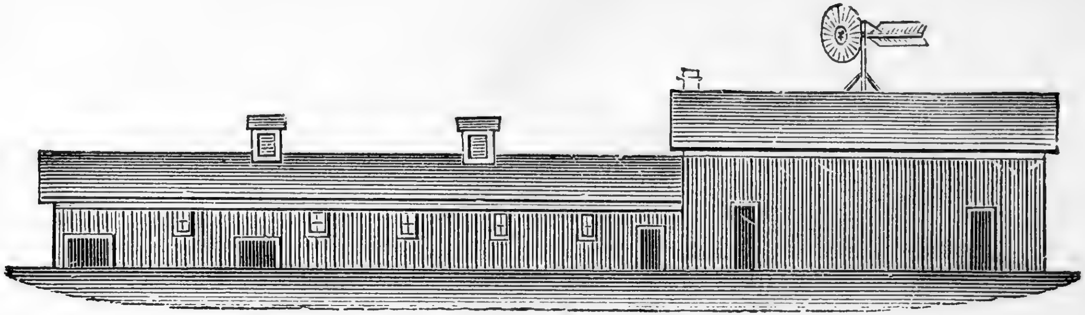


*Fig.* 16.—SIDE ELEVATION.

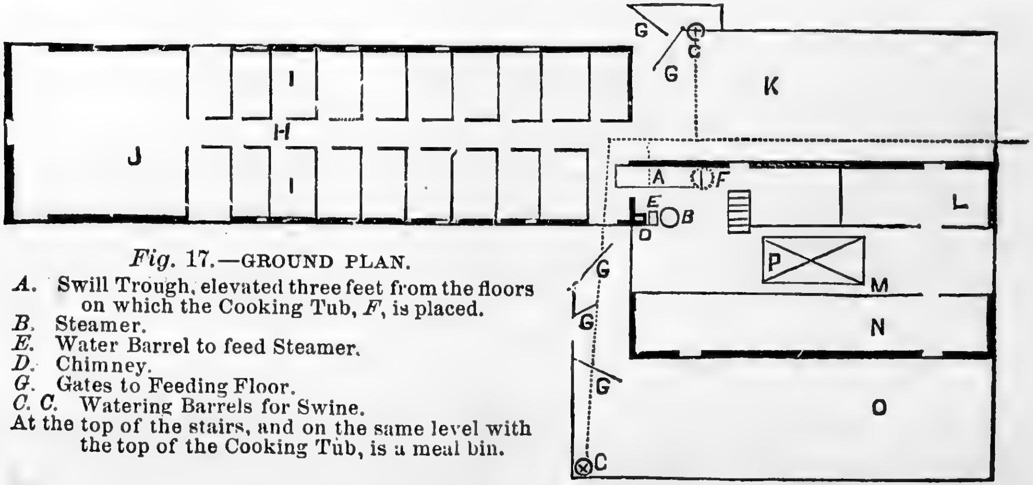



*Fig.* 17.—GROUND PLAN.

*A.* Swill Trough, elevated three feet from the floors on which the Cooking Tub, *F*, is placed.
*B.* Steamer.
*E.* Water Barrel to feed Steamer.
*D.* Chimney.
*G.* Gates to Feeding Floor.
*C. C.* Watering Barrels for Swine.
At the top of the stairs, and on the same level with the top of the Cooking Tub, is a meal bin.

Neponset, Illinois, Dr. Ezra Stetson. The doctor has been a very successful breeder and feeder for the general market. We are indebted for the illustration to the *National Live Stock Journal.* The engravings are upon a scale of 32 feet to the inch.

Figure 16 shows a side elevation of the building, which is a very plain, unostentatious structure, but substantially built. Figure 17 shows the ground floor, with its subdivisions. The main elevation at the right (Fig. 16) is devoted to corn-cribs and the cooking apparatus. This part of the building is 26 × 48 feet, and is divided as shown in Figure 17; *L* being a corn-crib, 9 × 20 feet; *N* a corn-crib, 9 × 48 feet; *M* a hall, or drive-way, 8 × 48 feet; *P*, platform scales for weighing grain, hogs, etc.; *O* is a platform outside of, but adjoining, the corn-crib on the south side, and is 16 × 56 feet, with doors opening to the corn-crib, as shown in the diagram. This platform is surrounded by substantial fence. Before feeding, the gates *G*, *G*, *G* are all closed, and the platform swept perfectly clean. The corn is then placed on the floors, the gates are opened, and the hogs walk in to their repast. When it is designed to load a part of the hogs in the wagon, to take them to the market, the gates *G G* are closed, in a line with the west end of the platform, leaving the southern gate, which swings across the platform, open. As many hogs as are wanted are then driven into this wing, or *L*, of the platform, and the south gate is closed across the platform from the fence to the southeast corner of the corn-crib. The hogs are thus securely confined in a small inclosure. The large, outside gate *G* is then swung round toward the corn-crib, across the platform, and this reduces the space to which the hogs are confined to about one-half. The wagon is then backed up to the small gate *G*, which is then opened, and the hogs are loaded without difficulty.

*K*, represents a platform, 18 × 48 feet, constructed similarly to the one at *O*, on the opposite side of the corn-crib. This is used for feeding the pigs. Dr. S. uses a steaming apparatus to make slops for the sows and pigs. This he believes causes the sows to give much more milk and thus to hasten the growth of the pigs. Long troughs are placed upon this floor, *K*. The gates are closed; the floors and troughs are thoroughly cleaned; the slop is put in the troughs, as described in the communication of the Doctor, to the Journal, given below; the gates are opened, and the pigs rush to the feast.

The long wing to the left of the corn-crib and feeding floors is cut up into pens, as shown by the diagram. These pens are 6 × 10 feet, and the alley (*H*), running through the center, is four feet in width, opening at one end on to the feeding floor (*K*), for pigs. At the extreme left of this wing is a large, inclosed feeding floor or pen (*J*), 24 × 24 feet. Dr. S. is strenuously opposed to putting anything between the beds upon which the pigs sleep and the roof which covers them, as he considers free, upward ventilation essential to the health of his pigs. Hence, he is opposed to all two-story pig pens. He usually keeps from 300 to 500 hogs.

The following is Dr. Stetson's explanation of his piggery:

"All corn-raisers know that the foundations of a corn-crib can hardly be made substantial enough. Ours rests upon six rows of stone and brick pillars, thirteen in each row, with the bottoms of the sills about two feet from the ground. The feeding floors are on the same level with the floor of the crib, and have a drop of six inches in the sixteen feet, to carry off the water from rains.

"The feeding floors rest upon four rows of posts set in the ground, twelve in each row, and sawn off to the proper level. Shoulders are then sawed on one side of these posts, and 2 by 8 joists spiked to them, on which the planks are laid. The outside row of posts should extend three feet above the feeding floor, and be closely boarded up all round except the gate to the entrance.

"The watering barrel may be placed where convenient. Two kerosene barrels are set side by side, connected by a short piece of gas-pipe. Water is let into the barrel with the valve and float from the reservoir, and can rise no higher than confined by the float, and as fast as drunk out will be immediately filled—provided, always, the reservoir is not allowed to get empty. By this arrangement a *perennial spring* is brought to the very place wanted.

"The cooking arrangement will probably be omitted by the great majority, should they build upon a similar plan. In raising large numbers of pigs, it is next to impossible to make slops for the sows and their pigs without some sort of a heating apparatus, and I think this has the merit of being convenient. We make the *wind* do all the lifting of the water, and a very small quantity of fuel, rightly applied, will boil a large quantity of water. The cooking tub may be of any desired size. Ours holds five or six barrels, and is made with a hinged valve; and the food is dropped into the cooling trough, where it is made of the proper consistency by the addition of cold water, drawn from the cooling trough, into a *truck*, and wheeled upon the platform, or where desired, and then *drawn* into troughs. There is no *lifting* of water or swill at any place.

"Our piggery is very cheaply constructed. Large cedar posts are sawn in half and set in the ground, for the framework. *Ribs*, 2 by 4, are spiked to these posts, to which the weather-boarding is nailed. The tops are sawn off to the proper level, and the plates spiked to them, upon which the rafters rest. These posts are set six feet apart; and as our breeding pens are six feet by ten, they form one side of each compartment. The partitions are removed when not wanted for breeding pens, and the whole space used as a sleeping floor for the fattening of hogs or pigs.

"The floor to the piggery is entirely unconnected with the framework. Stringers are laid crosswise of the building on which the plank floor is laid. The alley is four feet wide, with a door to each pen. With this arrangement of gates and doors, *one* man can put in place the most refractory old sow, or any other *hog*.

"Let me say that our floors are of hard pine plank, 2 by 10 inches; have been laid for eight or nine years, and that about 200 hogs have been fed upon them each year, and they now look as though they would last as much longer."

## Another Plan of Swine House.

As pork is largely grown in the West and accommodation is required for large herds, it will hardly be appropriate to give the description of a pen with a less capacity than for feeding 200 hogs in winter. As we have seen, economy in feeding requires that the pen should be warm, in order that the temperature may seldom, if ever, go below 60 degrees. With so large a number, the extra food required to keep up animal heat would soon pay for a warm pen. Perhaps the cheapest plan to build a warm pen is to use 2 × 4-inch studding, placed three feet apart, boarded up outside and in, leaving a four-inch air space; or, if the weather-boarding is to be perpendicular, ribs, 2 × 4 inches, may be spiked to outside of the studding, and the weather-boarding nailed to these, leaving a six-inch air space, to be filled with saw-dust or short-cut straw, well rammed in. To prevent this filling from being a harbor for vermin, mix a little coal-tar, or chloride of lime, or fine air-slaked quick-lime with every layer. With this latter plan the outside may be built of cedar posts, in the manner described by Dr. Stetson, above, placing cedar posts in the ground, six feet apart. The height of the pen at the eaves should be 8 feet. Our plan requires a building 28 feet wide, and 150 feet long, besides corn-cribs, cooking room and breeding pens. The floor is placed two feet above the ground. Each pen is to be 10 × 15, accommodating ten hogs. The feeding floor is 8 feet wide with a tier of pens on each side. This plan of swine house is intended as the most convenient form for economy of labor in cooking the food for a large number of hogs. It is also most convenient for any other system of feeding, if done in pens. A trough, 15 feet long, next the feeding floor, must be provided for each pen, with a swing door over each trough, to shut the hogs off while the feed is being put in. The hogs come out of the pen over the trough on a light bridge through a door in the partition next the feeding floor.

## A Self-Cleaning Pen.

Still regarding the greatest economy of labor, we would construct the floor as follows: Next and under the trough is a strip of solid floor 2 feet wide; and 5 feet next to this is an open, slatted floor, composed of oak strips, 1½ inches thich by 2½ inches wide, set edgewise, 1 inch apart, for the passage of the manure below. And next the wall is a strip of tight floor, 3 feet wide, for bedding, slanting 1½ inches toward slatted floor, so that water will run to slats. Under the open, slatted floor is a sliding-board, set slanting to the outside wall, along the side of which wagons can be driven, and, letting down a long swing door, the manure shoveled in and carried away. The pen cleans itself, all works through the slats, and no manual labor is required. If bedding is used, it may be placed on the tight floor next the wall for the hogs to lie on. Seldom any droppings will fall on the tight floor. To secure pure air, put a ventilator 2 × 4 feet in the ridge, every twenty feet, with slats on side to prevent storm from driving in. For the admission of fresh air, a slide 7 × 14 inches may be placed in the outside wall between each two pens, one foot above the floor, which can be opened or closed at pleasure. This will cause a circulation of air and keep it pure. The feeding floor is wide enough to drive a wagon through, and loads of dry earth may be brought in and thrown over the open floor, which mixes with the manure and deodorizes it. This open floor is not an experiment, but was in use by the late J. J. Mechi, in England, for 30 years; and the author has used it for single pens and found it to work well. No bedding is required, and the pigs keep much cleaner than is usual on tight floors where bedding is used.

It is intended to have the outside tightly closed below the floor, so as to prevent as much as possible the circulation of air under the slats. With a long-handled shovel the manure is easily loaded and requires no other labor than hauling to the field.

Since writing this description of the self-cleaning pen, the author has constructed one with iron slats or bars, one inch wide and $\frac{5}{16}$-inch thick placed $\frac{7}{8}$-inch apart. This grating may be four or five feet wide; ours is four feet, and the wooden floor for bedding is also four feet, with a grade 2 inches toward the grating, so that all liquid will run toward the grating. This proves to be a completely self-cleaning pen. This wrought-iron grating, with bars so thin, is not liable to clog, as is the wooden slats, from being so deep up or down. This floor and grate is elevated 18 inches, and the bottom is concreted so as to save all the liquid and solid dropping. A door one foot wide is let down and the manure is easily taken out with a long-handled shovel from the outside. It will only require cleaning once in three months. It is a pleasure, clean hogs in a clean pen.

## Cooking Hog Food.

When cooking is to be done for so large a number, economy requires an apparatus in proportion. An eight-horse boiler and engine should be placed in an extension of the swine house, which can shell and grind the corn, or better to grind the corn in the ear, leaving the cob to give bulk in the stomach, and cook the meal into the most palatable mush, for 200 or more hogs. And, that the cooked food may be handled with the least labor, two box-cars, on wheels two feet high, each car being five feet wide, three feet high and sixteen feet long, holding about 200 bushels, are required. There is a track in the middle of the feeding floor on which these cars are run. One of these cars, when full, weighing some four tons, may be handled by one man, and run along the track, so as to feed the pigs upon either side of the feeding floor. A small rope runs the whole length of the feeding floor and is fastened at the other end, whilst at the car end it runs over a small pulley or windlass, and with crank the feeder moves the car along from pen to pen. The mush, when thin enough, runs through a spout to the trough in the pen on either side. The feeder soon learns how to apportion it to each pen. The car, when full, contains 40 bushels of meal, 20 bushels of cut clover-hay and 640 gallons of water, or 16 gallons for each bushel of meal. The water is pumped by the engine into an elevated tank, holding the requisite quantity, which is heated nearly to the boiling point in the tank, and then drawn into the car through a pipe. There are marks inside the car to indicate each hundred gallons, so as to show the feeder when he has the requisite quantity. This water is brought to a brisk boil in the car, when the meal may be sifted into the boiling water through a sieve suspended above. The meal, when ground, is elevated into a hopper over the sieve, and, being drawn through the spout upon the sieve whilst that is swung back and forth, the meal is sifted evenly into the boiling water in the car, and no lumps are formed. After the meal is sifted in, one-half bushel of cut clover-hay to each bushel of meal is mixed in with a rake. When the mush is too thick to run it is taken out with a scoop and put into the troughs. We have found the best way to apply steam to such a mass, is to run it through a coil inside, placed on the bottom. The coil is in two parts, running backward and forward from the center each way, three turns of the coil, terminating in a goose-neck at each end of the car, which goose-neck comes above the water and descends within four inches of the bottom. This effectually prevents the pipe from filling with water or mush; and the steam, in passing around this coil, keeps it very hot, and, discharging near the bottom, keeps all the heat in. To assist in keeping the heat in, a folding cover may be used, which is spread out in a moment, and removed as soon. When mixed, it is allowed to cook for an hour and a half. It requires no stirring, as in boiling over a fire. These cars are lined with No. 22 sheet-iron, riveted and soldered, which prevents any break or swelling of the wood-work of the car. This lining is rubbed over occasionally with tallow, which prevents rusting, and the mush from sticking to it, or, better still, if the lining of the car is made of galvanized iron, which will not rust for a long time.

