FOOD INDUSTRIES

An Elementary Text-book on the Production and Manufacture of Staple Foods

DESIGNED FOR USE IN HIGH
SCHOOLS AND COLLEGES

by

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PREFACE.

After many years' experience in lecturing on the processes of food manufacture, the authors feel encouraged to submit the result of their labors as a guide to those who wish to study this most important and interesting subject.

Certainly no branch of general manufacturing has undergone so many and such important changes in the past twenty-five years as the food industries. The public have largely benefitted from these changes both in pocket and health.

Unfortunately there still lingers in the minds of many, the impression that food stuffs have not the same dietetic value they possessed in the past, and that manipulation gives them an appearance of quality they do not possess. It is the universal experience of the authors that manufacturers have not only improved the quality of their products in every possible way, but having nothing to conceal except from competitors, are most anxious to enlighten the interested consumer in the processes involved.

Some mistakes have certainly been made in the past, but with no evil intent and largely through ignorance. As time passes these errors are corrected and it can confidently be stated that the public receives to-day better and cleaner material at a lower price than formerly. The economic improvement is largely due to the general utilization of by-products, many of which do not appear in any list of foods.

The following pages do not claim to deal with any industry from the purely technical standpoint, but aim to point out the most essential parts of each. A knowledge of chemistry and physics is not absolutely essential, but is very helpful.

As a pioneer book on the subject, any suggestions furnished by teachers would be very gratefully received.

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TABLE OF CONTENTS.

INTRODUCTION.

In regard to the production and manufacture of our food material, there is a prevalent ignorance among woman to-day which is a marked contrast to the knowledge possessed on this subject by the old-fashioned housekeeper. The reason for this can readily be seen for in the early days, and in fact until comparatively recent years, agriculture was very near the home and in the majority of cases the housewife herself was the manufacturer. The spinning-wheel, now so highly prized as a memento of the olden times, testifies to the fact that our grandmothers knew full well how to manufacture the clothing for their families. A closer look at these same days will show that they knew equally well how to prepare many food products and materials needed for household work.

As civilization has advanced the tendency toward the massing together of our population in towns and cities has gradually changed greatly the home life of the people. Agriculture no longer is carried on in proximity to the home, and large commercial establishments remote from the household now do the work that at one time was the daily duty of the housewife. Many such examples can be found. In our later study of the history of milling, we will find that among all primitive people, the woman was the miller, grinding each day the grain she was to make into bread; the preparation of the meal and breadmaking were practically one operation. Later on in the history of the human family, the making of meal and flour passed into the hands of the village miller, who ground the grain for the producers of his neighborhood, who in turn bought their sack of flour directly from him. As this business grew in size it gradually was moved further and further from the home, until the average housekeeper of to-day knows little of the mighty industry that is preparing the flour for her use. More and more each year, we find that the making of this flour into bread is in like manner passing into the hands of the modern manufacturer of bread. The old-time home-made loaf of bread is still found in isolated districts, but seldom in city life. In the preparation of alcoholic beverages we again find this marked change. As late as our own colonial days, every housewife knew how to prepare beer and wines and her reputation as a homekeeper was judged as much by the beer that she could brew, as by the loaf of bread that she could bake. The curing of meat and fish by salting and smoking, the drying of fruits and vegetables now are known only to the housekeeper in isolated sections of our country, for the city woman must depend on the manufacturer's supply. Even the preservation of our food by canning is rapidly passing into the hands of the canning industry.

These marked changes in our food preparation have brought new types of foods on the market and have greatly increased the variety. To the modern housekeeper, they have brought both advantages and disadvantages.

Advantages.—I. There has been a great lessening of household drudgery, giving an opportunity for broader interests and for more recreation than was known to our grandmothers.

II. In the majority of cases better products can be obtained for the methods of preparation used by the housekeeper were necessarily very crude. Manufacturers for financial reasons must give much study to their particular industry and new and better methods are constantly being sought. This has led to improved sanitary conditions and a standardizing of the quality of the product.

III. In recent years there has been a great extension of the open season; fresh fruits and vegetables are now quite common in the city markets the year round. The variety of food has been also increased by canning.

IV. Great improvements have taken place in the science of agriculture leading gradually to the raising not only of better products but to the increase in the area of production, of products which formerly were obtainable only from a limited section, as oranges and other fruits, sugar from the beet and wines.

V. New and improved methods of food preservation have been largely studied as canning and the use of cold storage.

VI. The co-operation with scientists has led to protection against certain diseases as tuberculosis from meat and milk, typhoid from the oyster, trachina from pork, etc.

VII. Articles of food are now put up in better and more sanitary packages and better packing material is being used.

Disadvantages.—I. The cost of living has been greatly increased.

a. Foods may be roughly divided into permanent and perishable material. Among the permanent foods, the cost has decreased, as sugar and flour. The great advance in price of our food material is found entirely in the perishable foods. Such material is now often brought from a long distance, thus adding cost of freight and many times the cost of preservation during transportation. The many hands through which food material must pass also increases the cost.

b. Packages are sometimes used without enhancing the value. Many times this means that the actual weight of the food material is less than the housekeeper supposes as the weight of the box or package is included.

c. The open market has led to expensive tastes. Luxuries look attractive and the cost is great where such products have been brought from a distance.

II. The women of our country represent about 90 per cent. of the retail buyers in food products. A lack of knowledge and many times of interest have led to great deception on the part of some manufacturers.

a. Until the Pure Food Law went into effect, there was a great amount of adulterated material put on the market and preservatives were most freely used.

b. The substitution of cheaper products with intent to deceive the purchaser was also a common practice. Butter substitutes were sold as butter, cottonseed oil as olive oil, apple jelly as currant, canned herring as sardines, potted veal for chicken, and the like.

c. Following these evils there gradually crept in the custom of printing misleading statements on the outside wrappers as to the effect and food value of the contents. Much advertising was done also giving these false impressions.

Had the modern housekeeper possessed the knowledge of her grandmother as to the production and manufacture of food material she was buying, manufacturers would not have found it advantageous to practice such frauds for so long a period.

The United States Government has for many years been studying and experimenting along these lines, and bulletins have been printed which can be procured free or at a very small cost, yet comparatively few housekeepers seek such information. This lack of knowledge and interest led the faculty of the School of Practical Arts, Columbia University, to introduce many years ago, into its domestic science course, a study of the manufacture of food material, hoping that a more extended knowledge of this subject would lead to greater interest and more intelligent buying on the part of the modern housekeeper.

In connection with the following course of lectures, excursions should be taken as frequently as possible to manufacturing establishments, where processes and methods can be studied and sanitary conditions noted. Wherever such excursions are not practical, illustrative material and demonstrations should be most freely used, accompanied whenever possible by the use of the stereopticon and moving picture slides.

CHAPTER I.

FOOD PRINCIPLES.

Food principles are types of chemical compounds differing in exact composition but of equal energy value. They are reducible to similar forms by the process of digestion.

Functions.—Food has two important functions: first, to supply tissue for the growth of the young child, and since life's processes are continually breaking down this body structure, to supply needed material for its repair; second, to furnish the organism with fuel which in burning gives power to carry on life's activities; the heat produced is utilized to maintain the temperature necessary to the organism.

Conservation of Energy.—Locked up in the resources of nature is a vast wealth of energy. Man has only to seize this energy and convert it into a form which he needs. Thus we find wood, coal, petroleum and natural gas being utilized to give heat and light. Should the energy be contained in a compound which can be finally assimilated by the human body he can accept it as a food.

Elements in Food.—Nature does not always give us these foods in a simple state; many of them are quite complex in their nature. When analyzed, however, it has been found that even the complicated forms are composed of the most common elements as carbon, hydrogen, oxygen, nitrogen, with a small amount of sulphur, phosphorus, iron, calcium, etc.

Food Principles.—Although these elements may be differently combined, they can be divided into groups which are called the five food principles:

1. Water composed of hydrogen and oxygen.
2. Carbohydrates composed of carbon, hydrogen and oxygen.
3. Fats composed of carbon, hydrogen and oxygen.
4. Protein composed of carbon, hydrogen, oxygen, nitrogen, sulphur, generally phosphorus, sometimes iron, etc.
5. Mineral matter—as sodium, potassium, calcium, magnesium, iron, sulphur, phosphorus, chlorine, and minute quantities of iodine, fluorine and silicon.

Examples of Each Group.—Among the carbohydrates we find such well-known foods as starch, sugar, cereals and vegetables. Fats may appear in different forms as liquids, semi-solids and solids, represented by olive oil, butter and suet. Protein in its most concentrated form occurs in the white of egg, large amounts being also found in meat, fish, cheese, eggs and milk. Usually we look to animal life for our protein supply, although it occurs also in the vegetable kingdom, relatively large amounts being found in beans, cottonseed meal, peas, lentils and smaller amounts in wheat, maize and other cereals. The vegetable kingdom supplies mankind with most of his carbohydrate food, animal carbohydrate occurring only in such forms as milk-sugar, glycogen and glucose. Fat occurs frequently in both animal and vegetable life.

Function of Each Group.—Although all of the food principles have nutritive value each group has its own special function. This work may be: first, directly building tissue; second, giving energy and heat; third, making it possible for other groups to carry out their special function. The great work of building tissue and gradually repairing it as it wears away can be performed by protein and inorganic matter, water always assisting in this work. The other food principles cannot build tissue; therefore, protein, mineral matter and water are absolutely essential to life. None of the three is alone sufficient. The work of producing energy is done by all the food principles, although only in a very limited sense by mineral matter.

Tissue Builders:
- Protein.
- Mineral matter.
- Water.

Energy Producers:
- Protein.
- Carbohydrate.
- Fat.

Protein alone is able to fulfil both of these functions of foods; for this reason it is of vast importance in the diet. Without protein life is impossible for any length of time for the wear and tear on the tissue must be replaced. With protein assisted by water life can be maintained for some time. In many classifications only four food principles are given, protein, carbohydrate, fat and mineral matter, water being omitted. It is claimed that water cannot build tissue, neither does it supply the organism with fuel from which to produce heat and energy; therefore, it cannot be called a food principle.

Importance of Water.—Whether this statement be true or not, tissue building and, in fact most of life's processes, cannot go on without the presence of water. Blood is the great carrier of the system and there water is essential. It acts as an eliminator, washing out the tissues and carrying away waste matter loitering there. Water acts as a chemical agent. It has the power of dissolving substances, is essential to hydrolysis and can, therefore, assist in bringing about such chemical changes that otherwise useless food can eventually become part of the living organism. Its services to all forms of life cannot be over-estimated. Whether we regard it as merely a chemical agent or as a true food, next to the atmosphere we breathe it is the most essential thing in life.

CARBOHYDRATES.

In order to obtain the necessary amount of heat and muscular energy it is necessary to supply the body with fuel. This work is done largely by the carbohydrates, a group containing carbon, hydrogen and oxygen. The hydrogen and oxygen occur in the same proportion as in water, and the carbon as six or some multiple of six in most of those forms utilized as human food. The carbohydrates owe their value as a fuel very largely to the carbon which on oxidation gives off much heat energy. They are found in a large variety of foods: flour, meal, cereals, sugar, starch, vegetables and fruits. Sometimes they appear in simple forms which can easily be made use of by the organism; at other times so complicated is the molecule, that only after many chemical changes do they assume a form simple enough to pass through the membrane of the intestines. From the standpoint of nutrition the alimentary canal must be looked upon as outside the body, the lining of this canal being the outer coating of the body proper. All foods, therefore, must be reduced to chemical compounds which are capable of passing through the walls of the intestines before assimilation. The most important properties for assimilation are solubility and osmotic power. Those carbohydrates which cannot be reduced to forms having these properties cannot be utilized as food.

Classification.—

I. Monosaccharids or Simple Sugars, $C_6H_{12}O_6$.
- Glucose or grape sugar, formerly called dextrose.
- Fructose or fruit sugar, formerly called levulose.
- Galactose.

II. Disaccharids or Double Sugars, $C_{12}H_{22}O_{11}$.
- Sucrose or sugar.
- Maltose.
- Lactose or milk sugar.

III. Polysaccharids or Complex Sugars, $(C_6H_{10}O_5)_n$.
- Cellulose.
- Starch.
- Dextrin.
- Glycogen.

Formation of Carbohydrates.—The monosaccharids or simple sugars are built up in the leaf of the plant, by the absorption of the carbon dioxide and water of the atmosphere. With the assistance of the chlorophyll cells of green plants and the energy of the sun's rays, the following compounds are formed in the leaf:

$$H_2O + CO_2 \rightarrow HCHO + O_2$$
$$6HCHO \rightarrow C_6H_{12}O_6$$

Glucose, $C_6H_{12}O_6$, is soluble and diffusible so it can pass from one part of the plant to another. When this material is to be stored as reserve food for the plant, water is withdrawn and starch, an insoluble and colloidal compound, is formed:

$$nC_6H_{12}O_6 \rightleftharpoons (C_6H_{10}O_5)_n + H_2O.$$

Occurrence.—Glucose is an important simple sugar widely distributed in nature, and is found to a great extent in the same plants as contain sucrose. Grapes contain about 20 per cent., hence the common name grape sugar. It occurs also in sweet corn and most of the garden vegetables and fruits. In animal life it occurs in small quantities in the blood, 0.1 per cent., where it is constantly being burned to produce energy. Where the body has more or less lost the power to burn glucose as with diabetes, it accumulates and is finally eliminated by the kidneys.

Fructose is usually found associated with glucose. It occurs in the juices of sweet fruits, the largest amount being found in honey.

Galactose is not found in nature. It occurs only in the splitting of lactose or milk-sugar during the process of digestion.

Sucrose is the most important of the sugars as it is the ordinary crystallized sugar of commerce. It is found widely distributed in the vegetable kingdom in the fruit and juices of a variety of plants, many times occurring in relatively large amounts as in the pineapple, strawberry and carrot. It is extracted commercially from the sugar cane, the sugar beet, the sorghum cane, the date palm and the sugar maple.

