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THE SCIENCE AND PRACTICE OF STOCK FEEDING.

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THE SCIENCE AND PRACTICE OF STOCK FEEDING.

For the next two hundred days the subject of stock feeding must necessarily occupy much of the time and attention of the successful New Hampshire farmer, and as the importance of this subject is often overlooked I will will briefly state the latest available statistics on live stock.*

There are within our State, to-day, not far from 60,000 horses, 20,000 oxen, 95,000 cows, 50,000 other cattle, and 150,000 sheep, and the success of the year's agricultural work depends largely upon the profitable feeding of these, for it is just as important to dispose of the fodder economically as to produce it cheaply.

We will assume that the average horse weighs 1,000 pounds, the ox 1,400, the cow 900, other cattle 400, and the sheep 100. This gives us the following aggregate, live weight:

60,000 horses,	@ 1,000 lbs.,	60,000,000
20,000 oxen,	@ 1,400 lbs.,	28,000,000
95,000 cows,	@ 900 lbs.,	85,500,000
50,000 other cattle,	@ 400 lbs.,	20,000,000
150,000 sheep,	@ 100 lbs.,	15,000,000

Total weight of all neat stock, horses and sheep, 208,500,000

It has been found, by numerous experiments, that on an average, it will require twenty pounds of hay, five pounds of corn meal, and two pounds of cotton seed, or an equivalent of these, daily for one thousand pounds of live weight,—this is necessarily an average for horses, oxen, sheep, cows, and growing cattle,—with this standard we find that the daily amount of hay and grain required for the entire winter are as given below:

		Daily.	For winter of 200 days.
Hay	required,	2,085 tons,	417,000 tons.
Corn meal,	"	521¼ tons,	104,250 tons.
Cotton seed,	"	208½ tons,	41,700 tons.

*Report of State Board of Equalization, 1887.

Referring to the Census of 1879, (and it is probable that our agricultural products have not varied greatly since then,) we find that we produced 588,170 tons of hay, and about 80,000 tons of corn fodder, oat, wheat and barley straw, and if we call these two-thirds as valuable as hay it will bring our available hay up to 641,500 tons.

We also produced 32,806 tons of corn, and 16,281 tons of oats, and as they are of practically the same feeding value, the whole may be stated as equivalent to 4,000 tons of corn meal. It appears, then, that we have a surplus of some 225,000 tons of hay, and a deficit of 55,225 tons of corn meal, and 41,700 tons of cotton seed, or the equivalent of these in some other grain.

To get some idea of the money value represented by these figures I have called the cost of hay, corn meal and cotton seed $8.00, $20.00 and $25.00 per ton, respectively. On this basis the following tabular statement is computed:

417,000 tons of hay,	@ $8.00,	equals	$3,336,00
104,250 tons of meal,	@ 20.00,	equals	2,085,00
41,700 tons of cotton seed,	@ 25.00,	equals	1,042,500
Total value of food required for 200 days,			$6,463,500

While the total of the hay, straw, corn fodder, corn and oats produced amounts to $6,119,100; thus showing that we are producing very nearly the amount of food that is required by our live stock, exclusive of poultry and hogs. But to make this fodder produce the best results it is necessary to exchange the 225,000 tons of hay for grain. Here is where a study of the science of stock feeding may aid us in the practical work. I have very little doubt but that better results might be obtained, at less cost for food, if the rations fed were better proportioned. A saving of even five per cent would amount to $323,175 in the aggregate, and I believe much more than this may be saved.

At the outset I wish to say, that the science of stock feeding is the key to better practical work. It should go hand in hand with the practice, pointing out possible improvements, and showing the losses which many old methods entail. Science can never take the place of practical knowledge, but it can point out the methods which lead to success. True science and *good* practice never conflict; if theory and practice lead to opposite conclusions, either the science or the practice is wrong. A practice not based upon science may be right, or it may be wrong, just as a man may guess right or wrong, but at best such practice, whether in agriculture or engineering, contains too many elements of uncertainty. Few would care to contend that the Brooklyn bridge could have been built without first, theoretically, determining the strain on each part; before a blow was struck the strain on every piece in that great structure was computed, and also the dimension of the parts required to safely withstand this load.

Good judgment, unaided by the science of the civil engineer, could hardly have directed the efforts of two gangs of men from points five miles apart, and given us the Hoosac tunnel. The fact that small enterprises are carried through successfully without the aid of science is too often used as a argument that theory is useless; because some small stream has been successfully bridged by some one who never knew how to compute the strain on a given brace, or post, or rod, therefore there is no need of applying the principles of mechanics to bridge building. This kind of reasoning is all wrong, and, to-day, no engineering project is undertaken without first working out the most minute details from a theoretical standpoint. Every brace and bolt, post and pin, every block of granite, first appears "on paper" in the office of the draughtsman, before a blow is struck by the workmen, who are to construct the bridge.

Theory and practice must go hand in hand to arrive at the best results in the best way. This is as true in agriculture as in any other pursuit.

The two factors with which we have to deal in stock feeding are *plants* and *animals*, and we will briefly consider the principles of their growth and composition.

Plants and *animals* are *mutually dependent* for their existence.

Without *plants*, *animals* would perish, and without *animals*, *plants* would in time die for lack of an atmosphere suited to their wants.

PLANT GROWTH.

When a kernel of corn is planted under favorable circumstances it produces a stalk and ear that may weigh five pounds. It is evident that the little kernel, weighing but a small fraction of an ounce, could not have furnished all the material from which the stalk was produced, and the soil and atmosphere must have made up the deficiency.

The leaves of the growing plant absorb from the atmosphere a gas, known as carbonic acid gas: the roots take up water, in which potash, iron, sulphur, lime, phosphoric acid, and magnesia, are dissolved, and the roots and leaves both take up nitrogen in combination with other elements. Within the plant these simple substances are combined in wonderful ways, forming many compounds having unlike properties, for example, the carbonic acid taken in through the leaves, and the water taken up by the roots, furnish the elements from which starch, sugar, oil, vegetable acids, mucilage, gum, etc., are produced. By the addition of nitrogen and sulphur a class of compounds are produced which resemble the white of eggs. Wheat gluten is an example of this class. One of the chief characteristics of plants is this power of taking the elements contained in the soil and air, and from a few, forming an almost endless variety of substances having the most diverse properties. Sugar and acids, starch and oil, strychnine and quinine, are a few of the many. This power is not found in animals. Not a grain of starch was ever produced from the elements of carbonic acid and water, except by plants: animals are dependent upon plants for their food. During the growth of plants they are constantly taking in carbonic acid, using a part of it in the production of starch, sugar, etc., and giving off oxygen; the result of this is to use up the carbonic acid of the atmosphere and overcharge it with oxygen; animals, however, produce just the opposite effect: they take in and use oxygen and give off carbonic acid. This is the one thing that keeps nature's books balanced.