In the center of the feeding floor should be placed a pair of eight-ton platform scales, for the purpose of weighing any pen of hogs at will. A movable railing placed across the floor at each end of the scales, with a small gate in one to let the hogs in, and the hogs from any pen may be driven upon the scales in two minutes, without disturbing the rest.

This is a general sketch of the swine-house proper. The corn-cribs and the engine-house will be at one end, and may be made as roomy and convenient as the feeder chooses. The breeding-pens may be added to the end opposite the corn-cribs and engine-house; but this same feeding floor should run through all, so that the car can reach every pen. It is intended that there shall be no freezing in this house; and, with the use of the engine, water is easily pumped into an elevated reservoir, from which it may be run to any part for any purpose. Ventilation is made so complete, that fresh air is constantly admitted and vitiated air carried off. This engine furnishes power for every purpose required; and when the cost is divided by the number of hogs fed, it is so trivial as hardly to be worth considering. It is intended that 200 hogs shall be constantly fattening, and their places supplied by others as fast as sold. Hog-feeding may thus be reduced to a system as perfect as that of cotton-spinning.

## No Storing Period.

We have treated, in a general way, of all its various stages of growth to the time of the final fattening period; and it has been plain, from our illustrations, that we believe in a growing period commencing with the first day of its life, and continuing till the last, and that there should be no stand-still period in any correct system of feeding. But the winter-*storing* system has taken such a deep root in the minds of pig-raisers that Dr. Andrew McFarland, a former superintendent of the Insane Asylum at Jacksonville, Ill., conceived the idea of placing the pig in compulsory hibernation in winter, so as to have him ready for rapid growth the following summer. This, he thinks, a most important object to secure; and if the storing system is necessary, we cannot dispute his conclusion. He cites the case of a fat hog that was accidentally buried under a straw-stack, in the fall, where it remained several months, and on discovery, came out alive and apparently well, having lost little flesh; and another case of a hog, buried under a snow-drift, remaining some eleven weeks, coming out alive, though gaunt and lean, having lost its fat in keeping up animal heat. From these and other instances, he supposes it quite possible to devise a system of hibernating the pig much cheaper than feeding it. He would "select a dry spot, and place a young hog, in good flesh, under an inverted box, containing 80 to 100 cubic feet of free air—the box to be perforated with holes, or made of lattice work—then four feet of well-packed straw on the sides, running to a cone above, placing the hog in this position at evening." We give this ingenious conception of the doctor's because it may be regarded as much cheaper, and quite as merciful, as the system that some feeders adopt during the winter. But if the hog could be safely hibernated, it would scarcely be profitable, when it is considered that those animals that hibernate often come out with a loss of 40 per cent. in weight; and just think of the amount of food required to bring them back into a thrifty state! But that is not much worse than the folly of throwing away four to six months' food to keep pigs alive without growth. Still, as the general system adopted supposes a period when a special effort is made to ripen the pig for market, we propose to treat of this.

## Fattening Period.

A very large proportion of farmers keep their pigs through the summer on poor pasture and a little refuse from the kitchen, postponing till cold weather the fattening. This is, of course, a very bad plan, unless the feeder has a warm house in which to feed them, and then quite indefensible, as every feeder should make the most of the warm season for fattening, for it will take a large proportion of the food to keep them warm—much larger than is generally supposed. We desire to make this matter plain, and will give some experiments that have been made to test it.

Mr. Joseph Sullivant, in his pamphlet, gives an experiment, tried at Duncan's Falls, Ohio, in 1859, where a large lot of hogs were weighed, on the 10th of September, and turned into a forty-acre corn-field, where they remained till October 23d. Having eaten down the field, they were again weighed, and found to have gained 16,000 pounds; or ten pounds per bushel of corn, estimating the yield at

40 bushels per acre. He then selected from the lot 100 hogs, averaging 200 pounds each, placed them in large covered pens, with plank floors and troughs, and fed them upon corn-meal, ground in the ear, and well steamed. At the end of a week they were weighed, and found to have gained 20 pounds for each 70 pounds of cob-meal—the weather being warm for the season. The first week in November (the weather being much colder) these hogs gained only 15 pounds to the 70 pounds of steamed meal; the third week of the same month (the weather being still colder) they gained only 10 pounds per bushel, and the next week (it getting still colder) they only gained 6¼ pounds per bushel. This lot was then sold; and he selected another and fed in December. The weather being about the same as in November, they gained 6¼ pounds per bushel. This lot was weighed again the middle of January, and the corn fed during a week only increased their weight 1¼ pounds per bushel—the thermometer being down to zero. Another week, on being weighed, they just held their own; the temperature being from one to ten below zero.

This experiment is a fair representation of the effect of temperature upon the thrift of fattening hogs. When very cold, the hog can only eat enough to keep up animal heat, and the food, producing no gain, is thrown away. It must thus be seen that postponing the fattening till winter is very bad economy, and unless the swine-house can be kept at a temperature of about 60° there can be no profit in winter-feeding. This it is not difficult to do; and no large feeder can properly excuse himself on the ground of cost or economy, for his losses from cold in a single winter would build and equip a swine-house in which such a temperature could easily be maintained.

## Selecting Pigs for Fattening.

Many of our Western readers buy the pigs they feed, instead of raising them, which may be necessary in some cases, but cannot be recommended as a system. The feeder gets his profit on a lot of hogs, purchased for finishing for market, from the increase in weight and improvement in quality that he expects to make. He will, therefore, be governed by different considerations in the purchase of pigs for fattening than he would in rearing his own pigs. In the latter case, he would find his profit in keeping them growing as rapidly and constantly as possible. He would want them always in condition for slaughter; but, in selecting pigs for feeding, he will look for a well-developed, rangy frame, with more muscle than fat, and healthy, vigorous condition; and, by good feeding, he will expect to increase the weight rapidly, and add to his profit. But these lean hogs were raised at a loss, which must be pocketed by the seller. When vigorous, lean hogs are put up and well fed, they have simply to fill up with fat, to round out into great weight. Such hogs will stand heavy feeding with clear corn for a few months, and make very profitable packing pork.

## Philosophy of Cooking Food.

Our first inquiry here should be, what is the effect of cooking food? The bulk of all our cereal grains used as food for pigs is composed of starch; and starch, as manufactured, or as found in the cells of vegetables, consists of globules or grains, contained in a kind of sac, and in order to burst these grains, heat must be applied. Payen, on mixing starch with water, and heating to 140° F., examined it with a microscope, and found only some of the smaller grains had absorbed water and burst, most remained still unaffected, and only bursting when heated to from 162° to 212° F. These experiments have been often repeated, and seem to show, conclusively, that the heat of the animal stomach is not sufficient to fully utilize starch. Pereira, one of the best writers upon food, says: "To render starchy substances digestible, they require to be cooked to break or crack the grain." Raspail, a writer upon the chemistry of foods, says:

"Starch is not actually nutritive to man till it has been boiled or cooked. The heat of the stomach is not sufficient to burst all the grains of the feculent mass, which is subjected to the rapid action of the organ; and recent experiments prove the advantage that results from boiling the potatoes and grain which are given to graminivorous animals for food, for a large proportion, when given whole, in the raw state, passes through the intestine perfectly unaffected, as when swallowed."

Every housewife is familar with the fact, that starch will not dissolve in cold water. It follows, then, that those grains containing the largest proportion of starch will be most benefited by cooking, and these (corn, rye, oats, barley) are most used as fattening food for pigs. Corn, especially, is considered the standard fattening food, and that contains about 64 per cent. of starch; rye, 54 per cent.; barley, 47 per cent., and oats 40 per cent. of starch. When corn-meal is well cooked, it is something more than doubled in bulk—the bursting of the grains of starch causes it to swell and occupy twice its former space—and some feeders have considered it as valuable, bulk for bulk, as before cooking; or, in other words, that its value is doubled by cooking. Hon. Geo. Geddes, of New York, a farmer of long experience, says:

"I find if I take ten bushels of meal and wet it in cold water, and feed 25 hogs with it, they eat it well; but if I take the same quantity and cook it, it doubles the bulk, and will take the same number of hogs twice as long to eat it up; and I think they fatten twice as fast, in the same length of time. By cooking, you double the bulk and value of the meal."

We have one complete, comparative experiment of our own to offer as illustrating this point. On the first of October, divided six pigs, of the same litter, into two lots of three each, they being of the same weight and thrift—225 pounds each lot—placing them in separate pens. Lot No. 1 was fed upon corn-meal, soaked about 12 hours in cold water—all they would eat—with a little early-cut clover-hay thrown into the pen for them to chew, to promote health. Lot No. 2 was fed corn-meal, thoroughly cooked, and fed lukewarm, *ad libitum*, with a lock of clover-hay. This experiment continued till the 8th of January, or 100 days. Lot 1 consumed 2,111 pounds of meal, and gained 420 pounds—average 140 pounds each. Lot 2 consumed 2,040 pounds, and gained 600 pounds—average 200 pounds each. This gives 11 pounds gain, for one bushel of meal, by lot No. 1; and 16.47 pounds gain, for a bushel of meal, by lot 2. Lot 1, ate on an average, 7.04 pounds of meal per day, and gained 1.40 pounds. Lot 2 ate on an average, 6.80 pounds of meal per day, and gained 2 pounds.

We have no doubt the gain would have been slightly larger in each lot if the meal had been mixed with the clover-hay, cut. We have reached, with a larger lot of hogs, 17.20 pounds to each bushel of cooked meal, consumed, mixed, before cooking, with a little cut clover-hay. This is, however, a larger average than can be counted upon in any large operation.

Mr. Joseph Sullivant, before alluded to, who made a thorough examination of all available statistics, summed up the evidence as follows:

"I conclude that nine pounds of pork from a bushel fed in the ear, twelve pounds from raw meal, thirteen and a half pounds from boiled corn, sixteen and a half pounds from cooked meal, is no more than a moderate average which the feeder may expect to realize from a bushel of corn, under ordinary circumstances of weather, with dry, warm and clean feeding pens."

He gives thirteen experiments in feeding raw corn; four experiments (those of the Shakers of Lebanon, N. Y., Thomas Edge, Prof. Miles, of the Michigan Agricultural College, and J. B. Lawes), showing that raw meal will make 12 pounds; five experiments to show that boiled corn will make 13½ pounds; and ten cases to prove that boiled meal will make 16½ pounds of live pork. But although these experiments do prove these conclusions, we cannot expect that common feeding will reach these averages. All these experiments are tried by more than ordinarily accurate and enterprising farmers; and we should cut down the averages as follows: By good management, the general feeder may reach, with raw corn, 8 pounds; with raw meal, 10 pounds; with boiled corn, 12 pounds, and with boiled meal, 15 pounds of live pork, per bushel.

There would not be so much difference between boiled corn and meal, if the corn were boiled long enough, or steamed under pressure, so as to burst the kernel and break all the starch grains; but it is not generally so thoroughly cooked as to effect this. The skin or rind of grain is very tough, and intended by nature to protect the interior or more nutritious part of the seed. When this rind is broken and ground to powder, the action of heat is made more rapid and effectual in bursting all the grains of starch, and in rendering it all digestible by the ordinary action of the animal stomach.

## Will it Pay to Cook for Hogs?

The answer to this question must depend wholly upon circumstances. The statement of experiments, showing what may be expected from the effect of cooking, will enable anyone to determine this question for himself. It will not pay to cook for a small number of pigs, because the cost of labor, fuel and apparatus will be more than the gain. It will cost as much labor to cook for ten pigs, with a small apparatus, as for fifty to one hundred with such an apparatus as we described a few pages back. Cooking on a small scale, will only be done where the farmer has a warm pen, and does his fattening in winter, when he has little else to do. If ten pigs are fed 100 days upon seven pounds of corn-meal each, per day—whole amount, 7,000 pounds, or 125 bushels—and if we suppose that cooking will give five pounds more to the bushel, or 625 pounds of live pork, and this worth five cents per pound, the feeder will receive $31.25 for the expense of cooking. It is for the farmer to determine whether he could afford to perform this labor for 31½ cents per day. But if he has 100 hogs to feed, he will receive $312.50 for the 100 days, or $3.12½ per day. It is easy to see that the latter will pay.

In our plan of cooking, we exclude all attempts to feed cooked food in troughs in the open air in cold weather. Nothing but failure can be expected of such attempts. The food will be hot or frozen. Great changes in the temperature of the food is not relished, and food in a semi-liquid state is to be avoided when the temperature is much below 60° F. If hogs are to be fed in the open air, in winter, it should be with dry food. Corn, then, will do best in its natural state; but if the weather is cold, as we have seen, it will require liberal feeding to produce any gain.

In rearing young pigs in winter, some arrangement for cooking will be quite essential to rapid growth. In preparing slops for the brood sows, to cause a generous flow of milk, cooking will be required. We quite agree with Dr. Stetson, on page 478, upon this point. Facility for cooking, will enable the feeder always to give a greater variety in the diet of young, as well as fattening hogs. In cooking, everything may be used to advantage. Pumpkins, potatoes, carrots, beets, turnips, cabbages, short-cut clover, oil-meal, wheat-middlings—each or all may be cooked with the corn or corn-meal, making a savory mess, greatly relished by pigs or fattening hogs. As in the near future, little corn will be sold, even in the West, except in the form of pork, beef or mutton, it is reasonable to expect that the economical preparation of food will be more carefully studied and accurately tested in large experiments, and when this shall occur, we have no doubt that the thorough cooking of the food of hogs will be established as an economy.

# CHAPTER XIII.

## WATER REMEDIES.

We may be expected to have something upon the treatment of diseases of stock. But we must confess at the beginning that our confidence is very slight in the ordinary veterinary remedies, aside from surgical remedies, which should be based upon true science. The attempt to make a specific prescription for a particular disease was long ago called, by a medical man, "a blow in the dark." Young practitioners believe in a large number of specifics—those of long experience are not certain of any. The stock-feeder should place his faith in prevention. "An ounce of prevention is worth a pound of cure."

The author wrote the following observations some fifteen years ago upon the

### Uses of Water in the Diseases of Cattle,

and he regards them as yet practically sound:

As bleeding, blistering, and all violent remedies for the human subject goes gradually out of date, so the milder treatment and greater trust in nature ought to be applied even to our animals. But still, all treatises yet extant for the guidance of the herdsman, after describing the disease, turn only to the medical vocabulary for relief; and the poor animal must be bled, purged, cauterized and irritated, instead of being soothed, quieted, assisted.

In garget, or swollen udder, for instance, bleeding or a purgative is first recommended. Let us examine the case.

The udder has become inflamed, probably the teats are swollen, the milk coagulated, with more or less fever. Now, the prescription says, bleed, purge with epsom salts, ginger, nitrate of potassa, molasses, etc. The operation of this purgative is to irritate the stomach, alimentary canal and intestines, and, by sympathy, other parts of the system, of necessity increasing, at first, the fever and irritation, which it is intended to allay. All purgative medicines operate by irritation, and not as a solvent. It is a direct attack upon the vital functions, which, in self-defense, pour upon it a watery secretion from the mucus membrane of the stomach and bowels, to dilute it and render it less harmful, while it is conducted along the alimentary canal by peristalic motion, and expelled from the bowels—called a cathartic, because nature *kicks* it out as an intruder, an enemy, yet this is called science !

But, says the conservative, if this is at antipodes with Nature, what shall we do to harmonize with and assist Nature to recover her balance ? Let us see :

The greater part of the animal body is composed of water. Three-fourths of the mass of the blood, and nine-tenths of the fluid secretions are water. All nutrient matters are conveyed in water to the blood, and through it to all parts of the system. Water is the only solvent for the alimentary excrementitious matter, and through which the wastes or effete matters are expelled by the excretory organs. Water can circulate through all the tissues of the body without producing irritation or injury. In short, water is in perfect accord with the whole animal system.