Maltose never occurs in nature in large quantities. It is the carbohydrate which is formed from starch during the germination of seeds. As a commercial product it plays an important part in the brewing industry, in the so-called malted breakfast foods and in malted milk.

Lactose occurs in the milk of all mammals usually from 3 to 7 per cent. It is the most abundant of the animal carbohydrates.

Cellulose or crude fiber constitutes the framework of all vegetable tissue, so we find it widely distributed throughout the vegetable kingdom. It occurs in wood, linen, cotton, hemp, flax and paper. Much of our food as cereals, vegetables and fruit contain cellulose, but as it cannot be made soluble in the organism it has no food value. Other forms of life can utilize it, however, and we find it serving as food for insects and bacteria.

Starch as it is found in nature is also insoluble and indiffusible, but here we find a carbohydrate which can be changed to a simpler form within the alimentary canal. It is found largely in vegetables where it is stored as food for the plant.

Dextrin or, as it is commonly called gum, is formed from starch by the process of hydrolysis. In nature it occurs in germinating cereals.

Glycogen is often spoken of as the animal starch, although it more closely resembles dextrin. It is found to the largest extent in shell-fish, especially the scallop. It is also abundant in the muscle and liver of both higher and lower animals, where it is stored and ultimately utilized as a source of muscular energy.

Important Properties.—Among the most important properties of the carbohydrates are found solubility, diffusibility, hydrolysis, crystallization and action on polarized light.

Hydrolysis.—This important property occurs repeatedly in the changing of complicated forms of food material, to such simple forms that they can be utilized by the organism. It has been defined by Alexander Smith as "A double decomposition involving water" and by other well-known chemists as "A simplification with absorption of water." Changes taking place during hydrolysis are always brought about by certain agents, which do not themselves enter in any way into the compound being formed. These agents may be heat, dilute acid, bacterial action, enzyme action, etc. The action always takes place in the presence of water, both the water molecule and the complex carbohydrate molecule breaking down to form a new carbohydrate molecule in which the hydrogen and oxygen appear in the proportion as in water.

$$\underset{\text{Starch}}{2C_6H_{10}O_5} + H_2O \rightleftharpoons \underset{\text{Maltose}}{C_{12}H_{22}O_{11}},$$

$$\underset{\text{Maltose}}{C_{12}H_{22}O_{11}} + H_2O \rightleftharpoons \underset{\text{Glucose}}{2C_6H_{12}O_6}.$$

Sucrose is a double sugar. When it breaks down under the influence of a catalytic agent it yields two simple sugars as

$$C_{12}H_{22}O_{11} + H_2O \rightleftharpoons \begin{array}{l} C_6H_{12}O_6 \text{ glucose,} \\ C_6H_{12}O_6 \text{ fructose.} \end{array}$$

A special name has been given to these two molecules, glucose and fructose. They are called invert sugar. This name has been given to them on account of their peculiar behavior toward polarized light. Before hydrolysis a sugar solution will rotate the plane of polarized light to the right, after hydrolysis to the left, hence the name invert sugar and the term inversion.

Hydrolysis also occurs in the digestion of fats and proteins.

FATS.

Composition.—True fats are composed of the elements carbon, hydrogen and oxygen. Little was known of how these elements were combined in the formation of fats, until the investigation by Chevreul in the early part of the nineteenth century. He discovered that they were essentially salt-like bodies formed together with water by the combination of an acid and a base. With the exception of some of the waxes the base is always the same, the triatomic alcohol glycerine, $C_3H_5(OH)_3$. The acid usually belongs to a series termed fatty acids and varies according to the fat. The three most common fatty acids are oleic, palmitic and stearic acid. Unless a fat or oil contains both glycerine and a fatty acid, it is not a true fat.

$$\underset{\text{Glycerine}}{C_3H_5(OH)_3} + \underset{\text{Oleic acid}}{3C_{17}H_{33}COOH} \rightleftharpoons \underset{\text{Olein}}{C_3H_5(C_{18}H_{33}O_2)_3} + \underset{\text{Water}}{3H_2O},$$

$$\underset{\text{Glycerine}}{C_3H_5(OH)_3} + \underset{\text{Palmitic acid}}{3C_{15}H_{31}COOH} \rightleftharpoons \underset{\text{Palmitin}}{C_3H_5(C_{16}H_{31}O_2)_3} + \underset{\text{Water}}{3H_2O},$$

$$\underset{\text{Glycerine}}{C_3H_5(OH)_3} + \underset{\text{Stearic acid}}{3C_{17}H_{35}COOH} \rightleftharpoons \underset{\text{Stearin}}{C_3H_5(C_{18}H_{35}O_2)_3} + \underset{\text{Water}}{3H_2O}.$$

Two or more of these fatty acids are generally present in all fats—mixed, not chemically combined. They differ in their physical nature. Olein is liquid at ordinary temperature and whenever this acid predominates, the fat appears in the liquid form as in olive oil. Palmitin is semi-solid; it predominates in butter and lard and is the largest part of the human fat. Whenever stearin is present in a relatively large amount, the fat is a solid as in suet and tallow.

Occurrence.—Fats are found widely distributed throughout both the animal and vegetable kingdoms. In plants the percentage varies to a great extent, approximately 1 per cent. being found in barley and 67 per cent. in Brazilian nuts. Fat usually occurs in inverse ratio to the starch. It is often difficult to extract as it is deposited throughout the plant; no part seems to be entirely wanting in fat. In animal life fats are present in all tissues and organs and in all fluids, with the exception of the normal urine. Large quantities are found in the abdominal cavity surrounding the kidneys, and beneath the skin of marine animals or those living in cold climates. Being present often in large quantities, it is very easy to extract.

Properties.—The most important properties are solubility, change of state, crystallization, drying and non-drying, emulsification and saponification.

Solubility.—Fats are soluble in gasolene, ether, chloroform, warm alcohol and carbon disulphide. These solvents may be used for cleansing purposes, for extraction and removal of grease stains.

Change of State.—All fats have a definite melting point. They exist as liquids, semi-solids and solids according to the temperature. This property is taken advantage of in the extraction of fats and as a means of identification.

Crystallization.—All fats are highly crystalline. They form definite crystals and can be readily identified under a microscope. This has been of great value in detecting adulteration.

Drying and Non-drying.—Certain oils are oxidized when exposed to the air and are converted into thick gummy masses. These drying oils when applied in thin layers on a surface form a dry, hard, transparent film. They are used extensively in paints and varnishes as linseed oil. Some oils such as cotton-seed possess this property to a limited extent, while others as olive oil show no sign of drying even when exposed to the air for an indefinite period.

Emulsification.—Fats can be broken up in small globules by mechanical agitation. If these globules can be coated with a substance which will prevent them from running together, they will remain in suspension. Egg albumin is very frequently the agent used in making an emulsion; example—mayonnaise dressing. This property is taken advantage of in soap-making and in the cleansing of fatty material by means of soap. It always occurs as an early stage in the digestion of fats.

Saponification.—The process of splitting a fat into its constituents, fatty acid and glycerine, is termed saponification. It may be brought about by such agents as heat, mechanical agitation, bacterial action and use of an alkali. Saponification always occurs in the digestion of fats and in the process of soap-making.

PROTEINS.

Composition.—The proteins are very complex compounds differing greatly in composition and properties, but all are of high molecular weight. They are composed of carbon, hydrogen, oxygen, nitrogen, sulphur usually phosphorus, sometimes iron, lime, etc. As nitrogen compounds they play an important part in human nutrition, for they are essential to the growth of the living cells which make up the tissue.

Classification.—The following is a modification of the classification recommended by the American Physiological Society and the American Society of Biological Chemists.

- Proteins
  - Simple
    - Albumins
    - Globulins
    - Glutelins
    - Alcohol solubles
    - Albuminoids
  - Conjugated
    - Nucleoprotein
    - Phosphoprotein
  - Derived
    - Primary
      - Coagulated proteins
      - Meta proteins
      - Proteans
    - Secondary
      - Proteoses
      - Peptones
      - Peptids
- Non-protein
  - Extractives
  - Amides
  - Amino-acids

Occurrence.—Albumin is found in both plant and animal life. It occurs most abundantly in the white of egg, where it coagulates on being cooked in boiling water and becomes a hard white mass. It appears in milk as lact-albumin, in egg as ova-albumin, in fluids of the animal body such as muscle and blood as serum albumin. A small proportion of the protein of plant life occurs as albumin.

Globulin is very similar to albumin, but differs from it in solubility. It occurs in both plant and animal life, but is far more abundant and wide-spread in plant tissue. Globulin is found in large proportion in hemp-seed, flax-seed, and in the seeds of the legumens. Animal globulin occurs in muscle and blood.

Glutelins are nitrogenous compounds found in the cereal grains. The most familiar example is the glutenin of wheat. Alcohol solubles is a form of protein also found in cereals. The principal one is the gliadin of wheat. Glutenin and gliadin in the presence of water form the well-known substance gluten.

Albuminoids occur in the skeleton of the body as the connective tissue, bones, hair, nails, hoofs and horns. It is that form of protein which yields gelatin on cooking.

Nucleo-proteins are complex proteins which are believed to be combinations of one or more protein molecules with nucleic acid. They are closely associated with the nuclei of cells in both plant and animal life and occur most abundantly in asparagus tips, the hearts of lettuce and internal organs such as liver, heart, kidney and pancreas. In the clearage of the molecule during digestion true nucleo-proteins are believed to yield uric acid.

Phospho-proteins are proteins closely combined with mineral matter as phosphorus and sulphur. The most familiar examples are the caseinogen of milk and the vitellin of egg.

Protein Hydrolysis.—As in the carbohydrates, protein must undergo hydrolysis or a simplification before such compounds can be assimilated by the body. This change involves a breaking down of the protein molecule, and the taking up of the elements of water, under the influence of agents such as heat, dilute acids or alkalis, bacterial action and enzyme action. The products formed are known as derived proteins. Primary derived proteins are those which have been only slightly modified, secondary derived forms those having been more completely acted upon by the hydrolytic agent. In this way are formed coagulated proteins, meta-proteins, proteoses, peptones and peptids. Peptones for a long period were believed to be the final product of enzyme action in digestion, but that action is now believed to be continued to the amino-acid.

Extractives.—The name extractives has been given to a body of substances which can be extracted from meat by the action of cold water. The most important are creatin and creatinin. Although nitrogen compounds, they are not capable of building tissue and it is believed that they have little or no food value.

Properties.—Among the more important properties of the proteins are solubility, curdling, coagulation and clotting.

Solubility.—Albumin is soluble in cold water; gelatin swells and all other proteins are insoluble. All proteins are soluble in dilute sodium chloride, and with the exception of albumin, all are insoluble in saturated sodium chloride. All proteins are insoluble in saturated solutions of ammonium sulphate.

Curdling.—Curdling is a change which occurs in connection with conjugated proteins such as the caseinogen of milk. It is the precipitation of a soluble matter by means of an acid, without serious chemical change.

Coagulation.—Albumins and globulins are made insoluble by heating to about 158° F. In concentrated solution such as the white of egg, solidification is caused throughout the mass. This is a chemical change always brought about by (1) heat sometimes with the aid of dilute acid or (2) the action of alcohol.

Clotting.—The term clotting is applied to conjugated proteins, when the molecule is split by means of an enzyme into two simpler proteins, for example,—caseinogen under the action of rennet is split into casein and para or pseudo-nuclein.

CHAPTER II.

WATER.

In chemical language we speak of water as a compound containing the elements hydrogen and oxygen, in the proportion of 2 to 1 by volume and 1 to 8 by weight. Such a compound, however, is never found in nature and the term as repeatedly used "pure water" is generally accepted, as meaning a water free from harmful ingredients and which can, therefore, be utilized for drinking and other household purposes; contaminated or polluted water contains material injurious to health.

Classification of Natural Waters.—

- I. Atmospheric
  - Rain—Contains very little dissolved solids but dust and gases of the atmosphere.
  - Snow
  - Fog
- II. Terrestrial
  - Sweet
    - Surface—Cloudy, usually a large amount of suspended matter, minimum of dissolved.
    - Underground—Clear, minimum of suspended matter, maximum of dissolved.
  - Salt
    - Brines—Over 5 per cent. soluble salts.
    - Sea water—3.6 per cent. solids.
    - Mineral—Excess of unusual mineral matter and gases.

It is known as the universal solvent; there is scarcely a substance existing which is not more or less soluble in water. Hard rock can be gradually worn away by its action, and glass, one of the hardest of known substances, will gradually dissolve. All natural waters are found, therefore, to contain foreign matter, gases and solid material of the atmosphere and earth, either dissolved or in suspension. Sometimes these materials occur in small amounts, at other times in relatively large proportions. The nature and amount of these gases and solids have a considerable influence on the effect of water to be used for household purposes.

The two great uses for water in the household are for drinking and for cleansing purposes. There is a standard to estimate the purity of each. For detergent purposes, the amount of mineral matter present plays an important part, while for drinking, organic matter received directly or indirectly from sewage or industrial waste, constitutes the chief danger. A safe water supply should be reasonably free from objectionable mineral and organic matter.

WATER SUPPLY.

Historical.—Even in remote antiquity a high value seemed to have been placed on an abundant water supply, and a keen appreciation existed of the danger should such a supply become contaminated. Settlements were made and communities grew near the source of available water, which many times was looked upon as a blessing bestowed by the gods. In districts where water was not abundant courses were constructed with much expenditure of time, money and labor to carry it from a distance where water was found to be pure and naturally plentiful. Such courses were built by the ancient Romans, where water could proceed by gravity from the distant mountains to the city where great reservoirs were built for its storage. These reservoirs were still in use during the middle ages and the ruins to-day show how well they had been constructed.

Methods of irrigation were used early in the history of the world, for reservoirs were known to have existed in Egypt before 2,000 B. C. They were utilized for the purpose of receiving and storing the surplus water during the annual inundation of the Nile, the stored water being used for irrigation during seasons when the river failed to reach the crops.