A plant put under a tight jar would in time so far use up the carbonic acid as to die from lack of food; a mouse under another jar would use up the oxygen and increase the carbonic acid until suffocated; the two if put under the same jar would keep the air right for both. The oxygen given off by the plant would supply the mouse while the carbonic acid exhaled by the mouse would furnish just the kind of food necessary for the plant.

FOOD.

This word has been used. What does it mean? Any substance that can support life, or help to support it, is *food*.

Plants require *food* to support them when growing, they find it in the air and in the soil. The food of animals consist of any and all substances which can be taken into the system and which contribute toward supporting life, or causing growth, and is prepared for them by plants. A *food* may be *complete* that is capable of furnishing all that an animal requires, as grass, or it may be *incomplete* or not capable of sustaining life, when fed alone, e. g.. starch, sugar, oil, etc. These are just as much food, however, as grass.

It has been intimated already that plants are made up of unlike parts, or constituents, and the first step towards and understanding of the use of food is to know what the food is, the chemist must be consulted in determining this. It is true that the eye detects differences in the external appearance of food, but if some one should ask for the exact difference between corn meal and shorts it would be impossible to answer him, without knowing the chemical composition of the two. In the machine shop the mechanic learns the peculiarities of different machines by taking them apart and noting their construction. In the laboratory the chemist learns the characteristics of various plants and fodders by taking them apart, so to speak, instead of the vise he uses the crucible, in place of the monkey wrench he uses various acids, alkalies, etc., to tear apart the plant and separate it into the constituents of which it is made up; instead of the accurate rule measuring to the $\frac{1}{10000}$ part of an inch he uses delicate balances, which weigh to the $\frac{1}{283502}$ part of an ounce. The object of both the mechanic and the chemist is to get a knowledge of the internal structure which simple inspection cannot give. If plants were made up of but one kind of material there would be no need of chemical analysis. But such is not the case. If we press out the juice of a stalk of corn and evaporate it we get *sugar;* if the dried kernels are ground into a paste, with water, and then washed and manipulated in certain ways a large per cent of *starch* is obtained. If another sample of this corn meal is boiled with ether and the ether poured off into a clean dish and evaporated there will be found a clear yellowish oil, *or fat,* which the ether dissolved out of the corn. If wheat dough is washed until the starch is removed, a tough, sticky mass is left, this is known as *gluten.* These four substances represent the most important constituents found in fodders.

The chemical composition of fodders and feeding stuffs is determined and expressed in the following way: *Water* exists in all plants, the amount is determined by weighing a sample of the given substance and then drying it at 212°, until it ceases to lose weight, the loss is water, the part which remains is called *water free substance* and is made up of: 1st, *albuminoids* or substance resembling albumen or the white of eggs, wheat gluten or "wheat gum," already alluded to is the most familiar illustration of this class. The albuminoids contain not far from sixteen per cent of nitrogen and on account of this they are spoken of as the nitrogenous constituents. 2nd, *Nitrogen Free Extract* includes starch, sugar, substances resembling gum, mucilage, etc. 3d, *Fiber;* this is the woody matter found in all plants, in the flax and in cotton plant it is the part that gives us the material from which linen and cotton cloths are made. 4th, *Fat;* this is determined by dissolving with ether and evaporating the ether, leaving the fat or oil to be weighed. In the seeds of some plants, for example, cotton and hemp, the fat is found in large quantities and is pressed out and used for numerous purposes. 5th, *Ash;* This is the part left after burning a sample of the substance.

The following table shows the chemical composition of corn meal and shorts; the figures are an average of many determinations made at the Massachusetts Experiment Station:

	Corn meal.	Shorts.
Water,	13.16	11.5
Water free substance,	86.84	88.5
Water free substance contains:		
Albumenoids,	10.19	16.1
Nitrogen free extract,	68.92	52.3
Fiber,	2.50	10.0
Fat,	3.87	4.0
Ash,	1.36	6.1
	86.84	88.5

This is the customary method of stating an analysis, showing the *total composition* of fodders. But it is not in shape to be used by the feeder as a means of determining the nutritive value of these two products, because the animal fails to get the full amount of nutritive matter shown by analysis. Food, to be of any value to an animal, must be rendered soluble, so that it can be absorbed and carried through the system in the blood. This process of making the constituents of the food soluble is known as *digestion*, and is effected by the juices of the mouth, stomach, intestines, etc. If animals could digest the whole of the albumenoids, or other parts of corn meal or shorts, then the analyses above given would show the nutritive value. But it has been found that such is not the case. Only a part of each substance is digested. We may illustrate this point by supposing that some one puts on the market a mixture of coal and gravel stones, eighty pounds of the former and twenty pounds of the latter, in each one hundred pounds. The value of this, as fuel, is only that of the eighty pounds of coal, and any estimate based upon the *total weight* would be erroneous. In the same way each constituent of corn meal is made up of two parts, one *digestible*, corresponding to the coal in our assumed mixture; the other, *indigestible*, and corresponding to the gravel stones. The value of any kind of food is based, not on its total total composition, but on the *digestible* parts. It is necessary, therefore, to know what portion of each constituent is rendered available by the digestive juices. The method employed is briefly as follows: An animal is placed in a stall where no food can be wasted, a record of all food consumed is kept, and from the analysis it is possible to compute the exact amount of *albuminoids, fibre, nitrogen free extract* and *fat*, that has been taken into the system during the entire experiment. All the parts of the food that are not digested pass unchanged through the intestines and are found in the manure, consequently, if all the manure is weighed and samples are analysed, it is easy to compute the albumenoids, fibre, nitrogen, free extract and fat, that has passed through the animal unchanged, and these subtracted from the amounts taken into the system will show what portion has been rendered available by digestion. The degree of digestibility is usually expressed by stating the number of pounds that are digestable in one hundred pounds of each constituents. For example, it has been found that of each one hundred pounds of albumenoids fed in corn meal eighty-five pounds are digested. This eighty-five represents the *per cent* of digestibility of albuminoids in corn meal, and is called *digestion co-efficient*. Of the nitrogen free extract, ninety-four out of every one hundred pounds is digestible, in other words, ninety-four is the *digestion co-efficient* of the nitrogen free extract of corn meal. In the same way it is found that thirty-four and seventy-six are the digestion co-efficient of the fiber and fat, respectively. For shorts the figures are eighty-eight, eighty, eighty, and twenty, for albumenoids, nitrogen free extract, fat and fibre. To get the analyses above given into shape to be of value to the feeder, it is necessary to determine what the composition is when *only* the *digestible* part is considered. This is done in the following table:

	Corn Meal.			Shorts.		
	Total composition.	Digestion co-efficient	Amount digestible in 100 lbs meal.	Total composition.	Digestion co-efficient	Amount digestible in 100 lbs. shorts.
Water,	13.16			11.5		
Water free substance,	86.84			88.5		
Albuminoids,	10.19	85	8.66	16.1	88	14.17
Nitrogen free extract,	68.92	94	64.78	52.3	80	41.84
Fiber,	2.50	34	.85	10.0	20	2.00
Fat,	3.87	76	2.94	4.0	80	3.20
Ash,	1.36			6.1		

In this table, in the third and sixth columns we have the available nutritive material in corn meal and shorts, but as the digestible nitrogen free extract and digestible fiber are equally valuable these two may be added together, and in most stock feeding tables this is done. the name carbo-hydrates being given to the sum of the two, this term, carbo-hydrate, means that portion of the digestable part of food which is made up of three elements, carbon, hydrogen and oxygen, the last two elements being in the ratio of two parts of hydrogen and one part of oxygen. The ordinary table would give the above results in the following form:

	Digestible. Albuminoids.	carbo hydrates.	Fat.
Corn meal,	8.66	65.63	2 94
Shorts,	14.17	43.84	3.20

In the tables given in this bulletin I propose to modify this form of statement, with the hope that it will very much simplify the matter of using them in practical work, and I will explain the modification at this point. It is customary to give what is called the *nutritive ratio* of each food. Warrington calls it the *albuminoid ratio.* This means the ratio of digestible albuminoids or nitrogenous matter, to the carbo-hydrates and *fat,* or non-nitrogenous matter, but as it has been found that a pound of *fat* will produce 2½ times as much *heat,* when burned, as a pound of *starch* or *sugar* it has been assumed that the *fat* in fodders is 2½ times as valuable as the *carbo-hydrates* for feeding purposes, consequently in determining the *nutritive ratio* the *fat* is multiplied by 2½ and the product added to the carbo-hydrates this has the effect of making the whole of the non nitrogenous part of the food appear as starch or sugar. An example will best show how this is done. Take the corn meal above tabulated, there are 8.66 pounds of digestable albuminoids; There are of carbo-hydrates (starch, sugar, fibre etc..) 65.63 lbs., of fat 2.94 lbs., multiplied by 2½ gives the equivalent of carbo-hydrate 7.35; the carbo-hydrate equivalent becomes 72.98; the ratio of nitrogenous to non-nitrogenous is as follows: 8.66 to 72.98, or as 1 : 8.4. This last is the nutritive ratio of corn meal. The modi. fication alluded to is this: instead of giving the carbo-hydrates and fat in *separate* columns I shall multiply the *fat* in each food by2½ and *add* it to the carbo-hydrates, and give the sum in one column under the term *carbo-hydrate equivalence*. The reason for this will appear in the practical work of computing rations, under "practical feeding."

The table last given would be changed to the following:

	Albuminoids.	Carbo-hydrate equivalence.	Nutritive ratio.
Corn meal,	8.66	72.98	1 : 8.4
Shorts,	14.17	51.84	1 : 3.6

What are the *uses of food* in the animal system?

Having considered what *food* is and finding it made up of parts having unlike qualities it is very natural to ask if the albuminoids and corbo-hydrates are of equal value, before this can be answered it will be best to see why animals require food. Some of the uses of food may be best explained by comparing the animal to the locomotive. We will take the case of a locomotive, standing idle in the yard, with the temperature of the atmosphere at zero. Under these conditions heat is constantly being given off to the air, and, if left to itself, after a time the fire goes out, the water gradually cools off, until it freezes. This tendency is caused by what is known as *radiation* of *heat* and the result is that the locomotive and air in time come to the *same temperature*. To prevent this, either wood or coal is burned in the fire-box. An ox, standing in a cold barn, or out of doors, loses heat by radiation, just as the locomotive does and is this loss was not made good in some way, it would only be a short time before the temperature of the air and the temperature of the ox would be alike. But as a matter of fact the temperature of the blood never varies much from 101° in health, and it makes no difference whether the air is at 30° below zero or at 90° above. The temperature of the body is kept up by the *food* consumed just as that of the locomotive is by the wood burned. Again the fuel consumed by a locomotive while standing idle is only, an amount sufficient to supply the loss of heat. This is a comparitively small amount, when the same locomotive is coupled to a train of loaded cars, and is started on an up grade, it will be found necessary to open the drafts and increase the consumption of fuel, in drawing this load, energy is required and this is obtained from the extra fuel consumed. An ox or a horse, when drawing heavy loads, must also expend more energy than when standing in the stall, and to develope this energy requires more food: *food* is to the ox what *fuel* is to the locomotive.

There is one other object for which we feed, namely, the production of growth, under this head comes increase of live weight whether in growing animals or fattening one, growth of wool, or the production of milk. If an animal weighs one hundred pounds at birth and fifteen hundred pounds when three years old this gain of fourteen hundred pounds must come from the food and water used, if a cow yields annually, six thousand pounds of milk, this also must come from the food and water consumed.

The uses of food, then, are: to produce heat; to produce force, (muscular energy); to produce new tissue, (including increase of live weight, growth of wool or yield of milk).

Having noted the use to which food is put we may inquire whether one part of the food is better adapted to one requirement, and another part to another requirement, or whether all the digestible parts are equally effective.

1st, what part of the food produces heat. The best authorities answer this by saying that the changes which take place in all parts of the body produce heat. The contraction of a muscle, the activity of the liver, etc., all liberate heat and hence it cannot be said that one constituent of the food more than another is the source, but that both the nitrogenous and non-nitrogenous contribute toward keeping up the temperature.

2nd, Force is produced in much the same way as heat, from all the constituentsof the food.

3d, New tissue. There has been much comflicting testimony on the formation of new tissue, the chief difficulty being to find the source of fat. At first, it was held that the animal only sorted out and stored the fat already existing as fat in the food; experiments soon showed that the fat produced by pigs and in the milk of cows largely exceeded that taken into the system in the food. It was then held that the albuminoids might make up the deficiency, or by others, that the albuminoids were the only source of fat. Laws & Gilbert showed, in certain experiments, that they carried on, that not only was there a lack of fat in the food, but that the fat and albuminoids taken together could not produce all the fat that was stored up, and consequently that the starch or sugar of the food *must* have contributed. It may be safely said that the elements from which the animal fats are made up come from the albuminoids, carbohydrates and fat. It is probable that the muscle and other nitrogenous parts of the animal come from the albuminoids of the food. This, however, is not fully concurred in by all physiologists.