Fever and inflammation are caused by some obstruction in the circulation of the system, sometimes by a sudden cold which closes the pores of the skin, and prevents the proper excretions. In high fever, or inflammation, it has been said, " blood is on fire ; extinguish the flame and the patient will be well."

What more is there necessary than to cool off the part, to relieve the system of this unnatural heat? Water is the most universal cooling agent in nature, is always at hand, and easily applied. Everything in nature seeks an equilibrium. Apply cold to the surface of the skin, and the hot blood rushes there to resist it, and to equalize the heat. The tendency to congestion of the internal organs in fevers is relieved by an application of cold to the surface. Water not only cools the skin, but opens the pores and promotes its excretions, and when we reflect upon the large amount of matter that passes off through the pores of the skin, we see the importance of keeping it in a clean, healthy state.

### Garget.

In case of the garget, the swollen udder only requires to be cooled and cleansed, and to be kept cool for a short time, to be restored to its originally healthy condition.

Water furnishes just the means for this purpose. Without exciting and irritating the whole system of the cow, which is already too much excited, water will quiet and soothe the inflammation, cool and soften the hot, dry skin of the udder, and soon give ease and comfort to the cow. But how shall the water be applied to accomplish this?

Washing and sponging the bag with water will not answer the purpose, unless unremittingly applied, which would require a more faithful attendant than is generally found. But if you take an oil-cloth or india-rubber cloth bag, made to fit the cow's udder, or nearly so, coming up to the body, flaring at the top, held up by a strap over the back, then filled with soft water of moderate temperature, say 65°, you will have an apparatus that will require very little attention. This can be applied by anybody, and with much less trouble than a purgative can be given. This mild water will absorb gradually the heat from the udder and not cause any shock to the system, or much determination of blood to the part.

Very cold water should not be used, unless there is much inflammation in the udder, as it will cause a great determination to the part affected. The water must be changed as often as it gets warm. And as there is generally more or less disturbance of the whole system, and an inclination to constipation, give the cow an injection of about three pints of soft blood-warm water—simple water, no medication in it. This will produce a movement of the bowels without any irritation, as the water liquifies or dissolves the hard fæces and cools off the intestines and bowels. If the first injection does not operate in an hour or so, it proves that there is much internal heat, that the water has been absorbed, and another should be given. These injections are perfectly harmless, and can certainly be given as easily as medicated ones; they may always take the place of the purgative, and will answer a much better purpose. When the application is completed, let the udder be slightly chafed with a dry cloth, and rubbed with a little lard. We have several times made this application and always with most gratifying success, seldom requiring more than a few hours.

## Puerperal or Milk Fever.

It may be thought that this disease offers insuperable obstacles to the use of water; that as the cow in many cases cannot stand, the remedy cannot be applied. We admit that this disease, as heretofore treated, has been alarming and difficult to the herdsman; that, as it sometimes comes on so suddenly, runs its course so rapidly, and is drugged so lustily, if not wisely, it leaves his mind in confusion and uncertainty. But there is no real difficulty in using water in this case. The true method is to treat cows before and at calving, so that this crisis in the disease will not occur. All stimulating food should be avoided and the animal kept where she may have uniform warmth and air, and, as in most cases, the udder is swollen and hot, make application recommended for garget; give copious injections of blood-warm water, which will relieve the bowels and intestines; then take matting or old carpeting, wide enough to reach from udder to foreleg, and long enough to reach around her, put it under her and bring it together over the back, then pour slightly cool water between the blanket and her side, thus wetting her over the principal seat of fever or inflammation, producing a fomentation and gradual cooling of the whole surface, modifying her fever and generally producing relief at once. It is well to wet and rub gently her back, hips and flanks. As often as this blanket begins to dry water should be poured in as before, until the fever passes away, when the blanket may be taken off and the cow gently chafed with a dry cloth until the hair is dry. Moderately cool water should be given her to drink, but no effort made to stimulate her appetite, which will return when Nature calls for food. Let it ever be remembered that this treatment and all treatment of sick animals should be performed in the gentlest manner. Let roughness and cruelty be monopolized by the butcher, and never used by the herdsman.

Milk fever is apt to be accompanied by more or less of *brain fever*, and in this case, what is done must be done quickly, and the best application is a drench of very cold water (ice water), delivered between the horns and on the forehead. This should be repeated several times, if necessary. It should not be continued till chills are produced. But when the disease has reached the brain, veterinarians do not acknowledge any probability of cure, yet the author has known of several cases recovering after the use of the cold drench. It is not very different treatment from that of brain fever in the human subject—pounded ice between two linen cloths applied to the brain. When the drench is applied the other applications must also be made.

If this fever should occur in cold weather, a dry blanket may be put over the wet one, to keep the heat from passing off too rapidly, but if the fever should be high there will be no danger of this.

Since writing the foregoing, several experienced dairymen have reported to us in confirmation of our treatment for milk fever, that finding a cow in the worst stages of this fever, and quite unable to stand, they caused her to be frequently and thoroughly washed, and covered with a blanket to keep the evaporation from being too rapid —that "it worked to a charm," as they phrased it, the cow soon recovering her usual strength and milk.

The reader will readily see how this treatment may be applied to other fevers and inflammations; in what is called common or *simple* fever, the same application should be made. In *inflammation of the lungs*, a similar application may be made to the chest, and in all cases of fevers and inflammation, injections should be freely used; they answer in all cases much better than the drug purgative.

In diarrhœa, the injection is valuable where a change of food is not sufficient to correct it, as it cools off the bowels and intestines, allays irritation, and enables Nature to resume her proper functions.

## Water Treatment for Horses.

*Wounds, Bruises, Sprains, etc.*—The best surgeons now regard water as an important auxiliary in treating wounds. Lavements, pourings, wet compresses, etc., are used for the human subject; and water answers equally well for animals.

*Simple cut wounds*, when cleansed and dressed with water, usually heal without suppuration, especially, if the blood be in a healthy state. There being a tendency in all wounds to fever and inflammation, water dressing, in the form of wet bandages, keep down the unnatural heat, and allow Nature to go on with the healing process. The lips of the wound may, generally, be held together with adhesive straps, and the water application put over. The most dangerous wounds, near some vital part, are frequently healed with the aid of water to keep down the inflammation. We remember a fine mare that stepped on a hoe, the handle of which had been split, leaving a sharp end, and throwing the handle up under her belly, caused a deep, ugly wound, and so lacerating the bowels, that, being in August, it was thought almost useless to attempt saving her. But by dressing the wound constantly with water, the flies were kept out, inflammation prevented, and the wound healed in two months, leaving the animal as valuable as before. Not long ago we had a mare that accidentally struck a nail deep into her foot, and being idle in the stable at the time, it was not discovered till the foot became much swollen; and when the blacksmith took off the shoe, the foct was in such an inflamed condition, that he thought nothing could prevent gangrene and loss of her foot. But a shallow tub was put into her stall, filled with water, and the foot placed in it. So much did this relieve the pain, that when the water was changed, the animal would, voluntarily, place her foot in it. The inflammation was soon reduced, and the foot became sound.

*Bruises and sprains* are most aptly treated with water, as they are liable to be followed by protracted inflammation. The parts should be immersed in, or poured with cold water, and then kept bandaged with water, often changed, till the inflammatory action is passed.

### Sprained Ankle.

We have seen the most remarkable effect of rubbing with water, followed by a water bandage, which was changed twice per day, upon the ankle of a horse whose foot was caught in a tread power, and doubled over so badly, that parties who saw the accident thought it very improbable that the horse should be able to work again in two months. But by rubbing the ankle in water for one hour, and then bandaging it in water for three days, he went to work again on the fourth day as if nothing had injured him.

A few months ago a friend of ours had a wiry, tough little mare who had been growing lame from a sprained ankle for several months, and he had about despaired of much improvement. We advised him to place a heavy water bandage on the ankle of the little mare when brought in towards evening. He did so, and in a few days she was very much improved, and in three weeks she was well.

## Treatment for Colic.

The best treatment for this ailment of horses is the preventive treatment in feeding. We do not think a horse ever had the colic without error in feeding too concentrated food, or, perhaps, driving rapidly on a full stomach. But these errors will more or less occur, and then the remedy.

It is always caused by indigestion and fever. The best application is, first rubbing the abdomen and chest with cold water, and then placing a heavy woollen blanket under the belly and bringing the ends up over the back, when cool water can be poured in between the blanket and skin, keeping the body wet just back of the foreleg. This will usually give relief in a few minutes. The author has seen a number of horses with colic led into a creek, in warm weather, when the horse would immediately lay down in the water and get relief in that way. We have never seen a horse with colic that would not make the application himself when given an opportunity. This application can be made in a warm stable in winter, but in that case the water should not be below 60°. If the horse is constipated injections of soft water should be used.

## FOOD MEDICINES.

Stock-feeders have not studied sufficiently the effect of foods upon animal ailments. The condition of the system can be completely controlled by food. There are laxative foods and constipating foods and food with other remedial qualities. A laxative food is anti-febrile; in fact, a proper understanding of the management of laxative food will prevent diseases. Fevers often arise from a too free and long use of a constipating food.

A close observer can tell at once what variation in food may be required to establish a healthy condition in a horse; that is, in horses constantly under his eye. But he must have studied the effect of foods and rely upon them, instead of the medical vocabulary. A horse should never be allowed to get into a condition in which food will not recover him. Flax-seed is, perhaps, the most convenient laxative food. Boiled flax-seed will take effect quite rapidly, and no veterinarian will say that this laxative is not milder, and to be preferred, where it will operate, to a medical laxative. Peas are slightly constipating, beans more so, finished middlings a little binding, and an occasional half pint of boiled flax-seed mixed in will keep the proper balance.

# APPENDIX.

## AMERICAN ENSILAGE IN ENGLAND.

THERE having been many questions raised in reference to the wholesomeness of ensilage as a food, especially for milk, we regarded the following correspondence and analysis of maize and rye ensilage by Dr. Voelcker, of England, as important enough to be added in an appendix, with other recent statements in this country. Mr. Edward Atkinson, of Boston, who has taken much interest in the development of this system of ensilage in New England, at the instance of an English friend, sent maize ensilage and rye ensilage to Prof. Voelcker for analysis and experiment. The following is Mr. Atkinson's letter to the *American Cultivator*, accompanying the report and analysis of Dr. Voelcker :

### IMPORTANT STATEMENTS BY PROF. AUGUSTUS VOELCKER.

An English friend of mine, having become greatly interested in the subject of ensilage, and having seen only samples of French fodder, carried to England in bottles, I suggested sending to him two casks, one of Yankee corn fodder, the other of rye; upon his assent thereto, the two casks were forwarded to Prof. Voelcker, the leading agricultural chemist of England, by whom they have been analyzed, and whose report is inclosed herewith. I have been informed that Prof. Voelcker had previously been very skeptical in regard to the value of this method of saving green crops.

It may interest your readers to know that I measured off half an acre of good land and planted it in the autumn with winter rye which I reaped a little too late, when the straw had hardened, about the middle of June of last year. I then planted Southern corn, the growth of which was checked considerably by the drought, but which reached an average height of ten feet, and which was cut in September. I computed the total of the two crops at twenty tons, and I think it would have been four or five tons more except for the drought. I shall carry my two cows from fall feed to summer pasture, with a considerable quantity left over.

The fact that this fodder could be taken from the pits, packed in casks and sent to England in good condition, is suggestive—first, as to the feeding of live cattle in crossing the sea. Would not good corn fodder, packed in casks, be better than hay and more suitable, bulk for bulk?

Second, may not persons who live in city or village raise fodder at some distance, permit it to wither on the field, so as to lose its elasticity, and then pack it in flour barrels or sugar barrels, using a lever to press it, to be brought in from the farm to the city or village, as needed for the family cow?

I am well satisfied that four cows can be maintained on an acre of good land for twelve months, if they are fed with a small ration of cotton-seed meal in addition to the ensilage, and the manure is all restored to the land. It would, perhaps, be more prudent to call the ratio three cows to an acre of good land for twelve months.

In another aspect this matter of saving green crops for winter fodder may greatly affect the prosperity of New England farmers. If I have been correctly informed, one of the obstacles to the raising of long-wooled sheep of the finer sorts with entire success, in Vermont and elsewhere in the North, has been the effect upon the staple, at about the middle of its growth, of the change in the habit of the sheep when transferred from the open pasture to the barn, coupled with the entire change in the quality and kind of food thereafter given.

It has been stated to me—whether it is true or not I do not know—that during the period when the sheep are becoming accustomed to the changed conditions, a short bit of weak staple is formed, where the fibre breaks when it goes into the combing machine at the factory, thereby greatly increasing the proportion of noils and waste. Now there is no condensed food upon which sheep thrive better than cotton-seed meal, and cotton-seed meal is one of the substances most frequently fed in connection with ensilage.

It is to be hoped that some Vermont farmer will try the experiment of feeding sheep with ensilage and cotton-seed meal, if it has not already been tried, graduating the change from the open field to the barn in such measure as not to affect the condition of the animal in the process. May it not thus be possible, not only to increase the quantity of wool in very great measure, but also to improve the quality at the same time?

May not ensilage extend the period of feeding upon succulent food throughout the year, and thus assure the production of fine, long-stapled wool of uniform quality? On the other hand, the rich manure of sheep fed in part upon cotton-seed meal will keep the corn land devoted to the ensilage crop in full heart.

BOSTON, MASS. EDWARD ATKINSON.

## DR. VOELCKER'S REPORT.

ANALYTICAL LABORATORY,
11 Salisbury Square, Fleet Street,
LONDON, E. C., March 10, 1883.

*Dear Sir:* The maize ensilage from Boston reached me in a perfectly sound condition. The rye ensilage was also sound, but here and there I found a few bits which were slightly mouldy. On exposure to the air the maize ensilage kept much freer from white mould than the rye ensilage. Both were decidedly acid, the maize ensilage much more so than the rye ensilage.

My impression is that well-made maize ensilage may be taken out of a silo and freely exposed to the air without becoming mouldy and unfit for feeding purposes. Rye ensilage appears not to keep so well when taken out of the silo; should be consumed without much delay.

The fact that maize ensilage keeps sound and free from mouldiness better than rye ensilage appears to me to be due to the circumstance that maize contains more sugar than green rye. In the silo the sugar in the green food enters into acid fermentation; and the organic acids formed from the sugar are, as you are aware, preventives of decay of organic vegetable matters. In the case of maize, more acids, such as acetic, lactic, butyric and similar aromatic organic acids, are generated than in the case of green rye, for the latter is much poorer in sugar than maize, and this is no doubt the reason why maize keeps better than green rye.

The proportion of acids in ensilage I find varies a good deal, and the nature of the organic acids in ensilage also is subject to considerable variations. In some instances I have found the prevailing acid in maize ensilage to be non-volatile lactic acid; in other samples lately examined by me most of the acids in ensilage I found to be acetic and butyric acid.

A short time ago a sample of maize ensilage was sent to me from Canada, in which I found, in round numbers, one per cent. of butyric and other volatile organic acids. This sample contained 85.69 per cent. of water, or fully three per cent. more than the sample which was sent to me from Boston, and although it has been freely exposed to the air for nearly two months, the ensilage is perfectly free from white mould. The Boston sample, on exposure to the air for about a fortnight, got slightly mouldy on the top layers, but not nearly to the same extent as the rye ensilage.