Pumping as it exists to-day was unknown among the ancients, but curious devices were constructed for the elevation of water, the ruins of which can still be seen in some parts of the Old World. One of the greatest curiosities of Zurich is the pump invented and erected by a tin-plate worker of that city. It consists of a hollow cylinder like a very large grindstone turning on a horizontal axis, and so constructed as to be partly plunged in a cistern of water. This cylinder is formed into a spiral canal by a plate coiled up within it like the main-spring of a watch in its box.

Bucket lifts in different forms seemed to have been employed the world over from the remotest historical times. In oriental countries an earthen pot attached to a rope wound around a windlass was used. Another form was the scoop-wheel composed of a series of curved blades, terminating in a hollow axle into which they discharged the water scooped up by the revolution of the wheel. A series of buckets was sometimes arranged around a huge wheel which in revolving scooped up the water. The well sweep or bucket and balanced pole, still frequently seen in certain rural sections of America, were water elevators of the same simple construction and principle.

The displacement pump acting on the principle that two bodies cannot occupy the same space at the same time finally took the place of the bucket lifts, and in the sixteenth century we find pumps being introduced into Germany and France. A little later than this Paris constructed a filtering plant. Methods of purification, however, had been studied much earlier for we read that 400 years before the Christian Era, Hippocrates had advised boiling and filtering drinking water should the supply become contaminated.

Classification of Potable Waters.—

I. Atmospheric.
II. Surface.
III. Sub-soil { shallow, deep.

I. *Atmospheric.*—Rain is the original source of all natural water. It results from the water-vapor rising from the earth, being condensed in the upper air and again falling to earth. In its descent it to a great extent purifies the atmosphere by taking up ammonia, carbon dioxide and other soluble gases and by washing down solid matter as dust, soot, industrial waste and disease germs. Near the seacoast, rain water is found to contain an appreciable amount of salt dissolved in it. In districts containing a number of inhabitants and factories rain water is never pure, for even after prolonged washing the atmosphere is still more or less impure. This is not true in the open country for there after the air has been purified by the first rain that falls, the water can be collected and stored. This is the purest form of natural water known.

Stored rain should only be used where natural water cannot be obtained pure enough for household purposes. In collecting rain the first flow should run to waste, thus avoiding contamination by dirt, soot and other impurities washed from the atmosphere and from the surface on which the water is collected. Such water should be filtered and great care should be given to the storage. Cisterns should be so constructed that they will be absolutely impervious to surface drainage, and so that they can easily be inspected and frequently cleaned. The best materials for building are brick, stone, cement and slate. They should be kept covered to prevent impurities from falling in and to exclude light. This will prevent the development of low forms of plant life.

II. *Surface Water.*—After reaching the earth a portion of rain water runs over the ground to join streams or larger bodies of water. Of these waters lakes and rivers form an important source of our water supply. They are known as surface waters. The composition varies greatly according to the character of the soil over which they flow. Should the soil be rocky a portion of the mineral salts would undoubtedly be added to the water, but it would be more or less free from organic impurities. If the water comes in contact with swampy land it will be very rich in organic matter. The character of these waters varies also according to the uninhabited or settled condition of the locality. Water from a clear lake or river, exposed to the sunlight and air, is one of the safest of water supplies in a thinly populated region. Such bodies of water, however, become highly polluted should they receive the drainage of city or town life. From every point of view running streams should be kept free from organic matter if they are to be used as a water supply.

III. *Subsoil Water.*—The portion of rain water which sinks into the ground is known as subsoil or ground water. It is used as spring water and shallow or deep well water. Subsoil water is greatly changed by the character of the earth through which it percolates. It passes to various depths according to the porosity of the soil and the arrangement of the strata. When it reaches an impervious formation it accumulates upon the level. In its descent to the earth and again in the soil, water dissolves more or less carbon dioxide. The presence of this gas greatly assists in dissolving mineral constituents of the soil. Thus we find in limestone regions a large amount of calcium carbonate in the water supply, making the so-called hard water. This greatly influences water to be used for detergent purposes. Rain water percolating through the ground may be changed also in regard to its purity as a drinking water. As it enters the soil it carries with it whatever organic matter it has dissolved from the atmosphere. In the upper layer, it again dissolves organic ingredients and becomes impregnated with micro-organisms, through the agency of which the organic matter undergoes very important chemical changes, gradually bringing about the purification of the water. Water which has percolated through the earth makes a very safe drinking supply, unless there is special contamination due to admixture with sewer drainage which contains excretory products.

Shallow wells are much more likely to be subject to pollution of this kind. As a rule deep wells, 700 feet or more, are not apt to be dangerous, but they are usually higher in mineral substances than surface waters.

Pollution of Wells.—The chief danger to the water supply comes from earth closets, cesspools and house-drainages. To avoid expense in construction, too often the well and cesspool are built comparatively near together. The bottoms and sides of the old-fashioned cesspool were usually left open, to allow the house sewage to drain into the surrounding soil. Such conditions are a great source of danger and it is hoped that the septic cesspool will be more universally constructed in the future. In the septic cesspool, purification takes place by bacterial action and the water is not allowed to drain from it until it has been more or less freed from dangerous material. As regards location it is a common belief, that if the well is built on slightly higher ground than the earth closet or open cesspool there can be no danger of pollution. This is a false impression, however, for it is not so much the location that determines the possibility of pollution, as the relative position of the cesspool and the point where the water enters the well. Great carelessness has very often been shown in this direction by the property owner, who has little regard for the rights of his neighbors unless compelled by legal restrictions. His own water supply may be carefully guarded, but the cesspool may be so located as to be a serious source of danger to neighboring wells.

Contamination of Public Supplies.—Much trouble has been caused in the past by the same carelessness in regard to larger supplies, that is, the location of earth closets and cesspools along the watershed of a public water course. This utter disregard of the rights of others has been practiced by communities as well as individuals. The municipal supply furnished to the larger cities and towns is often drawn from great bodies of surface water, as lakes and rivers. Here there is great opportunity for gross neglect of sanitary conditions. Steamships and sailing vessels make a practice of discharging their waste matter into the water. Manufacturing establishments along the banks add to the pollution. The greatest danger, however, comes from looking upon rivers as a convenient receptacle for the disposal of sewage, for as it has often been said by Mrs. Richards, "It is only after contamination with the waste of human life that danger comes to other beings." Many epidemics of typhoid in the New World and of cholera in the Old World have been caused by using the same body of water, as a water supply and as a means of disposing of refuse. One town may take its water from a point above and discharge its sewage at another point below, a second town farther down the river takes the already contaminated water for drinking purposes, and in its turn discharges the sewage at another convenient point.

Danger of Impure Water.—Hutchison in his *"Foods and Dietetics"* tells us that water is not absorbed by the mucous membrane of the stomach; it begins to flow into the intestines at once. The rapidity with which water passes through the stomach causes it to be a very dangerous vehicle of infection, for the hydrochloric acid of the gastric juice has not the opportunity to act upon any disease bacteria which it may contain. Once in the intestines pathogenic bacteria find an alkaline medium which is most favorable for their growth and reproduction. For this reason it is quoted that "Contaminated water is a more obnoxious carrier of disease than impure milk." Too much care cannot be given that our water supply be above suspicion.

While it is the duty of a city or town to supply a safe drinking water, to properly construct and maintain reservoirs and filtering plants, and to provide police surveillance for the water shed, it is also the duty of every citizen in such a community to cheerfully pay the necessary expense for its maintenance, and to guard his neighbors' rights as his own. Education of the people at large on this subject is one of the essentials of modern life.

Diseases from Water.—The presence of mineral matter quite frequently causes temporary intestinal derangement. This is more apt to be true with the visiting stranger to a community than with those accustomed to its use. The change from a soft to a hard water disturbs digestion and frequently causes constipation, while the change from a hard to a soft water may bring about diarrhœa. Organic pollution from vegetable origin has also been the cause of many mild epidemics of diarrhœal troubles. It is, however, to the typhoid and cholera bacteria that the world has owed its death destroying epidemics.

Cholera has its home in India and has been largely kept alive and scattered in all directions, by the pilgrimages taken to such sacred rivers as the Ganges. The pilgrims from all parts of India travel in large companies for hundreds and even thousands of miles. Exhausted, filthy and many times diseased at the end of their journey, it is their custom to bathe in and drink of the sacred waters. Poorly fed and sheltered in the midst of the most insanitary conditions, it is little wonder that a cholera epidemic is soon started and by returning pilgrims is carried to all parts of the country. The European and American nations hear with horror tales told of cholera in India, and yet although more enlightened and understanding more fully sanitary conditions, Europe and America have repeatedly been visited with typhoid epidemics. It has been said that we have not advanced far in civilization, when we have not yet learned as a nation to take care of the excreta from our own bodies. Not until the end of the nineteenth century were authorities fully awakened to this subject, and there is still much work to be done in this direction.

PURIFICATION OF WATER.

Public Methods.—With the constant increase in our population and the modern tendency toward city and town life, a pure water

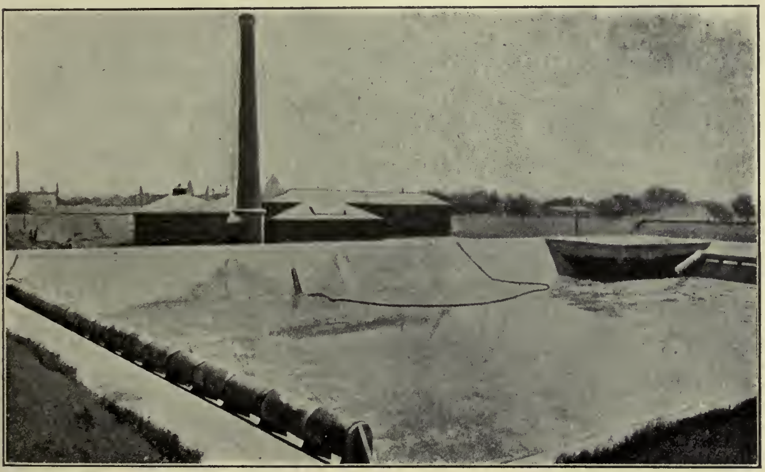


Fig. 1.—Sedimentation Basin.

supply has become almost an impossibility. The most that we can demand now is a safe water. Large sums of money have been used and much experimentation has been carried on of late years to determine the best methods of purification. Several very efficient methods have been discovered and are now in use, but which is best seems to depend on local conditions. The most important public methods are bacterial action, filtration and the use of chemical agents.

Bacterial Action.—This method is used largely in England and is commonly spoken of as the English Filtering System. It con-

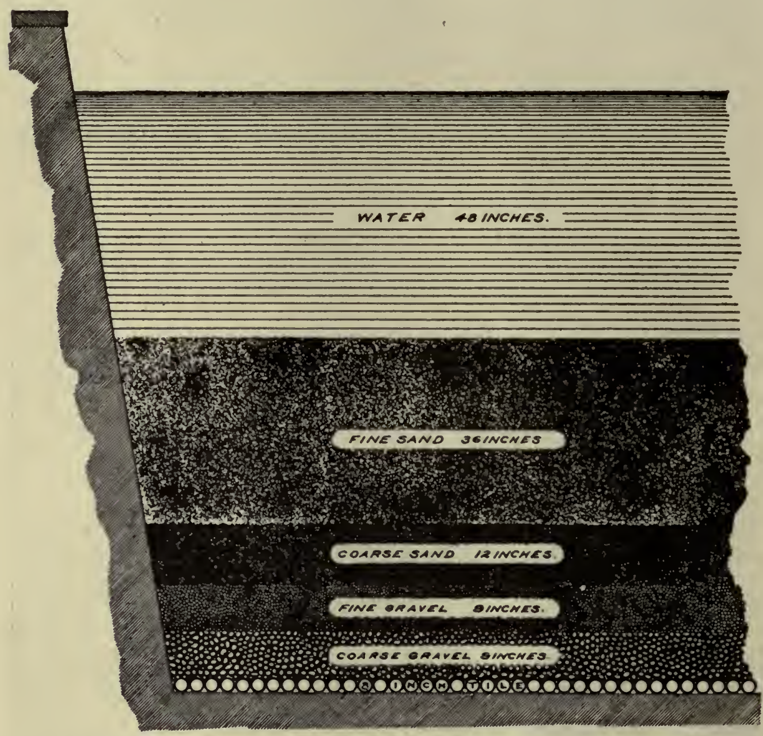


Fig 2.—Section of an English Filter Bed. (Courtesy of John Wiley & Sons.)

sists of a filtration through sand-beds which are filled with putrefactive bacteria. Water to be filtered is usually run into a sedimentation basin first, in order to allow suspended matter to settle (Fig. 1). This will prevent a too rapid clogging of the filtering beds if the water is materially turbid. After sedimentation has taken place, the water is delivered into the top of the

Fig. 3.—Cleaning London Filter-beds. (Courtesy of John Wiley & Sons.)

beds which are built of stone or concrete and have drainage pipes at the bottom, to discharge the filtered water into wells. In the beds are placed from the bottom upward layers of coarse gravel, fine gravel, coarse sand and fine sand (Fig. 2). The water percolates through the layers of sand and gravel to the drainage pipes which carry it away to the reservoir. Soon a slimy growth containing bacteria occurs on top of the filter beds; these bacteria are the true purifying agents. For a long period after this system was put in operation, the purification was supposed to be entirely mechanical, then it was thought to be due to oxidation. It was discovered eventually that the filter beds failed to work thoroughly until the layer of slime had formed, and after much experimentation the purification was traced to bacterial action. The slimy mass acts as a mechanical agent, and through its bacteria causes the oxidation of organic matter and destruction of pathogenic bacteria. When the sediment layer becomes so dense that the required amount of water fails to pass through, it becomes necessary to clean the bed by the removal of the top layer (Fig. 3). The scraped-off sand can be washed by a machine and stored for future use. Several days are required for the formation of a new sediment layer before the filter bed once more becomes effective.