The changes which food undergoes in the animal system are very complex, and just how hay, grain, cottonseed, grass, ensilage, etc., are changed into milk, muscle, blood, wool, fat, etc., is a problem which physiological chemistry has not yet definitely solved.

The whole object of this brief discussion of the principles of animal nutrition is to enable us to understand the meaning and use of the *stock feeding tables* which have been prepared for us, and as an intelligent use of these tables cannot fail to improve the methods of feeding too often practiced in our state. I shall try to show just what the tables are and how they are to be used.

PRACTICAL USE OF FEEDING TABLES.

Two questions cover the whole field. 1st: How much food does an animal require? 2nd: How can a ration, which will furnish this amount, be decided upon?

The answer to both comes from the *tables* that will be given later in this *Bulletin*. and, therefore, I will explain what the tables are, and how they were prepared.

The knowledge which we have concerning the requirements of various animals, under varying circumstances, comes largely from German scientists, who have devoted much time and monoy to agricultural investigations, their methods of working out the results that we have obtained may be best explained by giving the actual records. The first step is to determine the amount of food actually required to keep a given animal, without gain or loss, this is called a "maintenance ration." From "Armsby's Manual of Cattle Feeding," I select an experiment made by Henneberg and Stohmann. Oxen weighing one thousand pounds were fed on the following rations daily:

	Pounds.	Pounds.	Pounds.
Experiment 1,	19.5 clover hay.		
" 2,	3.7 "	13.0 oat straw,	0.6*rape cake.
" 3,	2.6 "	14.2 "	0.5 "
" 4,	3.8 "	13.3 rye straw,	0.6 "
" 5,	25.6 mangolds,	12.6 oat straw,	1.0 "

All of these, except the first, kept the annimals in good health, of a constant live weight, or nearly so. Let us take the third experiment and study it. We have a ration that will keep a one thousand pound ox without loss. This question comes up: What amonnt of albuminoids, carbo-dydrates and fat, does this furnish? The experimenters analysed the foods and determined the digestibility of each constituent. The following table shows the digestible matter per one hundred pounds of each article used in the test:

100 lbs. of	Albuminoids.	Carbo-hydrates.	Fat.
Clover contains,	6.00	39.5	1.0
Oat straw contains,	.87	45.5	0.30
*Linseed contains,	27.00	28.5	9.00

With this table we can compute the exact amount of digestible matter that the ox received in that ration. This is given below:

	Furnished digestible. Pounds.	Albuminoids. Pounds.	Carbo-hydrates. Pounds.	Fat. Pounds.
Clover,	2.6	0.156	1.02	0.026
Oat straw,	14.2	0.123	6.46	0.042
Linseed,	0.5	0.135	0.14	0.045
Total digestible matter daily,		0.414	7.62	0.113

*This rape cake is of about the came composition as the linseed found in the markets of the United States.

Here we have a definite quantity of nutritive matter, that was found capable of supporting an ox, now if from any combination of food we are able to supply this amount of digestable matter we may be tolerably certain, that the results will be satisfactory, for an animal that is standing still in a warm stall. A majority of farmers, however, do not care to feed simply for maintenance. but want growth, or milk, or wool, the same method of investigation has been applied to all cases, cows giving milk were fed on various combinations of such fodders as the German farmers produce, after many trials those rations, which seemed to be best adapted were taken as standard, and when their value was established by enough trials, the food was analysed and the same method of computation applied, as in the case above tabulated. In the same way fattening cattle, horses at work and resting, cows not in milk, growing cattle, swine, etc., have been experimented on and *standard rations* established.

Two tables are necessary in computing rations, one showing what quantity of *albuminoids* and *non-nitrogenous, material*, is required daily by various animals for each one thousand pounds of live weight, the other showing the composition of the digestible part of all the foods that the farmer is likely to have at hand.

In these tables I have carried out the modification explained on page 10.

TABLE B.

FEEDING STANDARD.

Showing digestible substances required daily by the following animals per 1,000 pounds of live weight :

1,000 lbs. of live weight require daily.	Digestible substances. Albuminoids. Lbs.	Carbo-hydrate equivalence. Lbs.	Nutritive ratio
Oxen, at rest,	0.7	8.37	1:12
Oxen, moderately worked,	1.6	12.05	1: 7.5
Oxen, heavily worked,	2.4	14.45	1: 6
Oxen, fattening,	3.0	16.55	1: 5.5
Cows, giving milk,	2 5	13.50	1: 5.4
Horses, light driving,	1.8	12.70	1: 7
Horses, heavily worked,	2.8	15.4	1: 5.5
Growing cattle,	2.5	15.0	1: 6
Sheep, for wool,	1.2	10.8	1: 9

Sheep, fattening,	3.0	16.45	1: 5.5
Swine, fattening,	4.0	24.0	1: 6

TABLE C.

FEEDING STUFFS.

100 lbs. of the following materials contain.	Digestible substances. Albumnioids.	Carbo-hydrate equivalence.	Nutritive ratio.
Herdgrass (timothy) hay,	3.45	48.71	1:14
Redtop hay,	4.74	48.19	1:10
Mixed hay,	3.71	47.61	1:12.8
Mixed hay and clover,	4.85	46.40	1: 9.5
Salt marsh hay,	2.27	45.83	1:20
Clover hay,	7.53	43.60	1: 5.7
Vetch hay,	9.20	37.67	1: 4
Oat hay,	4.85	44.83	1: 9.2
Winter rye hay,	10.3	51.7	1: 5
Millet hay,	4.67	45.43	1: 9.7
Rowen,	6.81	41.74	1: 6.1
Oat straw,	1.45	43.31	1:30
Bean vines,	5.00	36.45	1: 7.3
Corn stover,	2.15	41.38	1:19
Ensilage, (northern corn),	1.47	14.80	1:10
Ensilage, (southern corn),	1.32	12.73	1: 9.6
Ensilage, (sweet corn),	1.84	14.92	1: 8
Pasture grass,	2.5	10.9	1: 4.4
Green rye,	2.00	12.87	1: 6.4
Potatoes,	1.42	17.70	1:12.4
Sugar beets,	1.5	7.81	1: 6.5
Corn and cob meal,	7.13	66.52	1. 9.3
Corn meal,	7.78	71.60	1: 9.2
Barley meal,	9.54	65.95	1: 6.9
Oats, ground,	9.90	58.16	1: 5.9
Buckwheat, ground,	7.7	66.71	1: 8.7
Linseed, (old process),	28.12	53.21	1: 1.9
Linseed, (new process),	28.57	44.30	1: 1.5
Cottonseed meal,	31.36	42.26	1: 1.3
Shorts,	13.26	52.70	1: 4
Middlings,	13.35	57.72	1: 4.3
Gluten,	25.14	61.90	1: 2.4
Brewers' grains, (wet)	4.73	16.22	1: 3.4
Malt sprouts,	18.36	52.18	1: 2.8

Cow's milk, (whole).	3.00	14.0	1: 4.6
Skim milk,	3.23	6.94	1: 2.1
Butter miik,	2.9	4.50	1: 1.5

The table above given is made up chiefly from the compilations of Dr. Jenkins, in the 1887 Conn. state report, together with a full special analyses from Goessman, Armsby, and Jordan. The digestion co-efficients were taken from the Mass., state report for 1887, and a few from the American results, obtained by Jordan and Armsby.