The following are the results which I have obtained in the careful and detailed analysis of the average samples drawn from the two barrels of Boston ensilage.

Composition of two samples of ensilage sent from Boston:

| PERCENTAGE OF DRY SUBSTANCE SOLUBLE IN WATER, 4.08. | Rye Ensilage. | Maize Ensilage. | |
|---|---|---|---|
| Water | 75.19 | 82.40 | 5.75 per cent. soluble in water. |
| Fatty matters and chlorophyle | .86 | .59 | |
| Butyric and other volatile | .11 | .22 | |
| Organic acids | | | |
| Lactic acid | .02 | 1.26 | |
| Soluble extractive matters | 1.10 | 2.58 | |
| *Soluble albuminoids | 1.01 | .50 | |
| Soluble mineral matters | .98 | .60 | |
| Percentage of dry substance insoluble in water, 20.73. | | | |
| **Insoluble albuminoids | .75 | .76 | 11.85 per cent. insoluble in water. |
| Digestible cellular fibre | 8.41 | 5.43 | |
| Indigestible fibre | 11.08 | 5.14 | |
| Insoluble mineral matters | .49 | .52 | |
| | 100.00 | 100.00 | |
| *Containing nitrogen | .16 | .08 | |
| **Containing nitrogen | .12 | .12 | |

You will notice that the rye ensilage contains about seven per cent. less moisture than the maize ensilage, and much less acid than the latter. Probably the green rye was too far advanced in growth before it was put into silos, and not so rich in sugar as it was at an earlier stage, when it contained less indigestible woody fibre.

Much of the success in making ensilage depends upon the proper state of maturity of the green food. Green rye, maize, and, in fact, all kinds of succulent vegetable produce, should be cut down neither too immature nor overripe, but when the green food contains a maximum amount of sugar. The sweeter the green food the better it will keep in silo, and the more nutritious and wholesome it will turn out when ready to be consumed by cows or other live stock.

There can be no doubt that both the rye and the maize ensilage which you directed to be sent to me from Boston are good and wholesome foods. I prefer the maize to the rye ensilage, and consider ensilage specially useful to milch cows in winter. Decorticated cotton cake and ensilage go well together and make rich milk.

I may say in conclusion that I sent the ensilage not required for analyses to our experimental station at Woburn, and my farm manager reports to me that the cattle took to the ensilage at once and apparently liked it much, and, as far as could be judged, did well upon it. On the other hand, fattening pigs did not care for the ensilage, and would not touch it at first.

[Signed] AUGUSTUS VOELCKER.

Mr. Atkinson's suggestion that ensilage, packed in casks, might furnish an excellent food for fat cattle in transit to Europe, is a good one, but perhaps he overestimates the comparative value, and we can well believe it to be practical from experiments made by us more than 25 years ago. We took a large linseed-oil cask and pressed green clover into it in June, pressing in the head and sealing the seams with white lead. This was kept for a year without the appearance of fermentation, the blossoms looking bright on opening.

His suggestion of the use of ensilage in feeding sheep in New England is in the same vein as ours on pages 435–37. There is no doubt that ensilage will make the staple of wool uniform throughout. See experiment with steamed food, pages 456–7.

Dr. Voelcker's analysis and report are interesting and important, as showing that the acid in ensilage is principally lactic, which is supposed to be favorable to the production of agreeably-flavored milk. The Doctor gives a decided indorsement of ensilage for milch cows. His opinion of the comparative value of corn and rye ensilage arose, no doubt, from the too ripe condition of the rye when stored. We shall see that the practical test of comparison, made on Mr. Havemeyer's herd, showed rye ensilage much superior to green corn. Rye, when cut, just before blossom, shows, on analysis, nearly 50 per cent. more nutriment than green corn ready for the silo.

We find the following account of Mr. Havemeyer's use of ensilage in the *American Cultivator:*

## Ensilage in New Jersey.

"While the adoption of the ensilage system has spread enormously during the past year or two, it may be doubted whether so valuable and exhaustive a test of its merits has been made as at Mountainside Farm, New Jersey, the property of Theodore A. Havemeyer, of New York City. It was a bold measure, several years ago, to substitute ensilage exclusively for hay in the feeding of one of the finest and most valuable herds of Jersey cattle in the world, a herd that would probably sell at auction for upwards of $100,000, and where the income from the sale of high-bred calves was of the first importance. It was still bolder from the fact that in so doing the grain ration of the cows was cut down to one-half that which had previously been fed with hay, causing greater physical dependence upon the new food. It was still bolder when, having passed through the winter, the cattle were not turned upon pasture in the spring, thus giving a respite from ensiloed food, as has been the custom elsewhere. From October, 1881, until now, the entire herd, old and young, were kept upon ensilage, without intermission, save occasionally when, for a day or two, a change was made for the sake of experiment. The result has been, that, with half the amount of grain formerly fed with hay, the same cows have averaged over 100 pounds (fifty quarts) more of milk per month than they did on the old diet. Their coats look glossy and sleek, and every indication is that of blooming health. The calves that have been dropped upon the place from silo-fed parents, themselves silo-reared, are pronounced without dissent by the hundreds who visit the place to be of the best quality and in excellent condition. It may be doubted whether another lot of animals equally large, vigorous and healthful at various ages can be found short of a climate that affords pasturage the year round. While much of this condition is due to the fact that the parent herd, both as regards the imported and the native-bred animals, was selected with an eye to constitution and superior physical capacity, their blooming condition is unquestionably due, in a great measure, to the method of feeding.

"Notwithstanding the undoubted success of ensilage feeding, Mr. Havemeyer and his foreman, Mr. Mayer, admit there are some facts connected with ensilage that are hard to account for. While it appears improbable that the feeding value of green forage could be improved upon its natural condition when fresh by stowage under pressure in a pit, the experiments at Mountainside Farm raise the question at least to the dignity of a debatable one. When in August last the working force of the farm was concentrated upon the great work of transporting the fifty acres of green corn-fodder from the fields in which it grew, through the giant cutters and carriers, into the great pits where it was to be preserved for the coming year's use, a pit of ensilaged rye-fodder which had been stored earlier in the season, and from which the herd were being fed, gave out. To open a new pit would be to divert the use of the machinery and the time of three or four men from the special work of harvesting, to which all energies were being devoted. Mr.

Mayer, therefore, ordered that several loads of the corn-fodder cut fresh in the field should be placed before the cows instead of their customary feeds of ensilage.

"They ate it with great relish, and they ate a much larger quantity than they did of the rye ensilage; nevertheless, with the same grain ration, they fell off in milk. Thinking the result due to the fact that the ensilage had had the advantage of having passed through the cutter, the fresh corn-fodder was then submitted to that treatment instead of being fed long, but the milk continued to diminish until at the end of three days the average daily shrinkage per cow was four pounds (two quarts), which, when tested in quality, showed two per cent. less cream. A new pit of ensilage was opened, and in two days the cows were back to their full flow. This comparison between ensilage rye and fresh corn-fodder is the more surprising from the fact that as a fresh feed rye-fodder is inferior to corn-fodder.

"The discrepancy cannot be attributed to a difference in amount of food, for, as carefully ascertained, the cows ate sixty pounds of the corn against twenty-five pounds of the rye. The chemical theory is that the method of storing ensilage causes it to develop lactic acid, which is in itself a stage of digestion, and so effective in its action that the food renders a maximum of its nutriment to the support of the animal."

The value of the above statement consists in the main and undoubted facts stated—that a great herd of dairy cows had been fed upon ensilage, steadily, for 18 months, remaining in health and satisfactory yield of milk; calves healthy and of vigorous growth, with a large reduction of the grain ration. These are important facts. But the statement that the cows lost four pounds of milk each in *three* days by a change to green corn, and gained it again in *two* days on being fed corn ensilage, we must regard as an error in length of time at least. A change of food does not so suddenly affect the yield. Then it is an error to say that green rye in proper condition of maturity is inferior to green corn. It is true that cows prefer the taste of green corn—they even prefer it to green clover, but who supposes it to be superior to green clover!

### A Trial of Corn Ensilage with Dry Food.

Mr. Henry E. Alvord, the very intelligent director of Houghton Farm, gives, in a paper read before the New York Agricultural Society, and published in the last Report, an interesting trial of the effect of corn ensilage with grain compared with dry food and grain, in feeding two lots of six Jersey cows each, for twelve weeks. The following is a statement of the experiment:

These twelve cows were fed and treated alike for a fortnight prior to beginning the record, and then for twelve weeks their treatment was exactly the same, except that one set of six (lot A) received only corn ensilage, besides grain, while the other set (lot B) had dry forage only. The uniform grain ration was a mixture of four pounds of corn-meal, four pounds wheat bran and one and one-half pounds cotton-seed meal, fed in two portions. Lot A received sixty pounds ensilage per day, it being of average quality, as per analysis given hereafter, and lot B received twelve pounds of cut stover and five pounds cut meadow-hay daily. The coarse forage in both cases was fed in two portions, one separate from the grain, while at the other time these were mixed. The following is the milk record of the two lots for the twelve weeks' trial:

| Six Cows—Jerseys. | Milk per week at beginning of trial. | | Milk per week at close of trial. | | Total weight of milk produced in 12 weeks. | | Average milk produced per week. | | Average, twelve weeks, per day and per cow. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | lbs. | oz. | lbs. | oz. | lbs. | oz. | lbs. | oz. | lbs. | oz. |
| Lot A—ensilage ............ | 825 | 2 | 731 | 12 | 9.295 | 9 | 774 | 10 | 18 | 7 |
| Lot B—dry feed ............ | 816 | 6 | 722 | 14 | 9.375 | 5 | 781 | 8 | 18 | 10 |

The periodic loss or shrinkage of milk for every division of four weeks, comparing the quantity on the first and last days of these divisions, was as follows (gains marked + and losses —):

| Cows. | January. | | February. | | March. | | Total, 12 weeks. | |
|---|---|---|---|---|---|---|---|---|
| | lbs. | oz. | lbs. | oz. | lbs. | oz. | lbs. | oz. |
| Lot A.......................... | —60 | 2 | — 8 | 3 | —25 | 0 | 93 | 5 |
| Lot B.... ...................... | + 1 | 0 | —24 | 9 | —70 | 6 | 93 | 15 |

As to the quality of the milk from the two lots, these facts were ascertained, the figures being averages of the chemical and practical tests:

| Six Cows—Jerseys. | Specific gravity of milk. | Total solids in 100 lbs. of milk. | Fat in 100 lbs. of milk. | Cream volume, per ct. of milk. | Milk required for one lb. of butter. |
|---|---|---|---|---|---|
| | | lbs. | lbs. | | lbs. |
| Lot A .................. | 1032 | 14.16 | 3.95 | 20½ | 22.9 |
| Lot B .................. | 1029 | 13.81 | 3.93 | 18 | 20.2 |

The butter from the milk of the ensilage-fed cows was decidedly better, both in color and flavor, than that from the other lot. In April the ensilage was discontinued, and lot A put on entirely dry feed, the same as lot B. Then, after one week's intermission, the two were compared for four weeks more with this result:

Lot A, 687 lbs. 0 oz. milk per week, or 16 lbs. 6 oz. per day and cow.

Lot B, 702 lbs. 2 oz. milk per week, or 16 lbs. 11 oz. per day and cow.

Tracing this trial all through, it is seen that the results in quantity of product are slightly in favor of the dry-fed cows. But this is offset by the better quality of the butter as well as the more thrifty and healthful appearance of the animals fed on ensilage.

The great variation in the chemical composition of corn ensilage is shown in the following results of numerous analyses:

| PARTS IN 100 LBS. | Water. | Albuminoids. | Fat. | Carbohydrates. | Crude fibre. | Ash. |
|---|---|---|---|---|---|---|
| Maximum ...... | 84.9 | 1.9 | .9 | 13.4 | 7.9 | 1.4 |
| Minimum ..... | 74.1 | .9 | .3 | 7. | 4.7 | 1. |
| Average ........ | 81.4 | 1.3 | .6 | 9.6 | 5.9 | 1.2 |

It is to be regretted that Mr. Alvord did not note accurately the weight of each lot of cows at the beginning and the end of the experiment. This might have shown an important difference. He remarks the better quality of butter and the better and healthier condition of the cows fed on ensilage. These two points alone may furnish a very sufficient reason for feeding ensilage instead of dry fodder. There are some occult facts that chemistry does not as yet explain. Chemists think they have demonstrated that grass does not lose materially in nutriment in the process of drying. But still the great fact remains that cattle can be fattened rapidly upon grass, but cannot be fattened upon hay. It is practical nonsense to say that dry food has the same feeding value as it had when green and succulent.

There is much yet to learn in reference to the best ensilage crops, or, rather, it will be found that a greater variety of green food must be ensilaged, so as to furnish a well-balanced ensilage ration. By referring to page 224, analyses will be found of 20 green fodders in a proper condition for ensilaging. Dr. Voelcker's analysis shows that ensilage does not contain any important quantity of acetic acid, but mostly lactic and butyric acids, which may be considered helps to digestion.

# APPENDIX

## TO THE THIRD EDITION.

### Fastening Cattle in Stable.

It should be the aim of all feeders to give cattle as much freedom of motion and comfort in position as can be done without too much extra labor and expense. The most comfortable method is, of course, the box stall, but this is quite too expensive for common use; will be used only for the most expensive thoroughbreds—and the general dairyman is content to place his cows' heads between two sticks, called stanchions.

This last mode has simplicity and the minimum of labor to recommend it, but it is really unjust treatment of that most useful animal, the cow, and ought to be abolished. And for this purpose we invented the plan shown at page 98, Fig. 10. A post 4 x 6 inches (No. 9) stands between each two cows, and 12 inches above the floor is driven a three-quarter inch staple, 12 inches long, into the center of the side of the post, as seen in (10). There is another staple driven into the opposite post, and a quarter inch cable chain (11) stretching from staple to staple, with a ring on each end, to slide up and down on the staple, and a swivel ring in the middle to which the cow is fastened, by two branches of chain from this swivel ring around the neck. We first used a strap around the neck, with snap instead of these branches of chain, but the snap broke and the chain was substituted for the strap. This chain also gives less slack to the hitch. The cow is thus held in the middle of her space, and cannot move sidewise to annoy her neighbor. But as there is a little slack to the chain, and the strap can slip backward and forward upon the neck, she can move backward or forward, can lie down or get up as easily as if not fastened at all, and can turn her head and lick her shoulders, or any part of her body, as freely as she chooses. Her movement is remarkably free, and her position in lying down as unconstrained as in the field.

In order to allow this freedom of backing up without permitting her to pass her horns past the post to annoy her neighbor, a plank 12 or 14 inches wide is set edgewise behind the post, as shown in illustration No. 1, here given. And, not being able to back past this plank, she cannot molest her neighbor on either side. A plank 5 feet long, (12) in Fig. 10, seen also in Fig. 1, is set against the front edge of the post, reaching down to the manger. This plank in front prevents each cow from eating her neighbor's food.

After having tested this arrangement of staples in the side of the posts, and finding that the rings soon wear off by the friction in sliding up and down on the staples, we devised a way of avoiding this wear by stretching a quarter-inch chain 13 inches above the floor, the whole length of the stable, and fastening it to each post by a strong staple driven through or astride of a link. The chain is given a slack between each two posts, so as to allow the center of the chain to rise and fall six inches. This effects the same purpose as the long staples, and the chain does not wear so fast; besides, this fastening costs only about half as much as the other. The ring, in the center of each cow's space, is made a swivel, so that the cow cannot twist the chain. This swivel is made by forming a link, with one flat side 1 inch wide. The stem of the ring is inserted through the flat side of the link and headed, leaving play enough to turn easily. A link is cut out of the chain and the swivel link welded in. This new method is shown in Fig. 1, this Appendix. It was also found better to have two fixed standards or false stanchions to prevent the cow from reaching too far in the manger. These false stanchions are 12 inches apart, so that the head can be put through easily and withdrawn at will. These are also shown in Fig. 1.