Filtration.—A system much in use called "The American Filter System" depends on the use of alum and filtration through sand. As in the English System the water to be filtered is first run into a sedimentation basin, after which potash alum or aluminium sulphate is added, 1/10 to 1 grain per gallon. The water is then admitted to a filter which is cylindrical in shape, made of wood or iron and is filled three-quarters full of fine sand (Fig. 4). Alum will readily ionize in water forming a heavy white flocculent precipitate of aluminium hydrate, jelly-like in appearance.

$$K_2Al_2(SO_4)_4 + 3H_2O \rightarrow Al_2(OH)_6 + K_2SO_4 + 3H_2SO_4.$$

The precipitate collects on the top of the sand as the water filters through. The action of this mass closely resembles the clarifying of coffee with egg albumin. It entangles all suspended matter which may be purely inorganic or living organisms and deposits them on the surface of the sand. The jelly-like layer then acts mechanically much as the bacterial layer of the English filter-beds.

Use of Chemical Agents.—Chemical treatment has been long used as a means of purifying water and has been found very efficient in periods of epidemics. Permanganate of potassium has been used in India during cholera epidemics. This acts as an

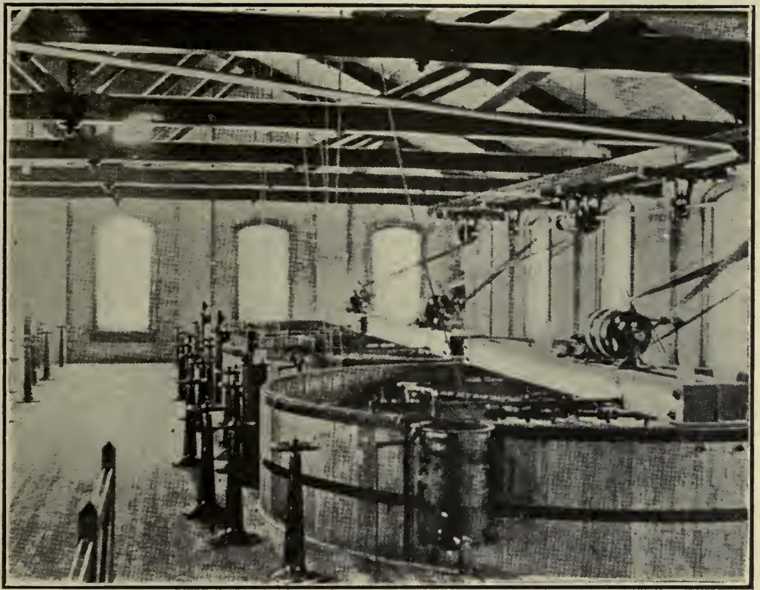


Fig. 4.—View of the Interior of the East Albany, N. Y., Filter-plant. (Courtesy of John Wiley & Sons.)

oxidizer of the organic matter in water and then attacks the bacteria, Sodium hypochlorite, chlorine and bromine are also effective in destroying micro-organisms. Perhaps alum is the agent most commonly employed for purifying water. It was first used in Egypt during the time of Napoleon to clarify the muddy water used by his army. As it has been previously described, alum will form a precipitate carrying down all suspended matter and will greatly improve the appearance of water.

This method of purification is used quite extensively in public baths. For drinking purposes it should only be used in small amounts. Where alum has been used to throw down coagulated matter, it increases the hardness of a naturally hard water. In order to overcome this hardness, sodium carbonate is added in amount calculated to precipitate all as carbonate of lime.

Household Methods.—Where public methods cannot be depended upon or in times of special contamination, it is often necessary for the householder to purify his water supply. The most common methods are boiling and the use of domestic filters.

Boiling.—Boiling is the oldest and simplest way of purifying water. It has been used from the earliest times and is still one of the most effective methods that we have. As the chief danger of a polluted water comes from the typhoid bacillus, whose thermal death point is below the boiling point of water, prolonged boiling is not necessary. Boiled water is not palatable as the air has been driven out. It is well to cool and pass it from one vessel to another or to agitate it in contact with the air to restore the original taste.

Use of Domestic Filters.—Most of the many varieties of house filters remove only dirt, iron rust and other coarse particles in suspension. They are usually small in size and contain a comparatively small amount of sand or charcoal. While sand is effective on a large scale and charcoal is a well-known deodorizer and clarifier, the amount is not enough to affect a large quantity of water run through them, with the pressure of the ordinary city supply. In a very short time these filters become impregnated with bacterial life, the growth and development of which soon make them a dangerous medium through which to pass water. Effective filters, however, can be bought, but at a much higher price than the ordinary house filter. The Berkefeld (Fig. 5), Pasteur-Chamberland and Aqua Pura are filters of this type. The filtering medium in the first two is unglazed, well-baked porcelain, and in the latter, sandstone. Both of these media are capable of holding back micro-organisms as well as suspended matter. Great care must be given these filters to have them work effectively. Bacteria soon cover the filtering surface and must be cleaned off by scraping or scrubbing. Most filters of this type also require sterilization by baking, boiling or sub-

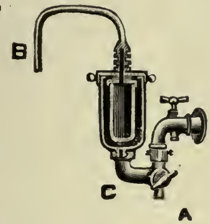


Fig. 5.—The Berkefeld Filter.

jecting them to live steam. Unless the housekeeper is willing to give the filter proper care it is far safer to simply boil the water.

Manufacturers' Method.—Boiling on a large scale has been

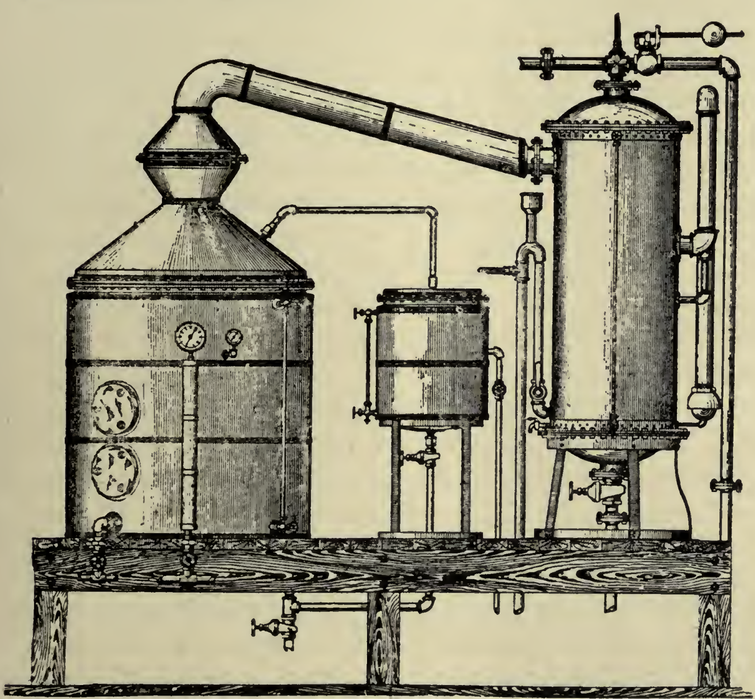


Fig. 6.—Distillation Apparatus. (Courtesy of Carl H. Schultz Co.)

found so troublesome, that most manufacturers who must purify water before using it prefer the method of distillation (Fig. 6). Here water is raised to the boiling point, passes off as steam to another receptacle where it is condensed. This produces a sterile water as bacteria do not pass over in the distillate. It, however, is tasteless and needs aeration.

Self-purification.—In the examination of surface waters, it has frequently been found that water taken from a river at a given point contains a certain amount of impurities; at another point farther down there is considerably less, while at a still greater distance it is practically pure. This is supposed to be due to the fact that water can in time bring about its own purification. It is accounted for in several ways: first, the water becomes diluted; second, changes take place due to oxidation and bacterial action; third, sedimentation; fourth, purifying influence of algæ and other low forms of vegetable life.

Could these agents always be relied upon there would be no need of constructing and maintaining expensive filtration plants. Undoubtedly they produce great results in many cases, but at other times the purification is only partial while at times it is of no special value. There is great danger, therefore, in relying on water to purify itself. Conditions might exist or arise which would prevent these agents from doing their work. Where self-purification is used, every precaution should be taken by the local authorities to guard the entire water-shed from all possible contamination.

Judging a Water Supply.—In regard to a drinking water the world at large still retains the primitive idea, that purity in appearance alone is necessary in judging a safe water. Expert examination has shown that appearance alone is of little value. A pure water is generally bright and sparkling, but it has been found that some highly contaminated waters show remarkable brilliancy. On the other hand water may be distinctly muddy, owing to minute particles of clay or turbid from the effect of iron, and still not be dangerous. Neither can safety be judged by color and odor. Color may be due to traces of iron or to leaves and other such color imparting substances. The presence of color does not indicate that water is unfit for domestic use, neither does the absence of color indicate purity, for many polluted waters are colorless. Repulsive odors in water usually mean stagnation, presence of dead animals or other decomposing organic matter which makes it unfit for drinking purposes, but many odors may be present in water which are perfectly harmless as grassy or peaty odors. The only safe way of judging the purity of a water supply is by chemical and bacterial tests. The chemical examination usually made is for the presence of organic matter, and consists of the quantitative examination for the total solids, free ammonia, albuminoid ammonia, nitrites, chlorides and oxygen consuming power. Such tests to be reliable should not be made by the amateur, but by an expert chemist in a room set apart for this purpose.

Great care should be given in collecting a sample of water to be sent for examination, since careless handling would make the analysis worthless. If the bottles have not been provided by the chemist, a glass bottle or a demijohn which has been thoroughly cleaned and fitted with a glass stopper or new cork can be used. Details in regard to further directions for collecting samples, the significance of the tests and analytical methods can be found in *"Air, Water and Food"* by Richards and Woodman or other standard works on water analysis.

Ice Supply.—The taking of ice from polluted waters has been a subject much discussed of late years. Many micro-organisms including typhoid are not killed by freezing, and it is claimed by many scientists that such ice is dangerous if put into drinking water for cooling purposes. It is a well-known fact that cold storage food will deteriorate rapidly when taken from ice. This would not be true if bacterial life had been destroyed. It has been discovered, however, that after prolonged freezing most germs are practically harmless, and for that reason some scientists claim that ice is safe to use even if taken from a contaminated water. If there is any doubt of the ice supply, it is far safer to chill drinking water by placing it in bottles on ice, rather than by putting the ice directly into the water.

MINERAL WATERS.

The term mineral water is usually applied to spring water which contains a larger volume of gases dissolved in it, or more solid matter in solution than ordinary drinking water. It may, therefore, exert a different effect on the human body.

Classification.—Acidulous.
Alkaline.
Bitter.
Sulphur.
Chalybeate.
Acid.
Alum.
Borax.
Saline.
Lithia.

These mineral waters may be either natural or artificial.

Natural Mineral Springs.—Mineral springs have been found in many countries of both the Old and New World, and from the early ages have attracted much attention. They often present remarkable appearances when relieved from subterranean pressure by losing their gases with great rapidity. This often causes them to be thrown upward to a height of 20-40 feet accompanied by a hissing or rumbling noise. Some waters are icy cold while others are at a boiling heat. These and other phenomena led to many superstitious beliefs in the early ages, and these waters were supposed to possess supernatural properties. There is, however, nothing unnatural about their origin. Subsoil water containing a considerable amount of carbon dioxide may sink to great depths, and may be subjected to great pressure or even heat. Should such water find an outlet it would tend to escape with considerable force. Much of the dissolved matter undoubtedly is obtained from rocky soil through which the water has percolated. The solvent action of water, greatly increased by the presence of carbon dioxide and sometimes heat, may take from one type of rock certain acids which later react with basic elements dissolved from another rock, thus producing salts. Salts of lime, magnesium and iron are quite frequently found in these waters.

Occurrence.—Mineral springs have been found to occur most frequently in volcanic districts where there is much carbon dioxide and many mineral compounds. They also occur in many other parts of the world and there are but few countries where they have not been found. France, Germany, Italy, Spain, Greece, Asia Minor, United States, and Canada are rich in mineral springs, while they can also be found in Great Britain, Sweden, Norway and in many parts of Africa and the Orient.