With these two tables any farmer can gain a tolerable correct idea of what his live stock require, and also can compound rations which will satisfy these requirements and if from the variety of fodders which are to be found on most farms, together with such grains as are to be had in in the market, a daily ration can be formed which will contain the digestible albuminoids and carbo-hydrate equivalence, shown by table B, to be necessary for a given animal under given conditions, it may reasonably be expected that such a ration will be very satisfactory, I do not, however, wish to be understood as claiming that these tables are absolutely exact, for they evidently cannot be, but they are *guides* to good and economical feeding and when supplemented by good judgement and close observation are sure to give much better results, than can be obtained by good judgment alone. No man can afford to disregard the experience of careful men who have spent a life time in searching for the laws which govern the nutrition of animals, and the man who regards his own limited experience as superior to that of scores who have spent their whole time in studying this difficult problem, stands in his own light because certainly no evil can result from accuracy in feeling, and the chances all favor an improvement by such exactness.

HOW TO USE THE TABLES.

The first difficulty that must be met is that of determining the live weight of the animal to be fed. The following rule though by no means accurate, is of some value in determining this; Ordinary cattle, girting 5 ft, will weigh from 650 to 750 pounds, according to form and fatness; for each additional inch in girth, add 25 pounds, up to 6 ft, and for each inch after 6 ft, add 50 pounds.

The following table is constructed on the basis given in above rule, it is not however, claimed that the figures are very close, but I have found them to agree with actual weighing, in a fair proportion of cases, and it is given in this bulletin with the hope that those who have the opportunity will test it and report their results of actual weighing, in this way in time a table can be arranged which will be much better than the present one.

STEERS, OXEN, ETC.

Girth in		Store cattle.—Quality.		Medium fat.—Quality.	
		Fair.	Good.	Fair.	Good.
Ft.	In.	Lbs.	Lbs.	Lbs.	Lbs.
5	0	650	700	700	750
5	1	675	725	725	775
5	2	700	750	750	800
5	3	725	775	775	825
	4	750	800	800	850
	5	775	825	825	875
	6	800	850	850	900
	7	825	875	875	925
	8	850	900	900	950
5	9	875	925	925	975
5	10	900	950	950	1000
5	11	925	975	975	1025
6	0	950	1000	1000	1050
6	1	1000	1050	1050	1100
6	2	1050	1100	1100	1150
6	3	1100	1150	1150	1200
6	4	1150	1200	1200	1250
6	5	1200	1250	1250	1300
6	6	1250	1300	1300	1350
6	7	1300	1350	1350	1400
6	8	1350	1490	1400	1450
6	9	1400	1450	1450	1500
6	10	1450	1500	1500	1550
6	11	1500	1550	1550	1600
7	0	1550	1600	1600	1650
7	1	1600	1650	1650	1700
7	2	1650	1700	1700	1750
7	3	1700	1750	1750	1800
7	4	1750	1800	1800	1850
7	5	1800	1850	1850	1900
7	6	1850	1900	1900	1950

This table will enable those who have had but little experience in weighing, to form some idea of the amount of food required. A few examples will serve to illustrate the method of computing a ration:

Take a cow giving milk, and weighing 900 pounds, turn to table B, and we see that a cow giving milk, and weighing *one thousand* pounds requires to be furnished daily with food enough to contain 2½ pounds of digestable albumenoids, and 13½ pounds of carbo-hydrate equivalents, but the case we have taken does not call for so much, as the cow only weighs 900 pounds, the following proportion is capable of giving the exact amount required.

1000 : 900 :: 2.5 : albuminoids required, and

1000 : 900 :: 13.5 : carbo-dydrate equivalence requred.

The first proportion works out as follows: $2.5 \times 900 = 2250 \div 1000 = 2.25$ lbs.

The second proportion works out as follows: $13.5 \times 900 = 12150 \div 1000 = 12.15$ lbs.

That is, a 900 pound cow requires daily, albuminoids, 2.25 pounds; carbo hydrate equivalence, 12.15 pounds.

How shall we get this amount most economically? almost every farmer has one or more of the following course fodders, straw, corn fodder, bog meadow hay, also English hay, either herdsgrass, red top, or mixed hay, and corn meal; many have ensilage, and on the coast salt hay.

The quantity of English hay, that should be fed daily, when hay is the standard fodder, is from 1 to 1½ per cent of the live weight of the animal, and with it from ½ to ⅔ as much of some course fodder, like straw, or cornfodder, or bog meadow hay, this gives bulk to the ration and is the framework to which the grain ration must be fitted.

Let us see what this framework will furnish, to do this turn to table C, and opposite "mixed hay" and "oat straw" we find that 100 pounds of the former will furnish 3.71 lbs. of digestable albuminoids and 47.61 lbs. carbo-hydrate equivalence, the oat straw, 1.41 lbs. and 43.31 of the same nutrients, consequently.

	Albuminoids.	Carbo-hydrate equi alence.
12½ pounds mixed hay will furnish	0.47 lbs.	5.95 lbs.
5 pounds oat straw will furnish	0.070 lbs.	2.17 lbs.
To this add the followin grain ration:		
3 pounds cotton seed meal will furnish	.94 lbs.	1.26 lbs.
2 pounds shorts will furnish	.27 lbs.	1.05 lbs.
2 pounds middlings will furnish	.27 lbs.	1.15 lbs.
4 pounds corn meal will furnish	.16 lbs.	1.43 lbs.
	2.18	13.01
Required as shown by Table B,	2.25	12.15

This gives a ration near enough for all practical purposes, in finding what quantities of the various constituents are needed, it will usually be necessary to make several trials before the right proportion of albuminoids and carbo-hydrate equivalence is secured, but as a general rule, the more coarse fodder used the greater should be the amount of cottonseed, linseed, gluten or shorts in the grain ration, and the less the amount of corn meal. Now let us see how the hay and straw framework would balance if, as is too often the case, only corn meal is used.