## Watering Cattle in Stable.

Watering is a very important part in the management of cattle. Each animal should be able to drink in stable as free from molestation as it eats. The method of giving water in stable, seen in Fig. 10, page 98, (No. 7.) But this shows a sheet-iron trough, which was found to rust out in about five years from the action of salt; and we found a V-shaped trough of one and one-half inch Norway pine, much better, as well as cheaper. This trough being of resinous wood will be very durable. It is placed in the center of the bottom of the manger, because it could not be drawn out of the reservoir in our barn if placed higher. When the bottom of the reservoir is high enough to draw the water into a trough two feet from the floor, then it is better to have the water trough on the inside of the front of the manger above the feed, where it will be more easily kept clean. This trough will be continuous the whole length of the stable, and there may be a light lid for each animal, which it will soon learn to open with its nose,

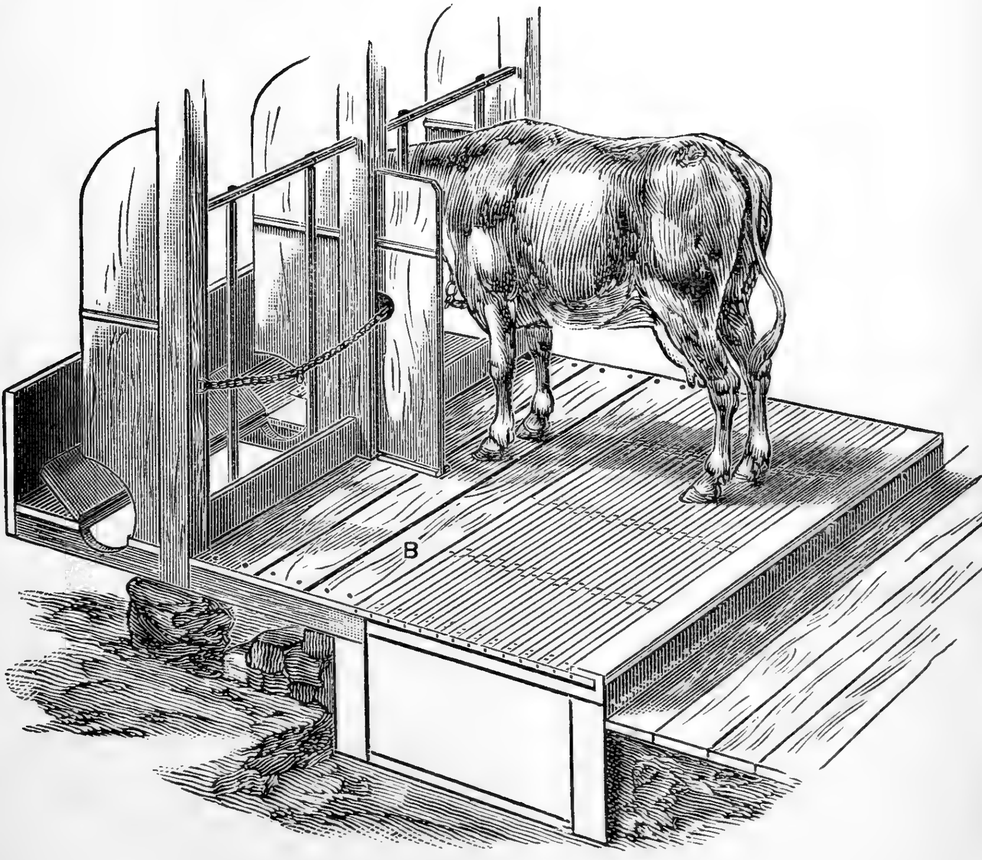



Fig. 1.

and then fall back when the head is withdrawn. The position for this trough can be seen in Fig. 1. This lid will keep all feed from getting into the trough. The water is drawn from a pipe into one end of the trough, and when nearly full runs out at the other, and is discharged into a drain. But to prevent waste of water, when that is an object, the water pipe can be closed when the trough is full. We discontinued the use of the lid in the bottom of the manger, because the hinges soon rusted and broke.

One important advantage of watering in stable in winter is the milder temperature of the water, thus saving the food required to warm the water in the cow's stomach from near the freezing point to about 60°=28°. It is no inconsiderable loss of food to warm 6 to 8 gallons of water daily in the stomach of each cow. There can be little doubt that the saving in one winter will repay the whole expense of such an arrangement for watering.

The animals may be let out for air and exercise to suit the ideas of the feeder, but it is bad economy to let out cows in stormy weather. The comfortable way of tying animals, here represented, renders it unnecessary to let them out except in fine weather. Cows do not need very much exercise. It may be said that no animal is more sensitive to cold than the milch cow, and none so seriously affected in product by such exposure. Milk cannot be produced profitably with cows exposed to the weather.

## Improvement of Breed by Feeding.

By an oversight the following experiment was omitted from the previous editions. We do not think there is any danger of inciting too much confidence in improved feeding. There has been a surplus of enthusiasm on the part of breeders, to impress the public of the cattle industry, that the only lack is the breed to warrant a commanding success. Whereas, it is most manifest, that the best and most judicious feeders of all the imported breeds have been the most successful. The Jerseys have made records twenty-five to fifty per cent. larger here than on their native Island of Jersey. It is quite as true also of the Holstein-Friesians. They have largely surpassed here any performance in their native land.

All imported breeds have found here congenial food and climate, and all have responded to our more liberal feeding. It would be simply absurd to suppose that our improved selection in breeding had advanced those breeds to a higher performance. They can transmit by heredity only such development as they have heretofore had, but can never produce anything beyond the combination of characteristics inherited in the animals bred. The most magnificent breed will soon be brought into contempt, however well selected, under a system of scanty feeding, such as is often given to common stock, whilst skill in feeding will greatly improve common stock in three generations. We think it not extravagant to say that all skill in breeding is comparatively useless without skill in feeding, whilst skill in feeding will grow profitable animals without skill in breeding. In this we do not intend to undervalue selection in breeding, but only to emphasize the point that skill in feeding is prerequisite to any adequate success in growing animals.

An abnormal development of the muscular or osseous systems, either or both, may be accomplished in the selection of food. Nature seeks uniformity in her productions, but yet that certain elements, both in the vegetable and animal bodies, may be developed out of proportion, is well known.

The same plant or seed will develop quite differently in different soils. Even one element may be substituted for another, such as potash for soda in the mineral elements of plants; the proportion of the elements may be changed by the composition of the food presented to it. The most intelligent feeders know that you may increase the size of the frame, or cause an unusual deposit of fat, by the selection of the ration.

Let us suppose that we have a breed in which a small frame is characteristic and of long standing. A few generations, of special feeding to that end, may so enlarge the frame as to appear like an essential modification of the original breed, and this, persisted in, becomes a fixed characteristic. And this change may be effected while simply breeding these animals together, which are subject to this special feeding without special selection of animals to that end. We must therefore credit special feeding with this variation of a breed.

A breed of cattle that has long been known for their lean condition may, by special feeding to that end, be made susceptible of laying on fat in large proportion; and this changed characteristic may be perpetuated by breeding. The old Longhorns upon which Bakewell experimented were of this sort, and according to one account, the chief merit of this breed, as he left them, was to make fat. He had so far changed them that they laid on fat as much in excess as they had before been deficient in fat deposit. He is said to have begun with two Longhorn heifers and a Longhorn bull, and confined himself to these and their progeny. It must be admitted that simply breeding from these three animals without any improvement in feeding could not have produced such a change.

The author tried an experiment over twenty years ago with three common blood heifers, red, with a few roan spots on sides, of thin angular habits, purchased under two years old from a poor feeder, whose greatest anxiety was to make his fodder hold out, whether his cattle did or not. These were in calf, and purchased to see what effect improved feeding would have upon them and their progeny for a few generations. A common scrub bull of similar color and breeding, but not of kin, was purchased to serve these heifers in future. The dams of these heifers were never known to give more than 20 pounds of milk per day at their flush. We began feeding them with the design of developing the milk yield, and also enlarging the frame, as they did not probably weigh over 600 pounds each. The grain ration consisted of oats and corn, in the proportion of three of oats to one of corn, and one bushel of flax seed to sixteen bushels of the mixture, all ground together; and with this was mixed an equal weight of wheat bran. As they had never before had any grain, we began with one quart of the mixture per day, and in ten days added another quart. This was continued about three months to their first calving. Those first calves were thin and scrawny, requiring a long time to give plumpness to them. They were two heifers and one bull, and all finally became thrifty, and averaged 600 pounds at a year old.

The dams of these had been fed well through this year with their first calves, but neither of them had given more than 16 pounds of milk per day at the best. One of the three had utilized her good feed in filling her lank places with fat, in straightening her top and bottom lines, and she became a very shapely heifer, but she had given very little milk. The second calves of all three heifers were in very decided contrast to their first. These fed finely from the start, and averaged 800 pounds at a year old. In fact, they did not appear to belong to the same breed as their dams when we bought them. Even those dams (the original heifers) had become very shapely cows—two of them had developed into fine milkers, and the other had taken on fat instead of yielding milk. She was still kept to test the effect of her fat condition upon her subsequent calves. Her second calf (a bull) born in her fat condition, was itself extremely well developed, and fed very well, reaching a weight of 825 pounds at a year old, and sold to the butcher for $55. Her third calf (a male) was not as good as the second, because her condition was too fat to bear a strong healthy calf. Yet this calf fed well, and laid on fat remarkably for its age; weight 600 pounds at 8 months, and sold for $36.

The heifer calves bred and dropped calves at two years old, and these calves were good feeders and good milkers, with only one or two exceptions. For four generations they continued to improve in form and size, and as milk yielders. Each generation became more economical of food—that is, produced a larger growth or more milk from a given amount of food. Some of the heifers of the third generation produced 28 to 30 pounds of milk per day with their first calves, yielding over 5,500 pounds of milk at two years old.

Two of the original cows increased in milk till seven years old, when they averaged over 7,000 pounds per year, yielding 40 pounds per day at the flush. The dams of these, as near as we could ascertain, had never yielded over

3,500 pounds of milk in a year, and yielding only 20 pounds per day at the best. Here the result of special feeding for a few years was equal to doubling the yield of milk, and the heifers had so changed in general appearance that the farmer who sold them to us could, with difficulty, be persuaded that they were the same animals, and on seeing them milked, declared that the yield of milk was fully twice as much as their dams had ever given. These heifers had also increased in weight some 40 per cent. over their dams, reaching 1,000 pounds. Two heifers, of the third generation, reached a weight of 1,100 pounds, and produced a yield of 7,500 and 7,800 pounds of milk. These heifers, in contour, would not suffer by comparison with the average Shorthorn. The third generation became remarkably uniform in conformation, size, color, form of head and horn. The color became a deeper red, with only a trace of roan.

These animals of the fourth generation were so near alike as to remind one of the members of a family of some special strain of blood of a thoroughbred race; and had the breeding been continued for four or six generations further, there was every appearance of success in the formation of a distinct breed, that would reproduce and perpetuate itself. It would have proved a valuable milking strain of blood — this quality was already produced with much uniformity. We enlarge upon this experiment because we think it is quite time that breeders had given more attention to the influence of food in the establishment of breeds.

## Preparing Food for a Large Stock.

Our attention has been called to the omission in the body of this work to describe the complete apparatus for preparing winter food in the various ways recommended.

Of late years basement stables have become more common than formerly, and this gives the opportunity for preparing the fodder in the story above the basement, and of arranging the apparatus most conveniently for saving manual labor. The American farmer has cheap food, but not cheap labor, and it is therefore of much consequence to have the labor done as much by machinery as possible. Our inventors have constructed the best cutters for reducing hay and other fodder to fine chaff, and thus save much labor of the animal in mastication. This extra labor of the animal costs more in food than the expense of running the machinery. Carriers are easily attached to the cutters, that will deliver the cut fodder wherever required. It becomes necessary often, not only to wet the fodder, but to mix grain food with it. The author some 20 years since invented a simple

MIXING CYLINDER,

which will completely mix together all the foods passed through it, without any manual labor.

When the cutting is done in the story above the stable, a circular opening is made over the feeding floor below, in a convenient position to drop food into a feeding car or a steam-box. In this circular opening is placed a straight cylinder 28 inches in diameter and three feet long, without heads, but a bar across the lower end, on which an upright revolving shaft is set in the center, provided with six round arms 26 inches long to turn inside. This shaft will pass through a like cross-bar on the upper end, extending above enough to receive a pulley of the proper size to revolve it about 300 times per minute.

Now above this *Mixer* will be placed a cask for water, with a water pipe leading into the mixer, having a stopcock to regulate quantity. This water cask may be filled with a force pump by the engine or by hand. An elevated meal bin, having a spout with a slide to regulate quantity, may deliver the heavy meal into the mixer. But if the feed be bran or malt sprouts, it will require putting in by hand or by small cups upon a revolving belt. But it is probably the better way to mix the corn meal, bran, oil meal, etc., together in the proper proportion, and put the mixture in the elevated meal bin, and all may be drawn through the spout together. A belt will be run from the pulley on top of the mixer back to a pulley on the straw cutter which is to revolve the shaft in the mixer. The carrier from the cutter will deliver the cut hay or other fodder into this mixer, and the water pipe will be made to discharge 3 gallons to every 5 bushels of cut fodder, and the meal will be let in in the proper proportion, and when the straw cutter gets under motion, all will be moving together, and as the feed and meal and water in falling through the mixer will come in contact with these swift moving arms on the shaft, all will be well mixed together, and fall into the feeding car or steam-box below.

Here the entire labor is done by machinery, except placing the fodder in the cutter, and one man may do all this labor of cutting for and feeding 100 head of steers or cows. After being wet and mixed as above, this may lie in mass in the feeding car and slightly ferment, when it will be well digested by the cattle; but as some may wish to go into thorough cooking before feeding, we will give descriptions of steam-boxes.

A wooden track should be laid in the center of the feeding floor on which to run the feeding cars. A box of matched pine plank will be placed on each car, 5 feet wide, 3 feet high, and 16 feet long, holding about 250 bushels of moistened and mixed feed.

If this is to be used as a steam-box, then inch pipe, perforated with $\frac{1}{8}$-inch holes every 12 inches, should be laid on the bottom of the car, in three lines—first, 12 inches from one side, next in the middle, and third 12 inches from the other side. Steam let in will be forced through the whole coil, and, escaping through the perforations, will be completely diffused through the whole mass. It would require two of these cars and boxes for a large stock, each holding a day's feed. Each of these boxes must have a close-fitting cover, hinged on the sides, and closing together in the center. The feed should be packed down solid before closing the cover, which will be held by three cross-bars, wedged down.

The upper edge of this car may have a strip of rubber for the cover to press upon to render it steam tight.

### Rotary Steam Box.

But if much cooking is to be done, then it will be better to have a rotary steam-box, in which steam may be held under some pressure, and cook the fodder more thoroughly. This is made in the form of a strong cask with two heads, made tapering so the heavy iron hoops may be driven to keep it steam tight; then bolt a 6×8 inch timber across each head, and in the center of each head put a 3-inch trunnion or gudgeon—introduce the steam-pipe through the trunnion. Hang this in a frame so as to revolve clear of the floor.