Medicinal Power.—Mineral waters have been used as medicinal agents from very early periods. The pages of ancient authors frequently contain wonderful tales of their curative power, and records speak of resorts where the sick bathed in healing waters or drank of medicinal fountains. These mineral springs seemed to have played an important part in the religion of some nations, for the Greeks frequently erected their temples near such places, where their gods could be worshiped and their sick healed of whatsoever disease they had. In the pages of Latin writers we meet often with allusions to medicinal springs, and the splendor of the buildings erected in their vicinity in Italy testify to the esteem in which they were held by the Romans. This faith in the curative power has come down from these early times to the present day. How much they do really affect disease is a question of much interest to the modern physician. Great difficulty is experienced by investigators of the subject for it is hard to eliminate other circumstances which contribute to the cure of the patient. A different climate, possibly a change in altitude alone has a remarkable effect in many diseases. Different diet, complete rest, change in hours of going to bed and getting up, new and possibly cheerful society, relief from the harassing cares of business or demands of social life are obtained. Patients after a short period at these springs return to their homes much improved, many times entirely due to rest, recreation, more open-air exercise, regular habits, etc. It is hardly fair, however, to state that the waters have had no part

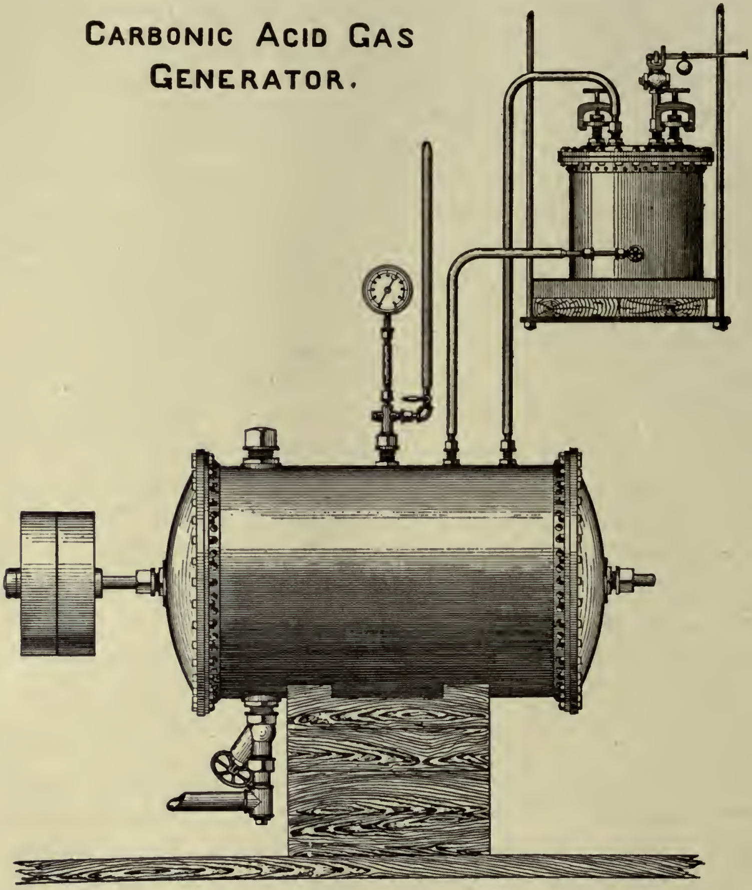


Fig. 7.—Carbon Dioxide Generator. By allowing sulphuric acid to flow drop by drop from the upper container into the lower tank which is filled with a solution of bicarbonate of soda, carbon dioxide gas is obtained. (Courtesy of Carl H. Schultz Co.)

in the benefits obtained. The feeling against these mineral springs or spas as they are frequently called has come largely from the quackery surrounding the resorts. The superstition of past ages gave to them the power of curing all diseases. This same "cure-all" style of advertisement is still largely used by proprietors of springs and local physicians in the hope of attracting large crowds, and has done much to bring odium on the spas and to disgust the modern scientist. Before taking these waters care should be given that the water is effective for the specific disease, and that sanitary conditions surrounding the springs have been carefully guarded. There is no reason to believe that mineral water will not become as highly contaminated as ordinary drinking water if exposed to sewage. It has long been a custom also to bottle and sell mineral waters, and should they be contaminated, disease can readily be carried to all parts of the country.

Artificial Mineral Waters.—In the latter part of the eighteenth century, Joseph Priestly suggested that an artificial aerated water could be made by charging water with carbon dioxide. The gas was obtained by the action of oil of vitriol on chalk.

$$H_2SO_4 + CaCO_3 \rightarrow CO_2 + H_2O + CaSO_4.$$

This carbonated water is still largely used, but most manufacturers at the present time prefer to use bicarbonate of soda as a means of generating the gas, as the soda compound being soluble is less troublesome (Fig. 7).

$$H_2SO_4 + 2NaHCO_3 \rightarrow 2CO_2 + 2H_2O + Na_2SO_4.$$

From this simple suggestion of Priestly has grown an industry for making not only carbonated water, but mineral waters closely resembling the natural mineral springs. By careful analysis of the spas, chemists have been able to combine mineral salts in the same proportions, thus giving an artificial water claimed by many to be as beneficial as the natural water. Care should be given, however, in the use of these waters that the firm placing them on the market is thoroughly reliable.

CHAPTER III.

THE KING OF CEREALS. OLD MILLING PROCESSES.

Taking the civilized world as a whole, both in the quantity produced and in its value as a human food, wheat has won the name of the world's King of Cereals. It is the cereal best adapted for bread-making and appears to meet the needs of civilized life more than the other grain foods. As the standard of living advances in a nation, wheat has grown steadily in commercial importance.

If there were time to look thoroughly into the history of this cereal, we should find that the growth and development of wheat has been interwoven with the very life history of the human race.

Origin.—It is impossible to tell how long it has been utilized as a food by mankind, for archæologists claim that its record began in prehistoric times. The most ancient languages mention it and the fact that it has been found in the earliest habitations of man is a proof of its antiquity. Specimens have been discovered in the Swiss lake dwellings and among the remains of Egyptian civilization. The Chinese claim that it was grown in their Empire over 3,000 years before the Christian Era and the Bible mentions its use as early as the Book of Genesis. If these accounts be true, wheat must have kept its place in man's diet for nearly 6,000 years. Such a record of long, faithful service could not be unless the grain of wheat had locked up within its kernel the elements which are most needed to maintain heat, and replace the energy and tissue which are constantly being worn away during life's processes. The savage in his hunger seemed to have instinctively turned to it as a food, and the wisdom of his choice can readily be seen by a study of its composition as given by Dr. H. W. Wiley, formerly of the United States Department of Agriculture.

Water	10.60
Protein	12.25
Fat	1.75
Fiber	2.40
Starch, etc.	71.25
Ash	1.75

Geographical Distribution.—The raising of wheat has so long been a practice with man that the geographical origin is unknown. Egyptians attribute its discovery to Isis and the Chinese claim to have received the seed as a direct gift from Heaven. It was at one time the custom for the Chinese Emperor to drive the plow in order to do homage to the dignity of agriculture. The belief that it originated in the Valley of the Euphrates and Tigris is more widely accepted than any other theory. Early it spread into Phœnicia and Egypt, finding a most suitable lodging place along the shore of the Mediterranean. The climate there was suited to its cultivation, dry and hot during the summer months. Italians as far back as the early Roman days obtained part of their wheat supply from the north of Africa, for that war-like nation was unable to produce enough wheat for its own consumption. Many of their warfares were for the purpose of capturing the harvest from their more successful wheat growing neighbors.

The migration of wheat from those early days was closely connected with the migration of the human race. Gradually spreading throughout Europe, it finally reached Germany, France and Great Britain, although this latter country has never been able to grow enough wheat to supply its population. Great Britain still obtains much of its wheat from countries where conditions are more favorable for the growth of this cereal. Extending into Russia, wheat once more found a suitable soil and climate which in time produced so large a supply, that Russia became known as "The Granary of Europe." That title she continued to keep until the famine of 1891-92 swept the country with a terrible scourge and from which she has never fully recovered. The failure of the crops during those years was caused not only by bad weather, but by the continued use of crude agricultural methods which in time thoroughly impoverished the soil. Should she use more up-to-date methods in regard to fertilizing, she might again regain that title, but the yield per acre at present is very small. The peasantry still cling to old methods slightly in advance of the Middle Ages. In Russia, there are still immense undeveloped areas that would make ideal wheat fields and much is being looked for in the Siberian wheat-growing area. It is difficult to predict, however, what part the Russian Empire will play in the wheat market of the future. The possibilities are very great, but many changes must first be brought about in the political and social condition of the people, for Russia is still sadly lacking in the institutions that are necessary to bring about progress and prosperity. Even with these great drawbacks Russia is still one of the greatest wheat producing countries of the world, largely due to the Siberian wheat fields.

When civilization moved westward, it was found that wheat could be grown in the New World for that cereal readily adapts itself to new environments. Starting along the Atlantic coast, it pushed farther and farther westward with the march of civilization, flourishing wheat fields shortly replacing the primeval forest. When the wheat line had reached Ohio it was thought by many European nations to have reached its limit on American soil. Warning was given to the Ohio farmer to care for the soil, for with the rapid growth of the United States it was feared that the population would soon outrun its wheat production. But the wheat line was not to stop; in the opening up of the northwest, this cereal was again to find favorable conditions for its growth. With fertile soil, intellectual farming, American enterprise and capital, the United States advanced to one of the leading wheat producing nations of the world.

Still farther north the wheat line was to travel, for it has been found in recent years that thousands of acres of land in Canada, which were considered waste land, can be utilized for wheat growing. This area is nearly three times as great as that used for wheat in the United States and the yield per acre is larger. As yet only about 5 per cent. of the land is under cultivation. In Canada the United States has found a powerful rival. The virgin soil is capable of producing enormous crops of superb spring wheat, much needed to blend with softer varieties, and the men behind the plow in this new wheat-producing country both read and think.

It would seem that with the development of the northwest area that wheat had at last reached its limit of cultivation on American soil, but agriculturalists prophesy that the line of march will next turn eastward, and that much land now lying idle in the eastern and southern sections will in time be utilized for the growing of wheat. With the development of drought resistant varieties, it is also hoped that more of the semi-arid land of the west can be used.

Of the South American countries, Argentine Republic has taken the first place as a producer and exporter of wheat. Here are found great natural advantages, extensive prairies very similar to those of Minnesota and the Dakotas, and a moderate climate which enables the farmer to work the land almost any time of the year. Cheap land, cheap labor and its nearness to the sea are also important factors. As in Russia, however, agricultural methods are still very crude. Land is not well cared for and the crops are not properly stored. This latter deficiency sometimes affects wheat to be used for milling. With improved conditions, Argentina promises to be an important wheat producer. At the present time more wheat is being raised than is necessary for home consumption, and large quantities are being shipped to Europe.

While Russia, United States, Canada and Argentina have been the most important wheat-producing countries, this cereal can be cultivated in a variety of climates. Regions having cold winters produce most of the world's wheat, but marked exceptions are found in Egypt and India. While Egyptian wheat is of little commercial importance to-day, in the age of the Pharaohs and during the Roman civilization, Egypt was the wheat center of the world.

Cultivation.—Wheat has always been a cereal that has needed the care of mankind; wild varieties are practically unknown. Little is told us in history of how the farmer of antiquity tilled, sowed and harvested his crop and it was not until the days of the Roman Censor, Cato (234-149 B. C.), that any written work can be found on the subject of agriculture. The tillers of the soil have always been marked by their independence, and it was not until modern times that we found co-operation among this class of workers. The early farmer worked many times in a more or less isolated position, independent and non-progressive, teaching his son and grandson to follow in his footsteps. For information as to the time of sowing, he had only the deities and medicine-men to consult. For centuries the farmer was left to work out his own salvation, but with the advance of civilization very gradually there arose the botanist, the physicist and chemist, the agriculturist and the bacteriologist to assist him in his work. So important is the work of the scientist in modern times that a single government has been known to spend many millions of dollars in the solution of a problem of great importance. Shortly after the colonists had established their independence, the suggestion was made to establish a national board of agriculture, but it was not until the days of Lincoln that the National Department of Agriculture was established. The experimentation carried on by Liebig and other scientists of his time led the way to the foundation of experiment stations, and in time to agricultural colleges both in Europe and America. Farmers' institutes and societies followed which have now grown to be of national importance.

Hand in hand with the progress of agricultural methods is found the progress in motor power. For centuries, undoubtedly only the muscular energy of man was used, and hand labor is still employed to a large extent in India, China, Japan, Egypt, Mexico and among many of the Eastern and South American nations. Animal power was the first that relieved man from the drudgeries of agricultural life, the oxen and the horse being almost universally employed. This power is still largely used, although as early as 1832 steam power was introduced into England, and is now used to a great extent in the Western United States and in parts of Germany and Hungary. Much experimenting is being done along the lines of electricity. As in motor power, so in implements can the progress of the world be seen by a comparison of the early plow as seen on Egyptian monuments with the modern combined harvester of the great northwest.

Structure of the Wheat Grain.—(Figs. 8 and 9.) I. *Husk.*—The husk is the outer layer and serves as a covering, thus protecting the grain from the attack of its enemies in much the same way as the shell does the nut. It is composed largely of cellulose, a woody fibrous material not available as human food.

II. *Bran coats* lie directly under the outer covering and are

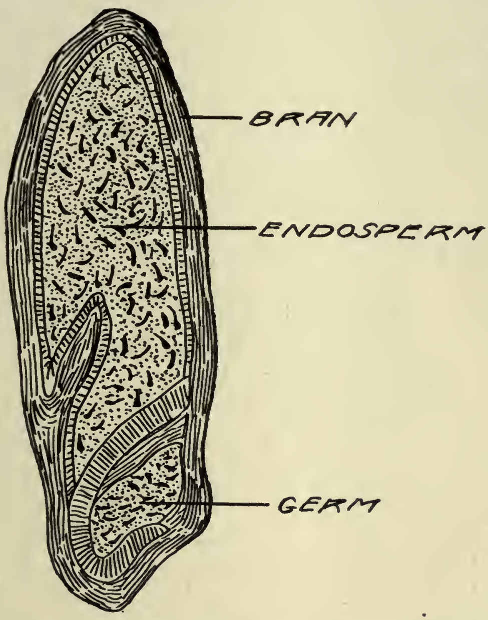


Fig. 8.—Longitudinal Section Through a Grain of Wheat.

composed of several distinct layers mostly cellulose impregnated with mineral matter. Here too are found cells full of pigment which give to the bran its characteristic color. Directly underneath the bran coats is found a single layer of large cells full of granular material of a protein nature. This coating completely encloses the endosperm and germ and is usually spoken of as the layer of aleurone cells or the cerealine layer.

III. *The endosperm* is the largest and most important part of the kernel; it is the food part of the grain, the portion utilized in the making of ordinary flour. It contains cellulose in the cell walls, a small amount of mineral matter, sugar and practically all of the starch and protein available as food. Nature designed it to serve as food for the young plant during the early stages of growth.