	Albuminoids. Lbs.	Carbo-hydrate equivalence. Lbs.
12½ pounds mixed hay,	0.47	5.95
5 pounds oat straw,	0.07	2.17
5⅔ pounds corn meal,	.44	4.05
Furnished,	0.98	12.17
Required,	2.25	12.15
Deficiency of albuminoids,	1.27	

This ration gives us a sufficient supply of starch, sugar, fat, etc., but less than ½ the required amount of albuminoids, if the German experiments are worth anything, they show that it is poor policy to use corn meal alone as a grain ration, for English hay and coarse fodders. Once more let us see what would result if we take a sufficient quantity of corn meal to get the required amount of albuminoids:

	Albuminoids. Lbs.	Carbo-dydrate equivalence. Lbs.
12½ pounds hay,	0.47	5.95
5 pounds oat stram,	0.07	2.17
22 pounds corn meal,	1.71	15.75
Furnished,	2.25	23.87
Required,	2.25	12.15
Excess of non-nitrogeous matter,		11.72

These two rations show very forcibly that either the practice of feeding corn meal alone, with hay and straw, is a bad one, or the feeding standards are worthless.

It will be noticed, that the proportions given on page —, have 1000 for their first term, this must always be so because the tables are computed for animals weighing 1000 pounds, this being so the determination of what a given animal requires, when its weight is known is very simple.

Rule for determining, the digestible matter required by an animal of *any* weight: *Multiply the number of pounds of albumi-*

noids, and carbo hydrate equivalence, found in table B, for the desired condition, in which the animal is, by the live weight and move the decimal point three places to the left.

For example, a steer weighs 1250 lbs., and it is proposed to fatten this animal, what amount of *nutrients*, (that is digestible albuminoids and carbo-hydrate equivalence) are required? In table B, it is seen that, "oxen fattening," require daily 3.0 of albuminoid, and 16.5 pounds of carbo-hydrates and fat per 1000 pounds live weight, applying our rule we get 3×1230=3750; removing the decimal three places gives 3.75 pounds of albuminoids, in the same way, 16.5×1250=20625.0; remove the point three places, =20.62 pounds of carbo-hydrate equivalence required.

To form a trial ration, take 1% of live weight of animals in hay, and 1% in corn fodder, then take about ⅓ of one per cent of one of the following concentrated feeding stuffs, cotton seed, gluten, linseed, or malt sprouts, and ½ the quantity of shorts. and make up the ration with corn meal and middlings, a few trials will give a combination coming close enough to the standards.

		Albuminoids.	Carbo-hydrate equivalence.
12½	pounds of hay,	.46	5.95
12½	pounds of corn stover,	.27	5.11
4½	pounds of cotton seed meal,	1.41	1.90
2¼	pounds of shorts,	.30	1.18
5	pounds of middlings,	.67	2.88
7	pounds of corn meal,	.55	5.01
		3.66	22.09

There are reasons for believing that this ration is fully as economical for the American farmer, as one corresponding exactly with the German standard, our conditions differ from theirs, corn is our standard grain, it is cheaply produced in the West, and must constitute a considerable portion of our rations here and hence a little less of albuminoids, and more of carbohydrate eqaivalence must be used. I am satisfied from the feeding experiments, that have been conducted on our college farm, that a considerable variation from the foreign standards may be economical, and that instead of a nutritive ratio of 1 : 5.4 for cows giving milk, we can do better with a ratio of 1 : 6 or 7, this may perhaps be considered a pretty wide variation, but I believe the cheapness which we can produce starchy foods, more than compensates for any loss that may result in quantity or quality of milk from the reduced quantity of albuminoids. The factor of cost of foods has been too much overlooked in American investigations, so that in pointing out the errors of the too common practice of feeding corn meal exclusively, we have tended toward the other extreme.

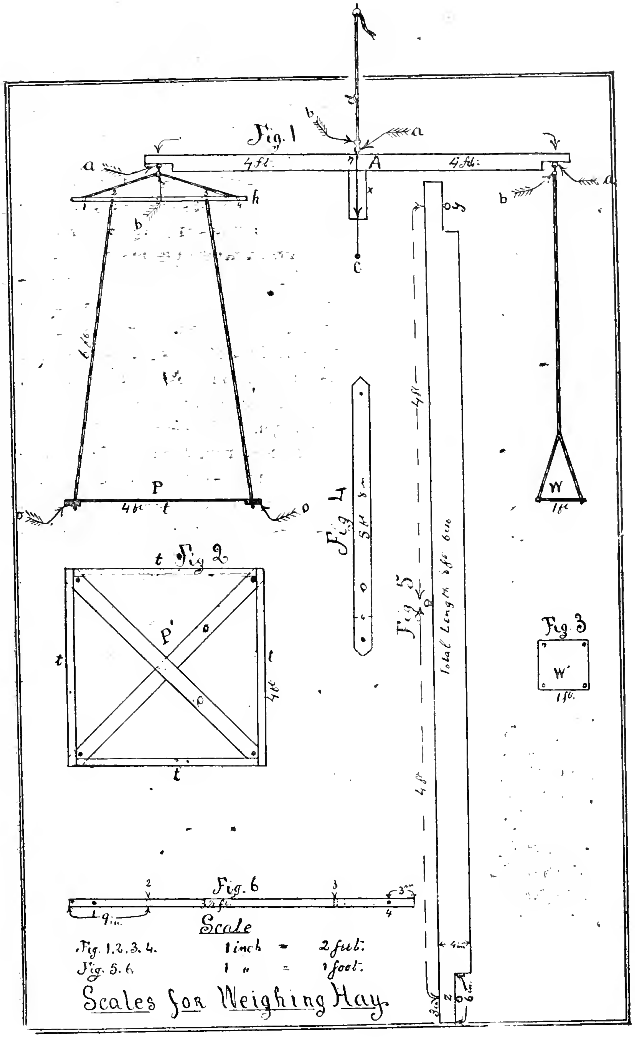
In the following computed rations the grain rations are given in pounds, and in parentheses are given the quarts and parts of quarts, computed from the following table, which gives the weight of the various grains per half bushel and per quart:

WEIGHT OF GRAINS.