The man-hole, $2\frac{1}{2}\times3$ feet, will be at the bilge, surrounded by a strong frame, bolted to the staves—with strong hooks at each corner through which to run two bars over the cover; wedges to be driven between the bars and the cover to hold it firmly closed. This steam-box may be made of 2 inch pine staves and heads. If this box be 8 feet in diameter and 8 feet long, it will hold when compressed about 400 bushels.

The advantages of this form of box are, that when filled and rammed in, the steam may be turned on and the upper half well steamed, when the man-hole can be turned down, and the steam will then rise through the lower half turned up, and thoroughly steam this part, the steam being forced down through the man-hole at the bottom; besides, if the water used to wet it has settled to the bottom, it will then settle evenly through the whole mass; and this box, holding the steam under some pressure, will soften the fibrous fodder much better.

It will be seen that this rotary box will be stationary, and must be directly under the mixer, so, when the man-hole is turned up, it is ready for filling. This would also hold enough for a day's feed for a large stock, and for a moderate-sized stock it would last two or three days.

The cooked food would remain over night in the steam-box only one feeding car would be required, and this would be run alongside, the man-hole turned toward the car, opened, and the cooked food hauled into it. This would be the most convenient arrangement for doing the work. This rotary box would also be valuable for use if the fodder was only moisted, mixed with the ground feed and left in this to soften before feeding; as after remaining a short time in position as filled, the man-hole could be turned down to insure even moisture. For very large feeding operations it would, probably, be better to make this rotary steam box of iron, which would stand more pressure, cook the fodder more perfectly, and in less time. The first cost would be greater, but the durability and more effective work of the iron steam-box might make it more economical in the end, yet the wooden rotary steam-box could be made so strong as to do good work.

The power for this large apparatus should properly be five to eight horse, and an engine is the most reliable. This would enable the stock-feeder, not only to cut the fodder, but to grind the grain for his stock. He could grind the grain whilst he was delivering at and returning it from the public mill, and he would then have it all, which often proves much more profitable in feeding operations. These engines are now well made at very low prices. Five horse-powers are sold as low as $210, and larger ones in proportion.

## The Cost of Good Beef.

The editor of the *Country Gentleman* referred to us a question propounded by Mr. Edward Atkinson, of Boston, "What does it cost to raise a steer three years old?" or, "What is the cost of good beef?" To which we replied, and the following contains the substance of said reply, with the addition of the animals shown at Chicago, November, 1885.

### What Does Good Beef Cost?

This is a very important question, standing at the threshold of a great specialty in agriculture—one that should have abundant facts to back a specific answer, as many millions of such steers are marketed every year; yet carefully ascertained facts are, by no means, abundant to prove, accurately, the cost of such a steer. The reports of our college experiment farms should contain the complete evidence required for an answer, but, alas! these reports give little upon this question, as upon most other practical questions in agriculture. That most devoted English experimenter, Sir J. B. Lawes, has thrown some light upon the cost of beef production in England, but his evidence bears mostly upon the cost of putting on weight during the fattening period. Very strange to say, that world-renowned Smithfield show has, until within a very few years, sought the heaviest beef animal, rather than the most economical beef animal. The question of age was never considered as bearing on the question of economy of production. No report was ever required of the cost of production.

But, happily, our American Fat Stock Show, in 1882, offered prizes under head of "Cost of Production," and the reports of this show will enable us to prove, pretty conclusively, the cost of a steer at three years old. It has always required the age of each animal to be given, and being weighed at its entrance in the show, it is easy to determine its gain per day from birth. They began in 1878, at the first show, to illustrate the importance of *early maturity*; and a proper understanding of the law of growth, in proportion to age, is now the first lesson in the economical growth of animals. It is a peculiar fact that farmers did not read this lesson, patent before their eyes all their lives, that the cost of putting weight upon an animal constantly increased as the age and weight of the animal increased. It may be stated, as a mathematical proposition, that (all other things being equal) every additional pound put upon a young animal costs more in food than the previous pound of growth. We are not now concerned in explaining the philosophy of this fact in animal growth, but we will endeavor to show that this fact is unquestionable. There have been numerous small experiments to prove it, but the most conclusive, because the most extensive, are shown in the reports of the American Fat Stock Shows at Chicago. We will give a mere summary of these for the various years, all teaching the same lesson, but farmers are so tenacious of the old ways, that a better one must be proved beyond possible dispute. These shows exhibiting fat stock, and offering prizes for early maturity, it may be inferred that the animals entered have all been well fed, and therefore may justly be compared together.

We shall give the number of animals of each class — average age in days, average weight, and gain per day, and we give every show, thus proving the result not to be exceptional:

| No. of Animals. | Age, days. | Av. weight. | Gain per day. |
|---|---|---|---|
| 1878— 4 steers | 669 | 1423 | 2.13 |
| 4 steers | 968 | 1637 | 1.74 |
| 10 steers | 1272 | 1801 | 1.41 |
| 1879— 5 steers | 569 | 1249 | 2.19 |
| 5 steers | 848 | 1481 | 1.76 |
| 6 steers | 1240 | 1869 | 1.45 |
| 1880— 6 steers | 671 | 1403 | 2.09 |
| 10 steers | 917 | 1678 | 1.83 |
| 8 steers | 1293 | 1756 | 1.35 |
| 1881— 3 steers | 631 | 1365 | 2.09 |
| 8 steers | 903 | 1423 | 1.58 |
| 8 steers | 1208 | 1702 | 1.40 |
| 1882—11 steers | 626 | 1483 | 2.38 |
| 15 steers | 1316 | 1956 | 1.55 |
| 1883—13 steers | 319 | 803 | 2.52 |
| 62 steers | 594 | 1239 | 2.11 |
| 20 steers | 957 | 1762 | 1.85 |
| 16 steers | 1302 | 2152 | 1.61 |
| 1884—10 steers | 281 | 757 | 2.70 |
| 28 steers | 614 | 1296 | 2.11 |
| 52 steers | 963 | 1720 | 1.79 |
| 29 steers | 1312 | 2016 | 1.54 |
| 1885— 7 steers | 287 | 780 | 2.71 |
| 33 steers | 565 | 1270 | 2.21 |
| 46 steers | 980 | 1688 | 1.72 |
| 41 steers | 1296 | 2040 | 1.57 |

## Summary of Eight Shows According to Age.

| | Age Days. | Average Weight. | Gain per day. |
|---|---|---|---|
| 30 head | 297 | 780 | 2.63 |
| 152 " | 612 | 1,334 | 2.18 |
| 145 " | 943 | 1,639 | 1.74 |
| 133 " | 1,283 | 1,938 | 1.51 |

## Gain in Periods.

| | | | |
|---|---|---|---|
| 1st period | 297 | 780 | 2.63 |
| 2d period | 315 | 554 | 1.76 |
| 3d period | 331 | 305 | .92 |
| 4th period | 340 | 299 | .87 |

This last table, showing the gain in periods, gives an instructive summary of the whole matter. All these large numbers of steers are supposed to have grown alike through each period; and this may properly be assumed, since we give only averages. The individual is lost in the aggregate; yet the individual modifies the averages, and as these averages include the animals of the shows of eight years, the figures should be considered reliable.

The first period of 297 days, each animal gains 780 lbs., or 2.63 lbs. per day. By deducting 780 (the gain of first period) from 1,334 lbs. (the whole gain of first and second periods) it will be seen that the gain of the second period, between 297 and 612 days, is over 44 per cent. less than the first period, and the gain of the third period is only half that of the second period, and the fourth period is still less. It is thus most conclusively proved that, by the natural law of animal growth, the daily gain decreases as the age of the animal increases, under good feeding as well as under poor feeding.

But the question arises whether the cost of the gain is less or more the first year than the second, the second than the third year—or whether early maturity costs less than late maturity. The commonest observation must teach every practical feeder that a steer, equally well fed, will eat more the second year than the first, and more the third year than the second. The reason is very easy to find; the food of support is in proportion to weight, and this weight increases with the age of the animal—so the cost of growth must increase with the age of the animal.

We propose to prove this also by the animals exhibited at these American Fat Stock Shows. Under the head of

COST OF PRODUCTION,

prizes were offered, and in the years 1882 and 1883, two different breeds and their grades were exhibited, accompanied by careful accounts of the cost of keep and care, and I here give the number of each breed or grade exhibited in both years, together with cost of keep and gain in three periods.

STEER OR SPAYED HEIFER, 1 TO 12 MONTHS.

| No. and breed of animals. | Cost of production at 12 months. | Av. weight at 12 mos. | Cost per lb —cts. |
|---|---|---|---|
| 4 Short-horn | $54.03 | 1,015 | 5.34 |
| 10 Gr. Short-horns | 33.42 | 1,013 | 3.29 |
| 1 Hereford | 23.75 | 700 | 3.39 |
| 5 Gr. Herefords | 26.27 | 663 | 4.15 |
| Average of all | $33.88 | 829 | 4.04 |

| No. and breed of animals. | Cost of production at 24 months. | Av. weight at 24 mos. | Cost per lb.—cts. |
|---|---|---|---|
| 2 Short-horns | $93.58 | 1,550 | 6.05 |
| 6 Gr. Short-horns | 83.81 | 1,654 | 5.08 |
| 1 Hereford | 52.35 | 1,100 | 4.76 |
| 1 Gr. Hereford | 61.61 | 1,370 | 4.42 |
| Average of all | $72.84 | 1,418 | 5.05 |

| No. and breed of animals. | Cost of production at 36 months. | Av. weight at 36 mos. | Cost per lb.—cts. |
|---|---|---|---|
| 1 Short-horn | 167.29 | 2,250 | 7 43 |
| 1 Gr. Short-horn | 186.82 | 2,250 | 7 60 |
| 1 Gr. Short-horn | 182.36 | 2,450 | 7.44 |
| Average of all | $178.82 | 2,316 | 7.49 |

I will now give from the secretary's report the cost of raising the heaviest steer to three years old—Mammoth, by John D. Gillette, Elkhart, Ill. Date of birth July 10, 1880. From birth to 12 months old—value at birth $5; 330 gallons of milk at 4 cents per gallon, $13.20; 2,520 lbs. of shelled corn at 71 cents per 100 lbs., $17.89; pasturage, $4,87; expense for care, $4; weight at 12 months 1,400 lbs., at a cost of $44.96, or 3.21 cents per pound. From 12 to 24 months—5,600 lbs. of shelled corn, $39.76; pasturage, $12; expense and care, etc., $6; weight at 24 months, 2,250 lbs., at a total cost of $102.72, or 4.56 cents per pound. From 24 to 36 months—8,400 lbs. of shelled corn, $59.64; pasturage, $15; expense for care, $9; weight at 36 months, 2,450 pounds, at a total cost of $186.36, or 7.60 cents per pound. From July 10, 1883, to Nov. 14—127 days—3,660 lbs. of shelled corn, $23.85; pasturage, $5.20; expense for care, $3.12; cost of 127 days keep, $32.17; weight at 1,222 days old, 2,445 lbs., at a total cost of $218.53, or 8.93 cents per pound.

It will be noted that this steer made a remarkable gain up to 24 months. The first 12 months he gained 1,400 lbs., or 3.81 lbs. per day—the 2d 12 months he gained 850 lbs., or 2.33 lbs. per day, and for the two years gained 2,250 lbs., or 3.08 lbs. per day; but the 3d year gained only 200 lbs., or 0.55 lb. per day. The gain the 1st year cost 3.21 cents per lb.; 2d year 6.79 cents per lb., or more than double the 1st year; 3d year 200 lbs. gain cost $83.64, or 41.82 cents per lb. At 24 months he would have paid $44.28 profit, but at the end of the 3d year he made a loss of $39.36.

King of the West (Short-Horn), fed by H. & I. Groff, of Elmira, Canada, also Canadian Champion, bred by the same firm, fed together, cost practically the same, and gained alike. At 12 months each of these weighed 1,000 lbs., and cost $34.67, or 3.47 cents per lb.; 2d 12 months gained 600, at a cost of $52.13, or 8.68 cents per lb., whole cost at 24 months $86.80, or 5.42 cents per lb.; 3d 12 months gained 650 lbs., at a cost of $81.50, or 12.54 cents per lb., total cost at 3 years, $168.30 per head, or 7.48 cents per lb. Each was worth more than he cost at the end of the second year, but less than he cost at the end of the third year. The gain the second year cost twice as much as the first year, and the third year cost 50 per cent. more than the second, and three times as much as the first. These three well-fed steers show that the best live weight can be produced at one year at 3½ cents per lb.; at two years at 5½ cents per lb.; at three years at 7½ cents per lb. But 20 steers show a cost of 4.04 cents per lb. at 12 months, and 5.05 cents per lb. at 24 months, and the average weight of these 20 steers was 1,418 lbs., a good market weight.

If, then, good beef can be produced at 24 months, we must consider this the limit of profitable production, since a year later these same cattle cost 50 per cent. more per pound. We do not need, therefore, to consider the cost of the third year to determine the *cost* of *good beef.* Let us go back to our tables, and we find 152 head, with an average age of 612 days, having an average weight of 1,334 pounds. This also meets the requirements of the market, as to weight, at a little less than 21 months old, and at this age beef can be produced at 4½ cents per pound. We do not now know how low good beef may be produced, since feeding, as a skilled art, is very little understood.

Mr. Gillette, the feeder of Mammoth, is one of the most intelligent and successful in all the West, and yet he reports this steer as eating 8,400 pounds of shelled corn in his third year, besides $15 worth of pasture. This is 23 pounds of corn every day in the year; yet he gained only 200 pounds, and he must have consumed the principal part of this large ration simply as the food of support. One-half of this ration, well digested, would have furnished abundant food of support. The shelled corn was very poorly digested, and therefore did not result in economical production. We believe the future will give us beef steers, of 1500 to 1600 pounds weight, at 4 to 5 cents per pound, and at 20 months old, and probably at the lower figure, this will be cheap and excellent beef. The practical question of the most economical beef production is, as yet, in its infancy. There has been very little inquiry into the best combination of food elements in the growth of animals, and much careful experimenting is to be done in its settlement, which will be likely to introduce great improvements into our present system. Shortening the time of maturing will be one of the greatest, and our American Fat Stock Show has been the greatest teacher thus far, and we have tried to present a complete illustration of the lesson so far taught. We hope it may be studied and heeded.

## A Few Definitions.

In the body of this work the terms albuminoids and carbohydrates are frequently used in explaining the quality of foods—on page 30 and following, we show the complete composition of fodder vegetables. But for those who have never studied chemistry we will explain the use of these different parts of foods.

Albuminoids make or grow muscle in animals, and foods rich in albuminoids are also rich in phosphate of lime to grow the bones — so that such foods grow the muscles and frame of young animals — such as oil-meal, pea-meal, wheat, bran, oats, clover hay, etc.

Carbohydrates are composed of carbon and water — this part of foods produces animal heat and makes fat — starch, gum, sugar, woody fiber and all the vegetable oils are composed of carbohydrates. Nine-tenths of the value of straw, ripe corn-stalks, etc., is in their carbohydrates.