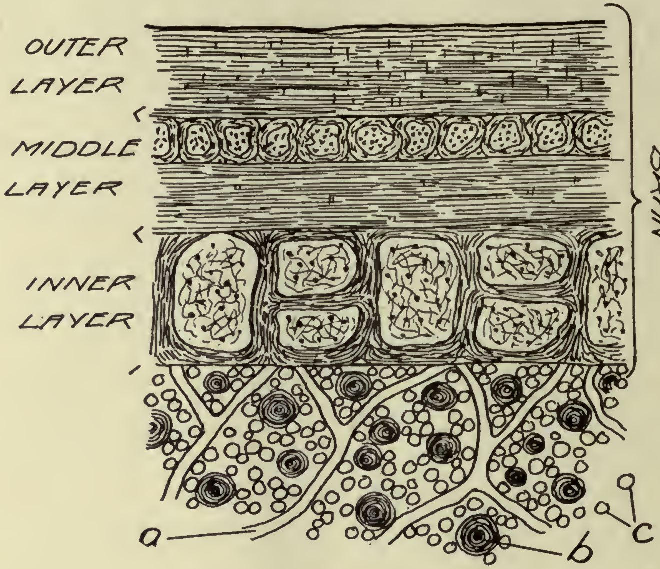


Fig. 9.—Section Through Part of a Grain of Wheat.
a—Cellular Structure. *b*—Starch Granules. *c*—Protein.

IV. *The germ* is the part from which the plant is to be reproduced. It is more complex in its composition, containing cellulose and soluble carbohydrates, a large proportion of nitrogenous matter and is rich in oils and mineral matter.

Value of Wheat.—Its wide adaptation to different climates and soils, the ease of cultivation, a quick and abundant harvest, great number of varieties and the intrinsic food value of the kernel would be sufficient to make wheat the leading food grain. There is still another reason, however, which gives it the rank of king among cereals. This lies in the fact that it can be so readily utilized in the making of bread. This quality wheat shares only with rye and both owe their bread producing power to the nitrogenous constituents of the endosperm.

Osborne and Voorhies in their investigation of the protein content of wheat discovered five distinct proteins, the most important of which were gliadin and glutenin, both occurring in the endosperm in about the same amount, 4.25 per cent. of the entire grain. In the presence of water these proteins unite to form gluten. To the peculiar properties of this gluten, wheat bread owes its lightness and digestibility, thus giving it first place among the civilized nations of the world. The other cereals contain similar proteins, but not in the right proportion to form gluten. With rye flour, gluten can be formed, but it does not make as light or as acceptable a loaf.

Varieties.—Migrating as it has for many centuries, meeting different conditions of climate, soil and methods of cultivation, wheat is now grown in a vast number of varieties. The United States Department of Agriculture after long experimentation reduced the number to 245 leading varieties. For the sake of convenience wheat can be divided into two large classes, winter wheat and spring wheat.

Winter Wheat.—For the varieties of winter wheat, seeds are planted in the fall. Enduring the cold and dampness of the winter, a maximum of starch and a minimum of protein are developed in the endosperm. Flour made from this wheat is soft and does not give enough gluten to make as desirable a loaf of bread as spring varieties, yet it was the flour used among the so-called civilized nations of Europe until the time of Liebig. He was the first to suggest that the right kind of flour was not being used for bread-making. Either the process of milling must be changed or a new wheat must be grown. His experimentation was along the lines of agriculture, to grow a variety higher in gluten-forming proteins and lower in starch content.

Spring Wheat.—Amid much ridicule and after many failures, Liebig finally convinced agriculturalists that wheat for bread-making should be grown quickly. The temperature was most important; dry, hot weather was necessary. Seed if planted in the spring would ripen in the early summer or fall and be ready for harvesting in August or September. This opened a new era in the cultivation of wheat. Soon a hard spring wheat was being grown that in time was utilized largely for the making of bread. An extended study of its production brought about many reforms along agricultural lines which were also felt by the growers of winter wheat. These new ideas have enabled farmers to grow many varieties of winter wheat higher in their protein constituents than the first spring wheat grown. With the development of hard spring varieties, new milling processes were found necessary, the development of which was to place the miller among the world's manufacturers.

OLD MILLING PROCESSES.

The history of wheat would be far from complete without a study of milling processes, for the story of wheat must ever be intimately connected with the history of the production of flour. Here again we find wonderful progress from the rude processes of ancient civilizations to the modern roller mills, where can be seen the greatest mechanical perfection and whose capacity is so great, that they can produce in a single day enough flour to feed a small city for an entire year.

It has been suggested that wheat was first eaten raw, for when driven by the pangs of hunger primitive man plucked the wheat grain from the stalk, using his teeth as mill-stones, and that it was this grinding motion which first gave him the idea of inventing some rude instrument which would break up the hard berry for him. Whether this idea be true or not, we find that various forms of apparatus were early invented to make the grinding process easier and more effective. All primitive nations reduced grain to a meal by means of a hand-stone.

Hand-stones.—The form of these stones was varied, but they all consisted of two stones, one of which held the grain while the other was used for pounding. Fig. 10. The first real grinding came into use when the lower stone was given a concave surface and the grain being placed within the hollow was rubbed back and forth by means of a stone-crusher. These primitive mills were always operated by women and were the only mills used for some four thousand years. They must have been used by the aboriginals of all countries, for large numbers of them have been found showing their use among the prehistoric Swiss lake dwellers, the Babylonians, the natives of Nineveh, Assyria and Egypt and again in many parts of the New World. So far as their structure, detail and finish are concerned, tablets indicate that saddle-stones made this side of the Atlantic were superior to those of Europe and Africa. Milling was not a separate industry, but part of the work of each household in which the meal

Fig. 10.—Hand-stone.

was first made then baked into cakes or bread. In some parts of the world this operation is still carried on. In sections of the northern part of Africa women are the millers, doing their work in saddle-stones in much the same way as it was done in the earliest historic times.

The Mortar and Pestle.—In time the stone-crusher became elongated into the pestle, and the saddle-stone was fashioned into the mortar (Fig. 11). This marked the step from barbarism into civilization. In the mortar period the Greeks substituted men as flour-makers. These men were called pounders and in the decline of Grecian supremacy, a band of them were led captives into Rome. As prisoners of war, these craftsmen were set to work at their occupation, grinding and baking. From this followed the custom of using slaves as the millers during the days of the Roman Empire.

Quern.—To the Romans, the ancient world was indebted for inventing the first milling machine in which the parts were mechanically combined. It was a simple grinding machine giving a circular motion and was known as the quern. It consisted of two stones, the upper one conforming to the shape of the lower upon which it revolved. This upper stone was hollowed out in

Fig. 11.—The Mortar and Pestle.

the center, making a hole sufficiently large to receive the grain to be ground and had on the side a handle to facilitate the turning of the stone. This was the mill in use at the dawn of the Christian Era and it still can be found in China, Japan, among the Arabs and in some isolated sections of Europe. It was the original British flour mill and was destined in that country to be the cause of a long political strife. In the early days of the use of the quern, women did the grinding, but gradually this work was given to slaves and criminals. The first marked improvement was the grooving of the grinding faces of the stones and in time the enlargement of the mill.

As the quern increased in size another motor power was found necessary. This for a long period in many countries was supplied by cattle, although in parts of northern and western Europe the water mill early came into use. With the enlargement of the mill and the introduction of different motor power, milling passed from the household to the hands of the professional miller, who at first did the village grinding, then passed to a larger district. In some countries wind was used instead of water and we find crude wind-mills appearing as early as 600 A. D. The earliest mills of the United States were operated by horse-power, wind and water being later introduced.

Grist Mills.—While the motor power was being changed, developments appeared in the mill-stones and the grist mill came into existence. At the end of the eighteenth century this mill, driven by either wind or water, was doing a thriving business and it is only a comparatively short time, since it had to give away to the modern roller mill. The structure at first was of few parts and the operation was simple. The entire wheat went into the flour; there was no bolting and no separation into grades. The grain was at first crudely cleaned by screening, blasts of air being passed over the wheat to blow away chaff and lighter particles. The wheat was then passed to the mill-stones to be ground. Two large stones known as burr-stones were used, the lower one of which revolved. They were very heavy, sometimes weighing 1,500 pounds, and as a rule were imported from France. The stones were made up of pieces bound together with bands of iron. The inner surface was cut much like a grater and, as it wore smooth, the miller would again cut its surface with a steel pointed hammer called a mill-pick (Fig. 12). When the two stones touched in revolving, it was spoken of as "low milling." The grain was fed from above and the grinding motion continued until the kernel was ground to a powder. The outer husks were torn into shreds and the germ, being plastic, rolled over and over until it assumed a cylindrical form. The main object of low milling was to make the largest possible amount of flour from the grain at the first grinding. The only separation made was that of the fibrous part which being lighter could be removed by a process of winnowing. As some of the bran was

Fig. 12 —Roughening Burr-stones.
(Courtesy of the Washburn-Crosby Co., Manufacturers of Gold Medal Flour.)

pulverized it was impossible to separate it from the flour. This gave the flour a dark color and impaired its keeping qualities. The germ also being rich in fat in time became rancid.

During the nineteenth century marked improvements took place in milling owing to the invention of many mechanical devices. Screens and bolters came into use which led to a practice of sifting and regrinding. The elevator, the conveyor, the drill and the hopper-bag were invented and finally the middling purifier.

With the invention of the middling purifier, "high milling" came into use. Here the stones were placed farther apart and the wheat was granulated rather than ground, sifted and reground. This gradual reduction being found advantageous, more stages were introduced until a flour vastly superior in quality was being placed upon the market.

When hard spring wheat, however, appeared other improvements were necessary. When our people visited Hungary, they were surprised to find what progress had been made along mechanical lines. There the grain was being crushed by means of rollers made of porcelain. Americans were very quick to see the advantage of this process and a roller-mill outfit was brought from Hungary to Minneapolis. Many changes in machinery were necessary to meet new conditions, but from 1881 the roller-mill rapidly increased, and before the dawn of the twentieth century the long honored grist mill had practically disappeared. The substitution of rolls for mill-stones was the most radical advance ever made in the history of milling. It made possible the operation of large flour mills which rank among our great commercial industries.

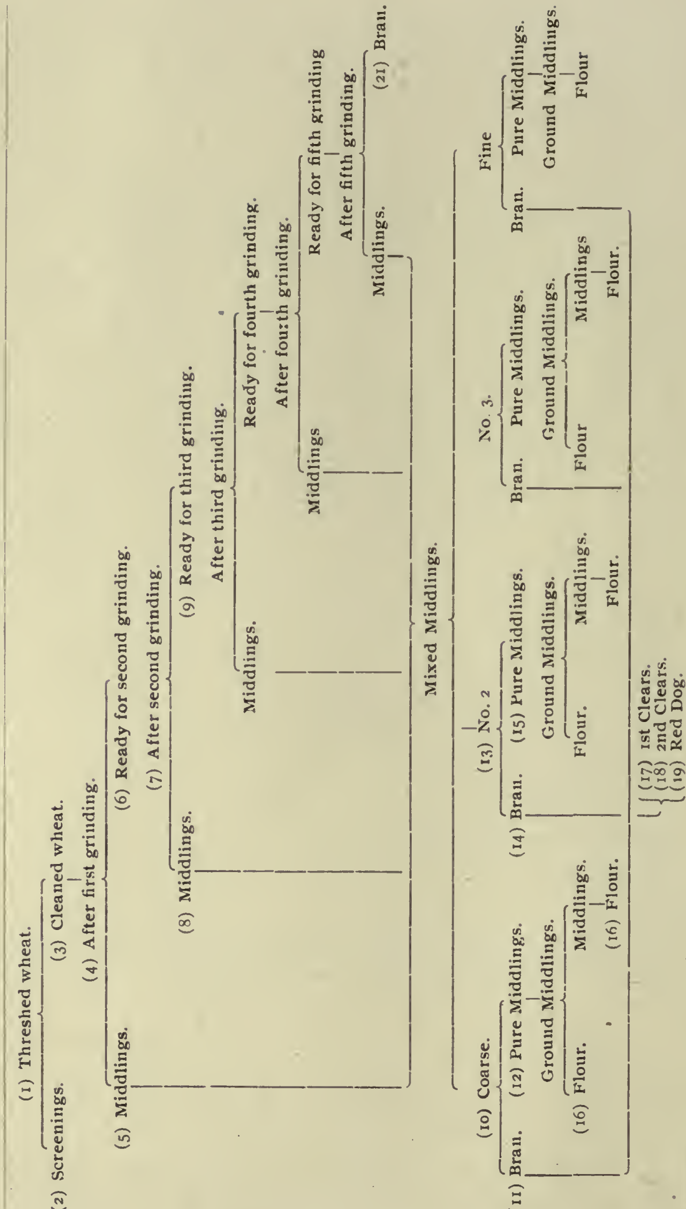
Disadvantages of Old Processes.—I. They were very slow. In the grist mill the stones were very heavy and could not be driven rapidly.

II. The flour could not be ground as fine. If the stones were placed too close together, there was danger of the stone itself wearing away and becoming mixed with the flour.

III. Friction caused heat which would affect enzyme action. Starch would be changed to a more soluble form and thus make the flour more liable to be attacked by molds and bacteria.

IV. The keeping quality was very poor. Farmers in olden times were in the habit of carrying grain to the mill in sacks and carrying home flour. It was said that the farmer was poor or

DIAGRAM OF FLOUR MILLING PROCESS.



Courtesy of the Washburn-Crosby Milling Co. Arranged by Wm. H. Noyes of Columbia University.

that he could not conveniently carry more, but these were not the true reasons. He had learned by bitter experience that the flour would not keep. It was long before the cause for this was known. Old-fashioned flour contained the germ within which is most of the oil of the wheat kernel. Oil becoming rancid soon spoiled and ruined the flour. In modern milling processes the germ is removed.

CHAPTER IV.

MODERN MILLING AND MILL PRODUCTS.

In visiting a modern mill, a curious device invented for the safety of the mill at once strikes the eye of the visitor. This is called a dust-collector. The milling of wheat always produces a large amount of flour dust which in case of ignition is capable of causing a terrific explosion. A disaster of this kind in the Minneapolis mills during 1877-78 led to the development of a large rotating diaphragm, which by suction collects flour dust from the various machines used throughout the mill, thus keeping the atmosphere comparatively free from dangerous particles.

To the novice there appears to be innumerable processes involved in the present day milling of wheat. From the time the grain is received, however, until it is packed for shipment as flour, the miller has in mind several fundamental objects; the thorough cleansing of the wheat, tempering, separation out of the middlings and the reduction of the middlings to flour.