	Weight per ½ bushel. Lbs.	Oz.	Per quart. Lbs.	Oz.
Corn meal,	23	8	1	7
Cotton seed,	25	8	1	9
Shorts,	11	4	0	11
Middlings,	18	0	1	2
Grounds oats,	12	0	0	12
Gluten,	26	0	1	8
Corn and cob meal,	22	0	1	6
Cracked corn,	28	0	1	12
Whole oats,	16	0	1	0

Or stated in another way:

1 pound of corn meal equals	0.7	quarts.
1 pound of cotten seed equals	0.625	"
1 pound of shorts equals	1.43	"
1 pound of middlings equals	0.90	"
1 pound of oats equals	1.33	"
1 pound of gluten equals	0.617	"
1 pound of corn and cob meal equals	.73	"
1 pound of cracked corn equals	.57	"
1 pound of whole oats equals	1.00	"



Scale

Fig. 1. 2. 3. 4. 1 inch = 2 feet.
Fig. 5. 6. 1 " = 1 foot.

Scales for Weighing Hay.

It is often difficult for many to weigh hay, corn fodder, straw, etc., for lack of suitable scales, but this is by no means a serious matter, for less than $1.00 outlay of cash and ½ days work, a balance can be made that will weigh very accurately, the cuts on page 23, represent the parts of one that is now in use in our feeding barn. Figure 1, is the complete balance, A is the beam, a, a, a, are the pivots which consist of "screw eyes," b, b, b, and common "halter snaps," which hook into these screw eyes. The cords which suspend the weight platform w and the spreader h pass through two of these "snaps" while the hook or cord by which the whole is suspended from a beam, (d in the cut Fig. 1) is attached to the third "snap." The platform P is suspended by its four corners by cords passing *through* the "speader" h at the parts marked, 2, 3, the "speader" being suspended by the cord shown passing through holes at 1 and 4, c is a plumb bob suspended from near the top of the beam at n, and when balanced should be in the center of the board x that is fastened to the center of the beam.

The material from which to construct such a balance consist of "three screw eyes" and three "halter snaps" these may be had at any hardware store, also 40 ft, of window weight cord and cloth or canvass to cover the hay platform, this is all that need be bought, and the whole cost is only 35 cents.

The beam is made of a straight piece of inch board, 4 inches wide, and 8 ft, 6 inches long, this is shown in Fig. 5, on the under side of this at each end, a piece is cut out, 6 inches long and 2 inches wide as shown, on the *top* side in the *exact center* one screw eye is inserted, now measure *exactly* 4 feet each way from this to the points y, z, Fig. 5, and insert a screw eye at each end on the *under* side, this completes the beam.

Next get out 2 pieces each 1 inch thick, 4 inches wide and 5 ft, 8 inches long, like Fig. 4, and cut the ends as shown; these are the pieces o, o, which cross in Fig. 2; cross them at right angles and nail securely; now take four lath, (t, t, t, t, Fig. 2), cut two of the 4 ft, long, and two 3 ft, 9 inches long. The cross piece o which is *underneath* must have two blocks of inch board, 4 inches square, nailed to each end, to bring the top up even with the other cross-piece. Now nail the lath on as shown. This is the skeleton of the platform which is to be covered with heavy cotton cloth, or canvass, or oil cloth, tacked to the lath frame, 3/8 inch holes are bored, one in each corner, through this the window cord will pass. The "spreader" h, is shown on a larger scale in Fig. 6; it is made from a rake stale and is 3½ ft, long; four holes are bored in this, two (1 and 4 in cut) are 3 inches from the ends, the spreader bail-cord passes through these. The other two are 9 inces from the end and are at *right angles* to the two first mentioned; through these (2 and 3 in Fig. 6), the cords which suspend the platform are to pass.

Fig. 3, is simply a piece of inch board, 1 foot square, with holes in each corner. On this platform the weights are to be put. The cuts show how the cords are arranged; where the spreader bale passes through the halter snap it must be tied so that it cannot slip through the ring of the snap. It is very important that the distance between the center "screw eye" and the end ones shall be *exactly alike.*

When the whole is completed it may be suspended from a beam in the barn floor by a rope, and if it is desirable this rope may pass through a pulley on the beam, and when the balance is not in use it may be *drawn up* out of the way, being lowered on to the floor when needed.

I was three hours in building the one we are using and most farmers or their boys or hired men, can build one without having a carpenter to do the work. The cost will then be less than fifty cents. Surely this sum need not prevent any one knowing what they are feeding.

When the whole is complete two bricks will nearly balance the hay platform. It then becomes necessary to have weights from which various combinations may be made. Two bricks may be selected that will weigh 4 pounds each; another may be broken, thus getting by a little chipping, a 2 pound weight; also a piece can, with a small amount of work, be made to weigh 1 pound. With these, even pounds from 1 to 11 can be made out.

I have just carefully tested the balance we are using and find it sensitive to ½ ounce. The grain rations may be weighed on the same balance or it may be measured. The former is more accurate but not quite as convenient.

The following rations have been adapted, as far as possible to New Hampshire conditions. They are, however, but a few of the possible combinations, but will serve as examples in their respective classes:

CLASS I.

RATIONS FOR COWS GIVING MILK, (LIVE WEIGHT, 900 LBS.).

Ration 1.

	Amount. Lbs.	Qts.	Albuminoids. Lbs.	Carbo-hydrate equivalence. Lbs.
Mixed hay,	12½		0.47	5.95
Oat straw,	5		0.07	2.17
Cotton seed meal,	3	(2)	.97	1.26
Shorts,	2	(3)	.27	1.05
Middlings,	2	(1¾)	.27	1.15
Corn meal,	4	(2¾)	.16	1.43
Total daily,		(9½)	2.18	13.01
Required,			2.25	12.15

Ration 2.

Clover hay,	10		.753	4.36
Corn fodder,	10		.215	4.13
Corn meal,	4	(2¾)	.160	1.43
Gluten,	3	(2)	.754	1.85
Shorts,	2	(3)	.265	1.05
Total,		(7¾)	2.147	12.82

Ration 3.

Herdsgrass hay,	10		0.345	4.87
Bog meadow or salt marsh hay,	10		.227	4.58
Corn and cob meal,	5	(3½)	.356	3.32
Cotton seed,	3	(2)	.940	1.26
Shorts,	2	(3)	.270	1.05
Total,		(8½)	2.14	15.08

Ration 4.

Ensilage, (northern corn),	50		0.74	7.40
Mixed hay with clover,	10		.485	4.64
Gluten,	4	(2½)	1.006	2.47
Totals,			2.231	14.51

Ration 5.

Ensilage, (southern corn),	40		0.53	5.08
Oat straw,	8		0.12	3.46

Corn and cob meal,	2	(1½)	0.14	1.33
Cotton seed,	3	(2)	0.94	1.26
Shorts,	3	(4¼)	0.40	1.58
Total,		(7¾)	2.13	12.71

Ration 6.