## Building Stables under Old Barns.

A stable in a wooden barn should always be in a basement under: first, because the liquids of the stable are constantly rotting the woodwork of the barn, and by placing the stable under the barn this loss is avoided; second, because, by building a concrete wall under a barn, the stable is cheaply and permanently made warm. The old barn may be raised with screws on blockings as high as is required to make a roomy and pleasant stable, for low stables are disagreeable to man or beast. It should be 8 feet in height. This gives head room for both horses and cattle. It is not well to go down much into the ground, because a stable should be dry and airy, as well as warm. The floor of the stable should not be more than 18 to 24 inches below the surface of the ground, and never below complete drainage —for a damp or wet stable is unhealthy for animals. When the barn is raised to the proper height and level on its blockings (let pains be taken to have it level), then place shores of 3x4 scantling plumb under the center of the sill, near enough together to bear the weight of the barn, but be careful not to place a shore in the way of a window or door to be put in (and the places for these should be marked). When the shores are all placed, with a flat stone or piece of plank under each one to keep it from settling before the wall is built, then set two long poles or shores on each side of the barn, slanting from the ground high up on the side, fastening each to the barn and the ground, so they cannot move. These long shores will hold the barn in a perpendicular position while the wall is being built. Four short shores should be set also slanting against the sills to keep those in position. The blockings on which the barn has been raised will now be taken out, and everything is ready for placing the

## Boxing for Concrete Wall.

If the barn be the common size, 30x40 feet, then 10 inches is thick enough for the wall. A row of standards (3x4 scantling) are set perpendicularly, 1½ inches outside of the sill, about 8 feet apart, fastened at the top to a block on the sill. The inside standards then will be set 13 inches from the outside ones. The boxing plank will be 1½ inch thick, 12 or 14 inches wide, and long enough to take 3 standards. It will be seen that when these planks are placed inside the standards, they will form a box 10 inches wide, giving a wall 10 inches thick—that is, the standards are placed three inches further apart than the wall is to be thick, to give room for the boxing planks. This leaves the shores, placed under the center of the sill to hold the barn up, in the center of the boxing, so that these shores will be built around, and left in the center of the wall. They are not in the way in putting in the concrete, as this forms around them. But to build an ordinary stone wall, these shores would be greatly in the way. They do not decrease the strength of the wall, even when they rot. The window frames and door frames are made with jambs as wide as the wall is thick, and the window frames are set into the boxes so as to come up under the sill, and the concrete filled against them.

If the barn should be much larger, say 40x60 feet, then the concrete wall should be 14 inches thick at bottom and 10 inches at the top, and the standards placed accordingly. If the reader will turn back to page 110, he will find directions for mixing and laying the concrete. If the materials are all convenient, the 30x40 foot barn can be raised, and wall put under for $75. A 40x60 can be raised and walled for $160. If the farmer does his own labor, the cost will be only for lime and lumber. In many cases the saving of food by a warm stable would pay the whole expense in one winter. Care should be taken to give plenty of light. A stable should be as light as the living room of a house.

It should also be remembered that in raising an old barn and putting under a basement stable, this stable will be new, and may be as warm and convenient as a stable of the same size under a new barn. There really can be no excuse for not putting such an improved stable under an old barn, as the cost is so small, and the old barn may then be used wholly for fodder.

### Improvement of Dairy Cows for Butter.

The matter under this head is made up by condensing and amending several articles written by the author for the National Live Stock Journal.

The Jersey breeders seem to be the most enterprising in developing their breed for the specialty for which it is recommended. Since they saw that large butter yields were of vastly more account to give celebrity and value to their cows than the possession of all the fancy points, they have discussed fancy less, but kept a sharp eye on performance. This was a wise departure. Cattle breeders have been quite too intent upon trivial points, which tickle the fancy, but have very little to do with real value.

And now, when the Jersey breeders begin the real improvement, it is not surprisng that they should make many mistakes in what they thought every farmer knew all about—feeding. They do know corn, oats, barley, peas, oil-meal, etc., from each other; but what do they know of the peculiar and distinguishing characteristics of each ? They have had no time to study the mere matter of foods which they had handled all their lives. But now that these Jersey breeders are getting their eyes open to the importance of knowing the practical quality of foods, it is necessary that they should know not only the quality of foods, but the constitutions of their cows, and how far and how fast their rations may be safely increased. This latter point is the one on which they have made their principal mistakes, and we have the broadest charity for them when we consider that the German professors tried to change the chemical composition of milk by feeding cows for fourteen days, and, because they did not succeed, reported that the composition of milk could not be modified by special feeding; or, in other words, that food had no influence on the composition of milk. They afterward experimented for thirty days, and reported that they had succeeded in increasing the proportion of fat to a small extent. Even these professors, with all their erudition, did not comprehend that an animal with fixed characteristics must require a long time to change, essentially, these characteristics. Some Jersey breeders have lately asserted that some cows are quite unsusceptible to any material improvement in their butter production. They have come to this conclusion from unsuccessful attempts to increase the yield of butter by feeding extra rations for a short time.

If these breeders would stop to reason a moment on this point, they would ask themselves, what special value the Jersey breed would have if its capacity for butter production could be materially changed in a few days? If that were the case, a new breed could be made in two weeks, and breeds would have no substantial value. No; these changes and improvements must be of slow growth on a breed that has been more than two hundred years in fixing its characteristics. The legend of the man who lifted the calf every day till it became an ox, and was able to increase his strength as fast as the calf grew, may be said to illustrate the procedure in developing the butter cow. She should not be crowded rapidly in her rations. The object should be to slowly develop her digestive capacity without clogging her organs, and thus, by richer alimentation, to produce a gradual increase in the secretion of rich milk, and therefore in butter. Some cows are much more susceptible to better feeding than others. Their digestive capacity is greater than the ration they have had, and they easily carry a considerable addition, which soon tells upon their production. It is a decided error to suppose that all cows which have had only common rations are not susceptible to improvement from better feeding, yet those with very limited digestive capacity must be managed accordingly. The increase in food should begin very small, with a little advance every week, often changing the kind of food to improve the appetite. This is all preparatory, but it will, in nineteen cases out of twenty, be found that the increase in food will increase the production in due proportion. We have taken the most ordinary scrub cows and added seventy-five per cent. to their production of milk in two years —the first six months showing only a slight increase in production, the largest part being applied to improving condition—and at the same time reducing the pounds of milk required for a pound of butter thirty-five per cent. To make it most convincing, we selected cows below the average to experiment upon. We therefore concluded, when any one asserted that common cows could not be improved in milk and butter production, that he had expected to accomplish his desired improvement in a few weeks. But we do not advise attempting to improve the lowest grade of cows by feeding—pass them to the butcher.

It is misunderstanding the point here explained that has caused the contradictory opinions in relation to the profit of feeding extra food to milch cows upon pasture. One who has a low-standard herd could not be expected to see profit during the first few months, and he would declare that the extra food was thrown away, while another herd of more developed cows would respond at once, and decidedly to the extra feeding, and its owner be enthusiastic on the question of profit in extra feeding. Shall we, therefore, conclude that the low-standard herd would pay better if kept on a low-standard ration? Certainly not. They should either be sold to those who know no better than to buy such cows, or they should be started on the system of slow development, after disposing of those 8 years old. The first few months time, which do not show much in milk production, is still far from being lost—the condition beginning at once to improve. The second year this herd will be improved from 25 to 35 per cent., and ever after will pay better, and much more than recompense the cost of development. This is encouraging to the advanced dairyman, for it shows him that he may profitably develop his average and better cows to a high standard, and long enjoy the fruit of his labor, for it is to be remembered that a fixed characteristic, such as a large milk secretion, is hereditary, to a large extent, even in our cows of mixed blood, so that after developing a herd of cows, it is thence comparatively easy to keep up a high-standard herd. Now, let us take the two greatest butter-producing cows in this country, and probably in the world, to illustrate the subject under discussion.

## Effect of Feeding upon Quality of Milk.

Princess 2d, in her test in the winter of 1884, gave 315 lbs. of milk and made 27 lbs. 10 oz. of butter in 7 days. This required 11.4 lbs. of milk to 1 lb. of butter. In her test one year afterward (1885), she gave 299½ lbs. of milk, and made 46 lbs. 12½ oz. of butter. This was a pound of butter to 6.4 lbs. of milk. Here was a gain of 44 per cent. in richness of milk in one year by constant feeding. And another remarkable fact is, that she made 46 lbs. 12½ oz. of butter from 50 per cent. less grain food than she ate the year before to make 27 lbs. 10 oz. of butter. This clearly proved that she had been overfed at the first test. They pushed her on feed injudiciously. She was fed more than she could assimilate, and it simply clogged her system and enriched the manure pile. This is a most important explanation of what appeared to be a contradiction of the principles of feeding—viz: that the cost in food of a large yield costs more proportionately than a small yield—her food was not all used for production of milk and butter, but was simply wasted.

Mary Anne of St. Lambert, in a test September, 1883, gave 251 lbs. of milk, and made 27 lbs. 9¼ oz. of butter. This was 1 lb. of butter from 9.10 lbs. of milk. In her last test, September, 1884, she gave 245 lbs. milk, and made 36 lbs. 12¼ oz. of butter, being 1 lb. of butter to 6.66 lbs. of milk. Here is a gain in richness of 27 per cent. in one year. But in reverse of Princess 2d, she consumed about 50 per cent. more grain food than the year before. It may be possible that she needed this increase of food, but she ate as much food as Princess 2d, at her second test, who made ten pounds more butter. If full credit is given these tests, this remarkable change in the richness of the milk, as a result of special feeding, would not seem to leave any possible standing for the German experiments. Those experiments were based upon too short a period of time.

## Is the Greatest Yield the Cheapest?

As we have often insisted, an increase in butter production must result in production at less cost. But if we could suppose that a strain of blood might be developed of cows that would give milk for the production of 40 lbs. of butter per week, and that the butter costs more per pound than that produced from cows yielding 8 lbs. per week, would such 40-lb. cows be desirable? Will dairymen invest in cows that reduce their profits instead of increasing them? There seems to have been no serious attention paid to the cost of food in these butter tests, and no attention paid to the comparative cost of the butter, but beating all other competitors is the one thing considered. In some of the most remarkable tests, the food is apparently accurately reported; but if really accurate, the cost of food alone is more than the market value of the butter produced. The Short-horn is the model beef breed, but if it cost more per pound to grow a Short-horn steer to 1,500 lbs. weight than to grow a scrub to the same weight and condition, would anybody want the Short-horn? The argument and the fact is, that it takes from 25 to 50 per cent. less food to grow the Short-horn than the scrub. But does it take less food, per pound of butter, to produce 27 to 46 lbs. per week from these remarkable cows than to produce 8 to 16 lbs. from the latter class of cows? This is a legitimate question, and must be answered, and upon the true answer will the popular estimate of developing cows rest. The great effort now is to get ahead on the production of butter, and there seems very little consideration given to rational feeding or the question of cost. Let us see what light, if any, the reports throw on the question of cost. But first let us say that we do not believe that the largest production will cost more or as much as the smaller, when the feeding is conducted upon sound principles.

To illustrate this question of food and production, we will take the two cows that have been alternately at the head. First, Mary Anne of St. Lambert, 9770, distanced all competitors, Sept. 23 to 29, 1883, by making in seven days, from 251 lbs. of milk, 27 lbs. 9¼ oz. of butter. Her ration was: 14 lbs. oatmeal, 14 lbs. pea meal, 7 lbs. oil meal and pasture. This would cost in Canada about 50 cents per day or about 13 cents per pound—a reasonable cost.

Next comes Princess 2d, 8046, in the latter part of the winter of 1884, winning by a nose in producing from 315 lbs. of milk 27 lbs. 10 oz. butter in seven days; but her ration was the most extraordinary ever yet reported, as follows: 35 lbs. clover hay, 48 lbs. mixed bran, 12 lbs. oat meal, 6 lbs. corn meal, 6 lbs. linseed meal, 35 lbs. carrots and beets. This would cost near Baltimore $1.50 per day, or 37½ cents per pound, or more than its value in market.

Then comes to the rescue of the record again Mary Anne of St. Lambert, Sept. 23 to 30, 1884, producing 245 lbs. of milk, from which was made 36 lbs. 12¼ oz. of butter. This was such a leap ahead that most people thought she would never be surpassed. Her ration was: 25 lbs. oat meal, 17 lbs. pea meal, 6 lbs. oil meal, 2 lbs. bran, in all 50 lbs. and pasture. This could not cost in Canada less than 65 cents per day, or 13 cents per pound.

But, alas, for all human triumphs! The owner of Princess 2d saw the situation, and from February 22d to March 1st, 1885, she came to the front with a bound and passed Mary Anne by 10 full pounds. From 299½ lbs. of milk she made 46 lbs. 12½ oz. of butter. Her ration was: 22 qts. oat meal, 22 lbs.; 15 qts. pea meal, 23 lbs.; 2 qts. linseed meal, 4 lbs.; 1 qt. meal, 1 lb:—50 lbs. in all—besides hay, carrots and beets. This would cost in that locality $1 per day, or 15 cents per pound, or less than half the cost per pound of the first test.

Let us examine some of the peculiarities of those two records. In the first place, it will be seen that Mary Anne, in her first test made the same amount of butter (only ¾ oz. less) as Princess 2d, on one-half of her food. Then, more remarkable still, Princess 2d's last marvelous increase of over 19 lbs. of butter in one week, above her first test, was made on two-thirds the food of the first test. That is, she made 46 lbs. 12½ oz. of butter on one-third less food than she required to make 27 lbs. 10 oz. of butter. What do these contradictions prove? except that the feeding was done very injudiciously—the same amount of food producing twice the product from the same cow at one time as at another. This shows the importance of studying this feeding problem, and the great importance of accurately reporting the exact ration fed at every test. The largest rations were greater than any cow, at first, can possibly utilize, and the excess only lessens production.

Now, let us compare these great yields with the more moderate ones.

The Jersey cow, Lesbie 9179, was lately tested for 7 days; from 187½ lbs. of milk she made 16 lbs. 3 oz. of butter: Her ration was 6 lbs. corn meal, 3 lbs. oil-meal, and 3 lbs. bran, or 12 lbs. grain, with a few roots and clover hay. This was only one-fourth the grain ration of Princess 2d or Mary Anne of St. Lambert. If Princess 2d's food for one week were fed to this Lesbie, she would have made from it, at least 50 lbs. of butter; thus, with the same food she would beat either Princess 2d or Mary Anne, and the largest yield of butter for a given amount of food or cost is the object sought.

2d. Miss Willie Jones 6918—May 21, 1883—7 days, 316 lbs. of milk, 16 lbs. 4 oz. butter; ration, 6 lbs. corn meal, 3 lbs. bran and pasture.

3d. Alfleda 6744—August 19 to 26, 1883—milk 250 lbs., butter 16 lbs. 4 oz.; ration, 4½ lbs. corn meal, 5 lbs. bran, pasture, short aftermath of clover and timothy.

4th. Maggie of St. Lambert 9776—April 1 to 6, 1883—milk 278 lbs; butter 16 lbs. 3 oz.; ration, 8 lbs. meal, 4 lbs. of bran, 1 peck of carrots and hay.

5th. Gold Trinket 9518—July 13 to 19, 1882—milk 240 lbs., butter 16 lbs. 2 oz.; ration, 3 lbs. corn meal, 3 lbs. bran, 1½ lbs. oil-meal, pasture.

6th. Fear Not 2d 661—June 3 to 9, 1882—milk 216 lbs., butter 16 lbs. 2 oz.; ration, 4 lbs. corn meal, 6 lbs. middlings, pasture.

7th. Moth of St. Lambert 9775—June 13 to 19, 1883—milk 235 lbs., butter 16 lbs. 2 oz.; ration, 4 lbs. barley meal, old pasture.

8th. Com 10504—June 4 to 10, 1883—butter 16 lbs. 2 oz.; ration, good blue grass and white clover pasture only.