After the grain is received and weighed, it is carried at once by means of elevators to the top of the mill where it passes through a preliminary process of cleaning.

I. **Cleansing of the Wheat.**—*Receiving Separators.*—These separators consist of several large sieves for separating out from wheat such matter as corn, sticks, stones, lint and nails. The sieves are kept constantly in motion, are slightly inclined and have holes sufficiently large to allow the wheat kernel to pass through. Foreign matter being retained passes down the incline and is caught in a receptacle.

Storage Bins.—From the receiving separators, wheat passes by conveyors to the storage bins for a reserve supply in advance of mill requirements.

Mill Separators.—When required for milling, wheat is drawn to the mill separators. Here are a series of sieves constantly shaking for removing dust, dirt, foreign seeds such as oats and imperfect kernels of wheat. Perforations are smaller than those of the receiving separators and hold back the wheat while foreign and imperfect grains pass through.

Scourer.—During the sifting processes the dust and dirt have not been fully removed. In this machine wheat grains are thrown against perforated iron screens. This loosens the dirt while a strong current of air passing through draws it out. Some scouring machines have brushes attached for brushing and polishing the grain.

Cockle Cylinder.—In the wheat fields there is a common weed known as the cockle. It has a small, round, black seed which frequently becomes mixed with wheat and must be separated out or the quality of the flour will be impaired. As they follow the wheat kernel in the receiving and mill separators, a special device has been invented for their removal. This is called the cockle cylinder.

Washing Machine.—The washing process is usually not considered necessary in mills, where scourers or the dry process of cleaning as it is called has been used, unless in case of special contamination. Some millers, however, prefer to wash all wheat, afterwards carrying it through a drying process.

II. **Tempering.**—This operation is carried on to make easier the separation of the outer part of the wheat kernel and is especially necessary with spring wheat. There are many methods of tempering, but all consist in a softening of the grain by means of heat and moisture. This may be accomplished by steam or water or by the application of both. The grain comes through this process having a warm, moist feeling and ready for the grinding process.

III. **Separation of the Middlings.**—*Roller Mill.*—The mill (Fig. 13) consists of two or three steel rolls about 2 feet long and having small teeth on the outer surface for the purpose of cutting the berry. They rotate at different speed. The grain passes from the rolls, ruptured and flattened and feeling like damp sawdust. The pieces are comparatively large for the reduction by the roller-mill process is gradual.

Scalper.—As the grain passes from the first roller or "break" as it is sometimes called, it consists of bran coats and the interior of the wheat which is known as the "middlings." A sifting process is next necessary to separate out as much of the bran as has been loosened. The sieve consists of a series of screens usually covered with wire or bolting cloth and is known as the scalper.

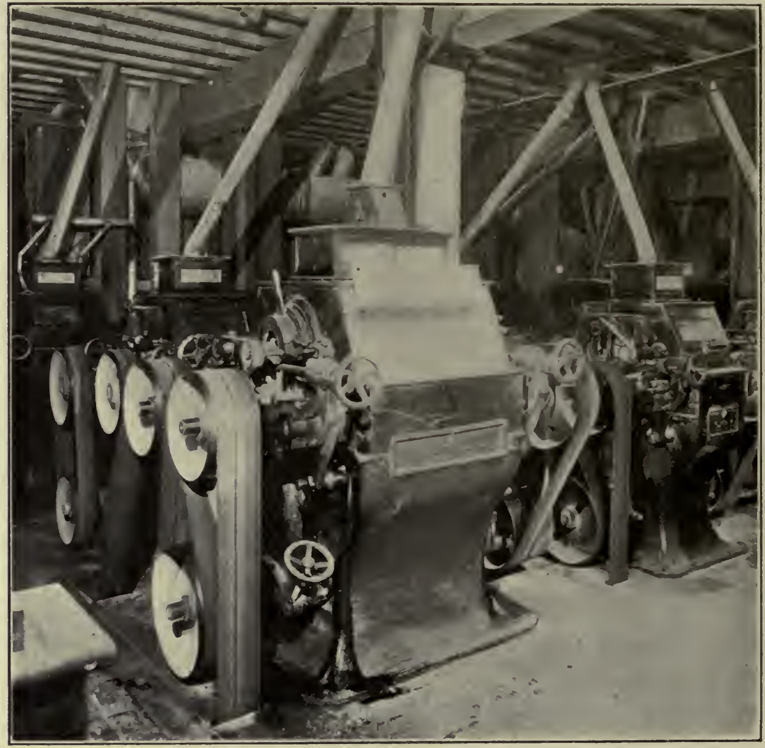


Fig. 13.—Roller Mills.
(Courtesy of the Washburn-Crosby Co., Manufacturers of Gold Medal Flour.)

Second Roller or Break.—The first separation was very crude, for the bran coats still carry much of the interior with them. To separate out this material, the bran is again passed through a roller-mill, the principle of which is the same as the first "break," but the rolls are set closer together. This tears the bran into smaller pieces and frees more of the interior.

Second Scalper.—This finer product is again sifted and more middlings are separated. The bran is now ready for a third grinding. The operations of rolling and sifting are carried on again and again, four, five, six or more times or until all the middlings have been obtained. The bran can be used as cattle food.

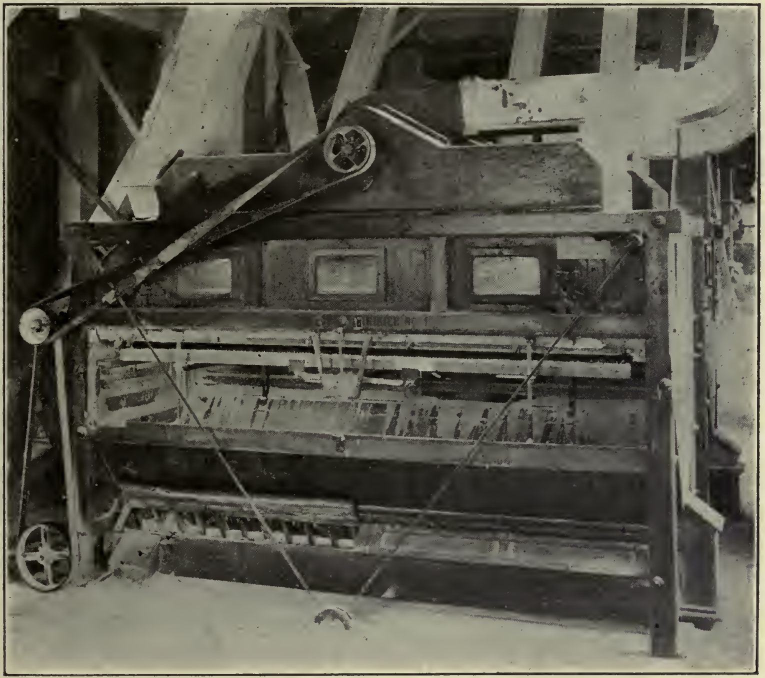


Fig. 14.—Middlings Purifier for Taking Impurities from the Crushed Grain. (Courtesy of the Washburn-Crosby Co., Manufacturers of Gold Medal Flour.)

IV. **Reduction of the Middlings.**—The middlings obtained from the various rollers and sifters are mixed and constitute the part that is to be made into flour. There are three important machines met with in this operation—the purifier, the smooth roller or pulverizer and the bolter.

Purifier.—The middling purifier (Fig. 14) is very complicated in its mechanical structure, but simple in principle. It consists of different mesh sieves about eight in number. The middlings are fed into the machine from above, flow down in a thin sheet while a current of air fed from below passes outward, carrying off small particles of remaining bran. Wheat being heavier passes down through the sieves and is caught in a receptacle from which it is conveyed to the smooth roller.

Fig. 15.—The Modern Sieve or Bolter. (Courtesy of the Hecker-Jones-Jewell Milling Co.)

Smooth Roller.—These rolls are made of steel and, as the name indicates, are smooth. They are really pulverizers. The purified middlings passing under the smooth roller are ground fine; this is the first reduction to the powder form, although not all is reduced to the same degree of fineness. This difference necessitates further separation and treatment.

Bolter.—The bolter (Fig. 15) is a large machine containing some 360 sieves made of silk bolting cloth with varying mesh. The machine moves with a side motion and makes from eight to twelve separations of the material. The fine flour is thus separated from the middlings and any remaining bran. Separation gives bran, middlings and fines. Fines represent flour. All coarser parts again go through the purifier and smooth roller repeatedly, finally being separated by the bolter. When the

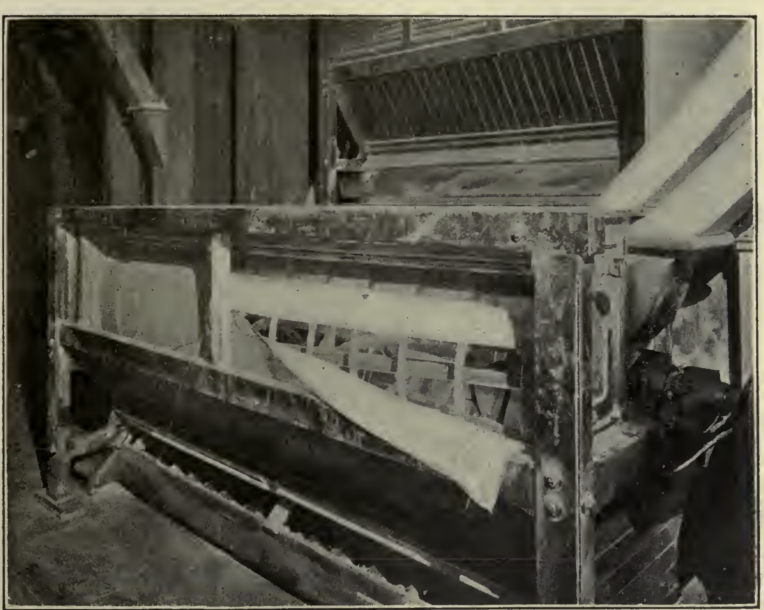


Fig. 16.—Bolting Reel for Separating the Flour from the Bran.
(Courtesy of the Washburn-Crosby Co., Manufacturers of Gold Medal Flour.)

separation is complete the flour is ready to be automatically packed in bags or barrels. The germ is separated out by the purifier during the early stages of the refining process as it gives a yellow appearance to the flour and impairs its keeping qualities.

Advantages of the New Process.—I. Increased capacity. The roller-mill has greater strength; there is greater centrifugal force, the mill can be driven faster.

II. Much less power is required to run the machinery; electricity is now used.

III. Present day process is much cleaner. All foreign matter is removed in different siftings, brushing and washing. The purifier showed marked progress in cleansing. From the time that the grain enters the mill until it is ready for shipment as flour, the human hand does not touch the wheat. It is carried from place to place, from process to process entirely by elevators, conveyors and other mechanical devices.

IV. The separation is much more perfect, only the part which is desired (the endosperm) is found in flour.

V. It is much more economical as there is less waste. In the old process much that was valuable was carried off in the bran; the working over this material again and again saves about 8 per cent. on each bushel. The price of flour is cheaper now than in former years.

VI. Rollers do not touch, so small particles of steel are not often found in flour. Should there be any, they can be removed by passing flour through a magnetic zone. This process was thought necessary in the early days of the roller-mill, but it is now seldom used.

VII. Modern flour keeps better, the germ has been removed and there is less heat by friction, so fewer undesirable changes take place.

Testing of Flour.—The material is tested at different stages of the process and again on the finished product before the flour is shipped. Except in comparatively few mills the tests are very simple; usually the quality is told by texture, color and by making it into bread. In the large modern mills may occasionally be found laboratories where, by chemical testing of the various kinds of wheat and flour, scientists are co-operating with the millers in the production of finer quality flour. The chemist's advice is particularly desirable in the blending and mixing of wheat to be used for flour making and in the manufacture of cereal products.

Wheat Blends.—One of the greatest problems that the miller has to meet is the production of a uniform quality of flour. A poor grading of wheat, or even changes which occur in the quality of the grain from season to season, necessitate a careful selection of wheats for blends on the mill. Wheats must be so blended that the "best qualities of each have the greatest chance of being effective in the resulting flour." A careful analysis of various wheats as to their starch and protein content, and the determination of the quality of the gluten in flour, greatly assist in the blending of winter and spring wheats of different strength. Successful blending usually insures that which the miller most desires, the uniform quality of his products.

Adulteration.—Many substances have been used to adulterate and cheapen flour. The most common custom has been the grinding of foreign matter with wheat or an admixture of starch from rye, corn, rice or potatoes. Occasionally, mineral matter such as alum, borax, carbonate of magnesia and various clays have been discovered. The United States Department of Agriculture, however, has found that very little adulteration of any kind has been practiced in this country.

Bleaching of Flour.—In former years flour was artificially bleached by using electrical or chemical means to make an inferior article resemble a superior one. While this custom still prevails in some countries, the bleaching of flour has been forbidden in the United States under the Food and Drug Act for interstate commerce.

MILL PRODUCTS.

The leading mills usually put out as many grades of flour as the market demands, blending spring and winter wheat of different grades. Generally speaking, flour is divided into four grades: (1) high grade patent; (2) bakers; (3) second grade patent, and (4) red dog. Red dog is so inferior in nutritive value that it cannot be sold as food; it is used largely for the making of paste.

Flour can also be divided into hard and soft varieties.

Hard Wheat Flour.—Hard wheat flour is made from spring wheat and represents the type now used almost universally for bread-making. It is rich in tissue building elements and gives the largest yield of gluten so necessary in the making of a light, porous loaf of bread.

Soft Wheat Flour.—This flour is made from winter wheat and has more starch and less gluten than hard wheat flour. It can be utilized for bread-making, but it is less nutritious and has a poorer flavor. It is often spoken of as pastry flour and is used largely for the making of cakes, pastry, crackers and the so-called "quick breads" as biscuit and muffins. Soft wheat flour, having less gluten, is particularly desirable for these products.