Ensilage, (northern),	40		0.590	5.92
Corn stover,	10		0.215	4.13
Corn meal,	2	(1½)	0.156	1.43
Linseed, (new process),	3	( )	0.860	1.32
Middlings,	2½	(2¼)	0.334	1.44
Total,			2.155	14.24

Ration 7.

Ensilage, (Sanford corn),	50		.92	7.46
Clover hay,	5		.38	2.18
Bean vines,	5		.25	1.82
*Mixed grain,	4	(3½)	.31	2.86
Total,			1.86	14.32

Ration 8.

Ensilage, (northern),	50		.74	7.40
Corn fodder,	6		.13	2.48
Clover hay,	5		.38	2.18
Corn and cob meal,	2	(1½)	.14	1.33
Gluten,	3	(1¾)	.76	1.85
Total,			2.15	15.24

Ration 9.

Ensilage, (northern),	50		.74	7.40
Clover,	5		.38	2.18
Corn fodder,	6		.13	2.45
Mixed grain,	4	(3½)	.31	2.86
Buckwheat,	2	(1¾)	.15	1.33
Total,			1.71	16.22

Ration 10.

Herdsgrass and red top,	8		.30	3.80
Clover,	5		.38	2.18

*Corn and cob, 90 lbs. + 25 lbs. oats.

Millet hay,	6		.28	2.72
Mixed grain,	9½	(8)	.74	6.80
Total,			1.70	15.50

FOR COWS WEIGHING 800 LBS.

Ration 11.

Herdsgrass,	20		.69	9.74
Corn meal,	3	(2)	.23	1.99
Shorts,	1	(1½)	.13	.52
Cotton seed,	2	(1¼)	.63	.84
Total,			1.68	13.09

Ration 12.

Mixed hay,	10		.37	4.76
Cured oats,	10		.48½	4.48
Cotton seed,	2	(1¼)	.63	.84
Shorts,	3	(4½)	.39	1.56
Total,			1.87½	11.64

Ration 13.

Mixed hay,	10		.37	4.76
Cured oats,	10		.48½	4.48
Cotton seed,	2	(1¼)	.63	.84
Shorts,	2	(3)	.26	1.04
Corn meal,	2	(1½)	.15½	1.43
Total,			1.90	12.55

Ration 14.

Herdsgrass,	20		.69	9.74
Cured Oats,	5		.24	2.24
Shorts,	2	(3)	.26	1.04
Middlings,	2	(1¾)	.27	1.15
Corn Meal,	2	(1½)	.15½	1.43
Total,			1.61½	15.60

Rations 7 to 14, inclusive, are rations that have been or are now used in our feeding, and though some of them are a pretty wide departure from the standards, yet they appear to be economical. But it must be remembered that the fodders used have not been analysed, and there is reason to believe that the results in table C are lower than they should be.

CLASS II.

RATIONS FOR FATTENING CATTLE WEIGHING 900 LBS.

Ration 15.

	Amount. Lbs.	Qts.	Albuminoids. Lbs.	Carbo-hydrate equivalence. Lbs.
Mixed hay,	12½		.47	5.95
Oat straw,	7½		.11	3.25
Corn and cob meal,	5	(3½)	.36	3.32
Cotton seed,	4	(2½)	1.25	1.69
Ground oats,	3	(4)	.30	1.74
Total furnished,			2.49	15.95
Total required from Table B,			2.70	14.90

CATTLE OF 1000 LBS., LIVE WEIGHT.

Ration 16.

Clover hay.	10		.75	4.36
Oat straw,	5		.07	2.16
Bean vines,	5		.25	1.82
Corn and cob meal,	5	(3¾)	.36	3.32
Cotton seed meal,	5	(3)	1.57	2.11
Ground oats,	4	(5⅓)	.40	2.33
Total,			3.40	16.10
Required,			3.00	16.55

WEIGHING 900 LBS.

Ration 17.

Mixed hay,	10		.37	4.76
Corn fodder,	13		.28	5.37
Corn and cob meal,	5½	(4)	.39	3.65
Cotton seed meal,	5	(3)	1.57	2.11
Total,			2.61	15.89

WEIGHING 1000 LBS.

Ration 18.

Mixed hay,	5		.18	2.38
Ensilage, (northern),	50		.74	7.40
Cotton seed,	5	(3)	1.57	2.11
Corn and cob meal,	5½	(4)	.39	3.65
Middlings,	1	(1)	.13	.58
Total,			3.01	16.12

Ration 19.

Ensilage,	50		.74	7.40
Bog meadow or salt marsh hay,	10		.23	4.58
Gluten,	6	(3¾)	1.51	3.71
Corn meal,	5	(3½)	.39	3.58
Total,			2.87	19.27

CLASS III.

WORKING OXEN, WEIGHT 1500 LBS. EACH.

Ration 20.

Mixed hay,	25		.93	11.90
Corn meal,	5	(3½)	.39	3.58
Middlings,	5	(4½)	.67	2.88
Cotton seed,	2	(1¼)	.33	.84
Total,			2.32	19.20
Required,			2.40	18.07

Ration 21.

Mixed hay,	10		.37	4.76
Corn fodder,	10		.22	4.14
Ensilage,	25		.33	3.18
Corn meal,	7	(5)	.54	5.01
Linseed, (new process),	3	( )	.86	1.33
Total,			2.32	18.42

Ration 22.

Mixed hay with clover,	20		.97	9.28
Corn fodder,	10		.22	4.14
Corn meal,	8	(5½)	.57	5.32
Middlings,	4	(3½)	.54	2.30
Total,			2.30	21.04

CLASS IV.

HORSES, (HEAVILY WORKED), WEIGHT 1000 LBS.

Ration 23.

Herdsgrass hay,	20		.69	9.54
Cracked corn,	4	(2¼)	.29	2.66
Whole oats,	12	(12)	1.19	6.97
Total,			2.17	19.17
Required,			2.80	15.40

Ration 24.

Mixed hay,	20		.74	9.52
Whole oats,	10	(10)	.99	5.87
Linseed,	2	( )	.57	.88
Corn meal,	2	(1½)	.14	1.33
Total,			2.44	17.60

CLASS V.

HORSES, (LIGHT WORKED), WEIGHT 1000 LBS.

Ration 25.

Mixed hay,	10		.37	4.76
Oats,	6	(6)	.60	3.49
Corn meal,	5	(3½)	.39	3.58
Shorts,	2	(3)	.27	1.05
			1.63	12.88
			1.80	12.70

G. H. WHITCHER, *Director.*

The Bulletins of this Station are sent *free* to all farmers in the State who request the same.

G. H. WHITCHER.