9th. Olies' Lady Teazle 12307—July 1 to 7, 1883—milk 275 lbs., butter 16 lbs. 5 oz.; ration, blue grass pasture alone.

10th. Belle of Patterson 5664—June 5 to 11, 1882, 5 months after calving—milk 241 lbs., butter 16 lbs. 6 oz.; ration, pasture only.

We have here given ten examples of Jersey cows that produce a pound of butter at less than one-half the quantity of food of either Princess 2d or Mary Anne of St. Lambert, taking the reports of rations as given. This, however, was not the fault of these wonderful cows, but of crowding down more food than they could possibly use in production.

We will here add an analysis of the rations of Princess 2d, Mary Anne of St. Lambert, and Lesbie.

### Analyzed Rations.

It is certainly important that the ration required to produce these large yields should be so given, that people may be able to judge correctly of the economy of such feeding. On philosophical principles, the larger the yield the cheaper the cost of production, because the food of support is the same whether production is large or small, or no production; so that all that a cow can eat, digest, and assimilate beyond that goes to production. The weight of Princess 2d has since been given at 1,050 lbs. This ration is so remarkable for quantity of food, that we give the items separately, and analyze each, giving the dry matter and the digestible elements of each, so that it can be clearly understood how much nutriment it took to produce 4 lbs. of butter per day.

DAILY RATION OF PRINCESS 2D (8046) DURING HER FIRST SEVEN DAYS

BUTTER TEST, 1884.

| KIND OF FOOD. | Dry Organic Matter. | Digestible nutrients. | | |
|---|---|---|---|---|
| | | Albuminoids. | Carbohydrates. | Fat. |
| | LBS. | LBS. | LBS. | LBS. |
| 35 lbs. clover hay | 29.40 | 2.27 | 13.37 | 0.59 |
| 48 lbs. mixed bran | 42.31 | 4.27 | 24.79 | 1.36 |
| 12 lbs. oat meal | 10.29 | 1.08 | 5.19 | 0.56 |
| 6 lbs. corn meal | 5.14 | 0.50 | 3.62 | 0.29 |
| 6 lbs. linseed meal | 5.46 | 1.65 | 1.64 | 0.62 |
| 35 lbs. carrots | 5.25 | 0.49 | 4.37 | 0.07 |
| | 97.88 | 10.26 | 52.98 | 3.49 |
| German standard ration for 1000-lb. cows in milk | 24.00 | 2.50 | 12.50 | 0.40 |

HER SECOND TEST, 1885.

| | | | | |
|---|---|---|---|---|
| 20 lbs. clover hay | 16.70 | 1.70 | 7.64 | .34 |
| 30 lbs. carrots | 4.53 | .42 | 3.72 | .06 |
| 22 lbs. oat meal | 18.86 | 1.98 | 9.52 | 1.03 |
| 23 lbs. pea meal | 19.71 | 4 64 | 12.53 | .39 |
| 4 lbs. oil meal | 3.63 | 1.10 | 1.08 | .41 |
| 1 lb. bran | .88 | .10 | .48 | .03 |
| | 64.31 | 9.94 | 34.97 | 2.26 |

DAILY RATION OF MARY ANNE OF ST. LAMBERT AT HER FIRST TEST SEPTEMBER, 1883.

| | | | | |
|---|---|---|---|---|
| 14 lbs. oat meal | 12.00 | 1.26 | 6.36 | 0.65 |
| 14 lbs. pea meal | 12.00 | 2.82 | 7.61 | .24 |
| 7 lbs. oil meal | 6.42 | 1.93 | 1.39 | .72 |
| And pasture. | | | | |
| | 30.42 | 6.01 | 15.36 | 1.61 |

RATION AT SECOND TEST OF MARY ANNE, SEPT. 1884.

| | | | | |
|---|---|---|---|---|
| 25 lbs. oat meal | 21.43 | 2.25 | 10.76 | 1.17 |
| 17 lbs. pea meal | 14.57 | 3.43 | 9.24 | .28 |
| 6 lbs. oil meal | 5.45 | 1.65 | 1.62 | .62 |
| 2 lbs. bran | 1.77 | 0.20 | 0.97 | .06 |
| And pasture. | | | | |
| | 43.22 | 7.53 | 22.59 | 2.13 |

RATION OF THE JERSEY COW, LESBIE (9179).

| | | | | |
|---|---|---|---|---|
| 18 lbs. clover hay | 15.03 | 1.53 | 6.87 | .30 |
| 6 lbs. corn meal | 5.14 | .50 | 3.62 | .29 |
| 3 lbs. oil meal | 2.73 | 1.65 | 1.64 | .62 |
| 3 lbs. bran | 2.65 | .30 | 1.45 | .09 |
| 16 lbs. carrots | 2.40 | .22 | 2.00 | .03 |
| | 27.95 | 4.20 | 15.58 | 1.33 |

This table will show how extraordinary a ration this cow, Princess 2d, is said to have eaten every day for a week at her first test. We give the German standard ration, for a cow of her weight, under it. It will be seen that the dry organic matter is four times the standard; the albuminoids, or nitrogenous matter, over four times; the carbohydrates (starch, gum, sugar, etc.), more than four times as much, and the fat over eight times as much as the standard ration.

Let us test this in another manner. This cow gave an average of 45 lbs. of milk per day. It would require of albuminoids to form the caseine in this milk, 1.80 lbs., but her ration contained 10.26 lbs., or nearly six times as much as required. She made 4 lbs. of butter. All butter has more or less water—fresh butter at least 15 per cent. If we deduct this water, it leaves 3.40 lbs. of pure butter. If we examine the ration, we find 3.49 lbs. of pure fat—this alone was quite enough to form her large yield of butter—and then we have 52.98 lbs. of digestible carbohydrates, and the extra starch, sugar, etc. of this was abundant, besides keeping up animal heat, &c., to have formed 6 lbs. more of butter. So that if this cow could really eat, digest, and assimilate this amount of food, she should have yielded more than twice as much butter as she did.

Again, let us suppose that this cow requires this amount of food to produce 4 lbs. of butter, what then is her value? But let us examine the ration of Princess 2d, at her second test. The food of this ration was 35 per cent. less than that of her first test, and she produced 69 per cent. more butter from this 35 per cent. less food—or stated concisely —her second ration was 153 per cent. more productive than her first ration, showing in the latter an utter disregard of all principles of cause and effect in feeding.

If we examine the first ration of Mary Anne of St. Lambert, we find that its food elements were not more than 40 per cent. of Princess 2d's first ration, although the product was practically the same. But her second ration showed a considerable increase, yet not disproportioned to her increased production. Her increased production was about 33 per cent., which was very nearly the increase of food. Mary Anne's rations and Princess 2d's last ration bear about the same relation of food to production.

But it is not certain that these latter rations were as productive as they might have been. This is seen in the ration of Lesbie (9179). This cow's ration of hay is estimated, as the amount of it and the carrots are not given. If we take her grain ration, it becomes quite evident that she produced more product in proportion to food than either Princess 2d or Mary Anne.

The point that every feeder should carefully study is to have the ration proportioned to his expected product. Food should not be given at random, as many of the testers of butter cows have done, but a calculation should be made as to the product which such a ration should bring, and the cow should become accustomed to the increased alimentation by careful testing of her powers of digestion and assimilation.

# ANALYTICAL INDEX.

## INDEX OF APPENDIX TO THIRD EDITION, WITH OTHER REFERENCES.

## INDEX TO FOURTH EDITION.

# SELF-CLEANING STABLES.

All dairymen have felt the necessity of some device that should lessen the daily labor of cleaning the stable, and especially that should succeed in keeping the cow clean, a very necessary requisite to pure and wholesome milk. There have been various plans of using a gutter behind cows or cattle; in all of them the cow was liable to get soiled.

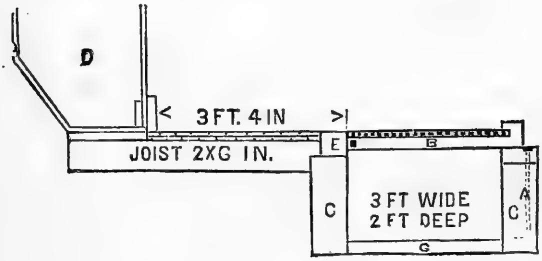



*Fig. 2.*

EXPLANATION. — *A*, iron anchor, to hold plank on wall; *B*, graded floor; *C*, concrete; *D*, manger; *E*, sill.

## THE PLATFORM

We are about to describe, invented by Prof. E. W. Stewart, has been in use in his octagonal barn basement for 10 years, accommodating 40 cows, keeping them clean. This platform made is represented by Fig. 1, page 517. The wooden part of the platform, marked B, is situated next the manger, 3 feet 4 inches wide, with stanchions, with loose tie 3 feet 10 inches. Behind this is the iron grating, (3 feet 2 inches wide by 3 feet 3 inches deep), resting on the back wall of manure gutter, and secured to the sill of the wooden platform in front, by eye-bolts so as to turn up, to clean the gutter when full. The gutter or receptacle for manure is under this iron grating, and is made of such depth as is desired, usually about 2 feet. This depth is convenient for shoveling out the manure. This reservoir, which will hold all liquid manure, may be made of concrete or brick, well plastered with two coats of Portland cement on the inside, or (which is just as good, and will last for years) 2-inch Norway pine. The gutter, 3 feet wide, will hold one yard under each animal. The iron joists are placed 18½ inches apart; across these, at right angles, are laid wrought iron bars one and a half inches wide, securely fastened.

It will be seen that the animal stands with the fore feet upon the plank, and the hind feet upon the flat iron bars. The droppings fall directly through the openings into the gutter below, when the manure is thin; and in winter, when dry food is given, the droppings are trodden through by the hind feet. The cow stands across the bars, and has always two bars to stand upon. Cows that have stood on this grating for 8 years have been very healthy, no trouble with the feet.

This grating is made of refined wrought iron (weighs 100 lbs. per cow), and its durability must be very great. It is built in sections for *two* or *three* cows, according to convenience, allowing 3 feet 2 inches in width and 3 feet 3 inches in depth to each cow; strong enough to hold cattle of any weight, all ready to be screwed by the eye-bolts to the wooden platform; will be shipped at $6 per cow. This low price is now made for the purpose of introducing it among dairymen. We make grates of any special width that is desired, charging in proportion over 3 feet 2 inches.

## MANURE.

Some, when first examining it, suppose that this quantity of manure must necessarily give off a worse odor than an ordinary stable, but this is an error, as the manure in the receptacle is undisturbed, and fermentation very slow. It takes less land plaster, or dry muck, to keep this manuré from smelling than to keep a stable sweet that is cleaned every day.

## POINTS FOR THE SELF-CLEANING PLATFORM.

*First.* It keeps the cows clean—a very difficult thing to do with any other stable, even with a moderate amount of bedding—whilst this requires no bedding.

*Second.* It saves all the ordinary labor of cleaning stable, which cannot be estimated at less than $2 per cow per year, and this would pay the whole cost in three years.

*Third.* It completely saves all the liquid manure, or more than double the value of the manure, and the value of this liquid manure is worth the whole cost of the grating in a single year.

*Fourth.* The saving in bedding, in villages and cities, will fully pay for the grating every year.

*Fifth.* It prevents wholly the rotting of the wood-work of a stable, as the liquid falls through the grating and does not come in contact with the floor, joists or sills. It often costs more to re-sill a barn, where the liquids of the stable have rotted it, than this grating costs.

*Sixth.* This self-cleaning platform may be used in any stable which does not freeze, and all stables may be repaired so as not to freeze, besides no dairyman can afford to keep cows in a cold stable.

*Seventh.* This self-cleaning stable is most admirably adapted to the Ensilage system of feeding, which gives succulent food the year through. Winter dairying will be promoted by this system, because the same succulent food may be given in winter as summer, and this grating will keep the cows clean, however thin the manure.

*Eighth.* The undersigned, sole agents and manufacturers of this self-cleaning stable, have adapted it to pig-pens, and with this pigs are kept absolutely clean.

Shall be glad to hear from you. Will give you further special instructions about putting it in your stable when you give us a description of your barn and stable.

Address,

STEWART BROTHERS,
Lake View, Erie Co., N. Y.

# REFERENCES.

The following parties referred to, might give many more:

E. T. HAYDEN, of Syracuse, N. Y., writes with reference to the form, represented in figure 2:

"DEAR SIR:—In regard to the 'self-cleaning floor' purchased of you, I can say that I am more than pleased with it. I think I save enough in bedding and labor of cleaning, besides the manure saved, in one year to pay for it. I absorb all the urine with muck, and this prevents all odor and turns the muck into excellent manure. I do not think that a quarter of a pound of manure adheres to my eight cows and heifers in a month. I would not try *to do without* this grating again."

EDWIN ALLEN, of New Brunswick, N. J., writes;

"Have had my sixteen cows on your grating many months, and find it only necessary to clean gutter once a month. It is a splendid arrangement to save *all the manure*, which I cart directly to the field before the valuable salts are washed out by rains. The cows do not object to standing or lying on it. They stand and get up much easier from this floor being level, instead of slanting, as in the old way. I use plaster and sweepings from a button factory as an absorbent and deodorizer for manure. Shall order grating for another row of cows next season." [He has since ordered for sixteen more cows.]

MR. CHARLES W. FOSTER, Fostoria, Ohio, writes:

"I find your self-cleaning grating gives me clean cows, a clean stable, and in fact is all I expected, and more too."

HON. LEWIS F. ALLEN, of Buffalo, N. Y., speaking of these self-cleaning grates in the *Country Gentleman*, says:

"I have recently put these grates into my own stables for fifty-two cows, greatly to my satisfaction, and I regard them as a decided improvement over any other plan I have ever seen. The cows stand with their hind feet upon these grates, without any bedding, yet keeping as clean as in a summer pasture. They lie down comfortably and warm, and chew their cuds as contentedly as if on beds of straw."

MR. JOHN C. SHERLEY, Anchorage, Ky., writes:

"In reply to yours of Sept. 29th, 1884, would say that I have been intending for some time, before receiving your letter, to write and express my perfect satisfaction with the grates. I would not be without them for any reasonable amount. I do not think they can be improved. There is but one objection (and that theoretical) that I have ever heard offered against them, that is, that they would be cold for cattle to stand and lie on in cold weather, but I have never been able to discover any bad effects from them, although last winter was very severe, and my stable rather open. I will take great pleasure in recommending the grates to any one that you may refer to me, as I feel that I should be doing them a favor, and paying a debt of gratitude I owe you for the invention."

DR. J. M. MEYER, Danville, Ky., says:

"I am abundantly satisfied with the use of your grates. I have published a little article of their merits, and Kentucky will use them in the future." [Dr. Meyer ordered grates in 1882, and has ordered twice since.]

Mr. J. W. BARNES, Memphis, Mo., writes:

"The self-cleaning grates, bought of you last May, have been in use continuously since September, 1883, and have worked very satisfactorily."

MR. J. H. BOSARD, Grand Forks, Dak., writes:

"The self-cleaning grate I purchased of you in May, 1882, for three cows, has been in use continuously since, to my great satisfaction."

MR. C. P. COGGESHALL, Chicago, Ill., writes:

"It would do you good to see how like a charm my new improvements work with your self-cleaning grates. I have not cleaned the offal from the barn for three weeks, and will not need to for one to come. It saves me their full cost in labor twice yearly."

MR. S. R. HARPER, Meadville, Pa., says:

"I have the grates I bought of you in, and cows on them, and they prove satisfactory in all respects."