Spring and winter wheat flours can be detected by simple experiments. Hard or spring wheat flour, on account of its gluten content, absorbs more water, has a gritty feeling and is deeper in color, having a yellowish rather than a white appearance. Soft wheat flour, having a large percentage of starch, cannot take up as much water; it forms a more pasty dough. It is white and has a soft velvety feeling when pressed between the fingers.

Prepared Flour.—This product is a so-called "self-raising" flour and has little commercial value. It consists of an ordinary flour mixed with other flour as corn and rice, salt and such ingredients as are found in baking powders, as bicarbonate of soda and acid potassium phosphate. The addition of water causes the bicarbonate and acid salt to unite chemically and carbon dioxide is given off. This gas in expanding gives a light spongy dough. Prepared flour is very convenient but more expensive than ordinary flour and baking powder.

Graham Flour.—In the history of milling there is still another side which has received much attention—how much of the wheat berry should be utilized as food?

In primitive milling the entire kernel except the husk appeared in the flour, but the refining processes of modern times had reduced this to the use of the endosperm only. During the nineteenth century there was much discussion in regard to the starchy nature of the flour; it contained only 8 per cent. protein and 3 per cent. mineral matter. This was the kind of flour that started experimentation by Liebig, which resulted in the production of a harder variety of wheat. Other experimenters were also at work on the problem, among them an Englishman by the name of Graham. Graham was a great temperance worker. In the hope of curing alcoholism, he recommended a change in diet, especially advocating an abstinence from meat. To supply this deficiency in nitrogenous matter, he suggested the use of bread having a higher protein percentage. To obtain such a flour Graham suggested the use of unbolted wheat, that is, the use of the entire wheat berry. This was practically a return to the earlier method of milling and produced a bread darker in color and having a coarser texture. Much agitation of the question followed, but people had learned to prefer white bread, and Graham bread, as it was called, never became popular in the diet.

On investigation by scientists, Graham bread was found to contain more protein and mineral matter than white bread, but it passed through the intestines more rapidly. At that time, this was thought to be caused by the mechanical action of the bran on the lining of the intestines; the bread was carried away before the system had extracted all the nutritive matter that it was supposed to yield. Evidently Graham had not solved the question of the starchy flour of his day. Liebig was far more fortunate, and in the cultivation of hard wheat a higher percentage of protein has been obtained than was found in the original Graham flour.

Entire Wheat Flour.—Just before the introduction of the Hungarian method which so improved the milling process another attempt was made along the lines Graham had worked. This resulted in the introduction of what is known as whole or entire wheat flour. This flour is prepared by a process very similar to that used in the milling of Graham flour, except that after the cleaning processes the outer bran coats are removed before the berry is ground into flour. Entire wheat flour, therefore, contains not only the endosperm but the layer known as the aleurone

a *b* *c*

a, 307.7 grams of bread from 227 grams of Graham flour; *b*, 302.5 grams of bread from 227 grams of entire wheat flour; *c*, 301.5 grams of bread from 227 grams of standard patent flour.

a *b* *c*

a, Feces from Graham bread; *b*, feces from entire wheat bread; *c*, feces from standard patent bread.

Fig. 17.—Bread Made from Entire-wheat, Patent, and Graham Flours, and Character of Feces from Same. (Courtesy of the U. S. Dept. of Agriculture.)

cells. This is not present in patent flour, being removed as shorts or middlings.

Upon investigation it has been found that entire wheat bread also acts as a laxative, although not to the same extent as Graham bread. This is now believed to be due to the peculiar character of the protein and mineral matter of the aleurone layer. Possibly this is the main cause in Graham bread, although it was for a long period believed to be entirely due to the action of the bran coats. Much discussion followed as to the relative value of entire wheat and patent flour. As regards composition, the difference lies entirely in the protein and mineral matter of the aleurone layer. Composition, nevertheless, does not tell the whole story, for the important question is—how much of the wheat kernel is available as food? White flour contains the gluten forming proteins which are the most important and believed by many scientists to be all the protein that is available as food (Fig. 17). Undoubtedly the claims made by manufacturers as to the value of the whole wheat flour have been greatly over-estimated, although its use occasionally gives a pleasant change in the diet.

Gluten Flour.—Gluten flour is a substitute for patent flour, much used by people having diabetes or such diseases that the use of starch is undesirable in the diet. It is prepared from an ordinary good grade flour. Flour is mixed with water and allowed to stand. In time the starch washes out and if allowed to settle, a separation can be made. Repeated washings are given until the starch is not over 50 per cent. The product is then dried and reduced to a powder. This process requires time and is troublesome, and the manufacturer should be paid for his labor. The sale price for such flour should be approximately 22 cents per pound. A cheaper product is sometimes found on the market selling for 7 cents per pound. Manufacturers could not afford to put flour through this process and sell it at so low a figure; cheap gluten flour is simply a low grade flour containing bran.

Cereal Department.—Many of the large mills have a cereal department where the so-called breakfast foods are manufactured by processes quite similar to those of the milling of flour. For further information see Chapter VI, Breakfast Foods.

Seminola.—The preparation from wheat of a coarse meal known as "Seminola" is now largely carried by the miller. Seminola is used in the preparation of macaroni. See page 105.

RYE.

Rye is a species of grain resembling wheat. During the Middle Ages it furnished much of the bread material for the great body of people in Europe, and is still extensively used in Russia and Germany by the peasantry, although it is gradually being superseded by wheat. Its cultivation is evidently not nearly as old as the other cereals, for there is no mention of it in ancient languages. It was known, however, to the Romans in Pliny's time.

Rye is a very hardy plant and will grow in a soil too poor for the majority of other food grains and too cold for the production of wheat. It thrives best and gives the largest yield under conditions favorable to wheat. The varieties grown are not nearly as great as the other cereals; the principal varieties are known as winter and spring rye.

Composition.—The starch content is much like that of wheat, a difference being detected only in the microscopic appearance of the granules. The nitrogenous constituents also resemble wheat as far as gliadin is concerned. There is no protein, exactly corresponding to glutenin; therefore, the gluten formed is not altogether similar to that prepared from wheat flour. It more closely resembles wheat gluten, however, than any other cereal and can be successfully used with or without a leavening agent for the making of bread.

Uses.—Rye ranks second as a world's bread material. Rye bread is highly nutritious, but is less pleasing to the eye than wheat bread. It is dark in color, moist and compact in texture and has a peculiar sour taste. An extreme example is the black bread or pumpernickle of North Germany. A partial rye bread is often made by mixing the flour with wheat flour. This gives a larger yield of gluten and makes a larger and more palatable loaf of bread. Rye flour is used largely in the United States, but chiefly by the foreign born population.

Rye is excellent for the production of malt used in the distillation of spirits, and is much used in Europe for the making of gin and in this country for the manufacture of whiskey.

The bran can be used as a cattle food and the straw for hats and in the manufacture of paper.

Adulteration.—The adulteration of rye flour has been very frequent, flour of other cereals being added. Such admixture may be detected with the use of the microscope. The rye granule as a rule is larger than wheat and frequently has characteristic markings as a cross, slit or star.

CHAPTER V.

CEREALS.

Biological Origin.—The botanist places cereals as belonging to the family of grasses, the long cultivation of which produces seeds which can be utilized as food. The word cereal can be traced to Ceres, the name of the Pagan goddess who was supposed to preside over the grains and harvests.

Kinds.—The most important are wheat, corn, rice, oats, rye and barley.

Geographical Distribution.—Cereals are extensively cultivated in all parts of the world except the Arctic region, and but few countries can be found which do not raise grain in some form as a staple food. The reason for the extensive utilization of these cereal foods can readily be seen.

I. Being easily grown, they are comparatively cheap.

II. There is little refuse as compared with such food products as meat, fish and shell-fish.

III. They contain a fair proportion of nutritive value.

IV. The keeping quality is excellent if the cereals are properly protected from dust and insects. On account of their dryness, they are not readily attacked by micro-organisms.

V. They can be easily prepared for the table, are palatable and when properly cooked are not difficult of digestion.

Use in Our Country.—The American people eat a great quantity of cereals. This is a natural outcome of early conditions in this country. When Columbus landed on the Western Continent, he found the native tribes had a cereal under extensive cultivation. This the early settlers called corn, the European name for the leading cereal food of the country. So exclusively was this grain grown in the New World that in time the word lost its original meaning and came to be applied only to Indian corn or maize.

Columbus is supposed to have carried grains of corn to Europe on his first return voyage, but its cultivation there spread very slowly. Although introduced into Spain at the end of the fifteenth century, it did not reach France until a hundred years later. It was finally carried into Asia and Africa by the Portuguese. In the Western World it advanced with the progress of the white race.

AVERAGE COMPOSITION OF GRAINS IN DIFFERENT FORMS

	Water	Protein	Fat	Starch	Fiber	Ash
Wheat:						
Grains	12.0	11.0	1.7	71.2	2.2	1.9
Meal	12.1	12.9	1.9	70.3	1.6	1.2
Flour	13.0	9.5	0.8	75.3	0.7	0.7
Oats:						
Grains	10.0	10.9	4.5	59.1	12.0	3.5
Meal	7.2	10.2	7.3	65.9	3.5	1.9
Rye:						
Grains	11.0	10.2	2.3	72.3	2.1	2.1
Meal	—	—	—		—	—
Flour	11.2	6.7	0.9	80.0	0.8	0.4
Corn:						
Grains	12.5	9.7	5.4	68.9	2.0	1.5
Meal { Old process	11.4	8.5	4.6	72.8	1.4	1.3
Meal { New process	12.5	6.8	1.3	78.0	0.8	0.6
Rice:						
Grains	12.0	7.2	2.0	76.8	1.0	1.0
Polished	12.4	6.9	0.4	79.4	0.4	0.5
Flaked	11.7	7.9	0.5	79.5	—	0.4

INDIAN CORN OR MAIZE.

Origin.—Indian corn or maize is indigenous to the tropical countries of America. The prevalent opinion is that it was a native of Central America and Mexico, and that it passed through the same stages of cultivation and dissemination as other cereal foods. It resembles the sugar cane of the tropics rather than other cereals and has the most beautiful and luxuriant growth of all the grain grasses.

From Central America it is supposed to have spread into South America traces of it having been found in the ancient tombs of Peru, to the West Indies and finally into North

America. It has been found in the prehistoric mounds of Ohio and in the cliff dwellings of the southwest, but never among the remains of Egyptian monuments, thus strengthening the belief that it is solely of western origin.

Early Cultivation.—Evidently it had been cultivated long and extensively before the discovery of America, for by the time European travelers penetrated into the New World, maize was being grown by most of the North American Indians. When Cartier ascended the St. Lawrence, he found fields of it where Montreal now stands. The early chronicles of Virginia and other colonies contain many descriptions of its cultivation; the white man first receiving this food from the Indian, then learning the secrets of its successful growth from his red brother.

The climatic conditions seemed to have been particularly adapted for its cultivation—an abundant rainfall and a high temperature during the growing season. We read, too, in history of another possible reason for the successful growth of this cereal. All along the Atlantic coast the Indians made a practice of fishing. The menhaden, which is inedible, was placed at once on the corn hills. After using the edible varieties of fish, it was also their custom to put the bones into the fields for fertilizing purposes. Modern scientists have discovered that these bones contain phosphates, the material best adapted as a fertilizer for corn.

When the early settlers first received this food from the Indian, its excellence seemed to have quickly impressed itself upon them, for the history of the American Colonies was afterwards closely connected with the cultivation of this cereal.

Varieties.—Popcorn, flint, dent and sweet corn represent the chief bulk, although there are some seven hundred varieties of corn grown in the United States. Most varieties have white or yellow kernels, but various other colors are represented, such as black, blue and red.

Early Methods of Preparation.—Hulled corn was used early by the colonists and in time became one of our typical American foods, especially among the natives of New York and the New

England States. Corn was taken in its dry state and immersed for several hours in a solution of wood-ash called lye. In time the outer coat became soft and could be removed by gently stirring without impairing the inner part. After careful washing to remove the alkali it was ready for a long, slow process of cooking. The method of cooking used was an old Indian custom and strongly resembled our fireless cooker of to-day. Large stones were thoroughly heated by means of a fire and when sufficiently hot were piled around the utensil holding the corn. Along the coast seaweeds were used to cover it. The corn was kept in this heat until it was ready to be eaten.

Old Milling Method.—The early colonial records tell us that the Indians pounded corn after parching it before an open fire. The handstones or "corn" stones were of the mortar and pestle type, closely resembling those used by primitive people the world over. Many of these ancient stones have been found near the Indian settlements in Texas as well as other parts of the United States. After crushing the corn to a coarse meal, sometimes nuts and berries or bits of meat and fish were added. The colonists took very kindly to this dish as it closely resembled Scotch oatmeal where meat broth was added.

Samp, Hominy and Cornmeal.—Very early in the history of the colonial days, samp was placed upon the market. It was prepared by a purely mechanical method by which the hull and germ were separated out by a process of cracking and sifting. Samp is the edible part of the corn; it is practically the whole kernel minus the germ and hull. When coarsely ground it appears as hominy. The maize kernel was also ground between stones, bolted to remove the bran, and a meal thus produced which could be used directly as human food. Hominy or cornmeal could be boiled as hominy, mush or hasty pudding or baked as hoe-cake, johnny cakes, corn-bread and muffins.

Modern Milling.—Modern milling operations have greatly changed the method of producing cornmeal and flour. Corn after being carefully cleaned is kiln dried to remove moisture, crushed between grooved mill-stones to desired fineness or ground between cylinders, and sifted to remove particles of bran. Not only is the outer bran removed much more carefully than in former years, but to a large extent the germ also. This is particularly true of flour meant for exportation, thus avoiding changes of a deleterious nature taking place during transportation. In corn the greater part of the fat occurs in the germ which in time is apt to become rancid. The removal is, therefore, a distinct advantage as far as the keeping quality is concerned, but it greatly impairs the palatability and nutritive value of the prepared meal. Dr. H. W. Wiley claims that "Refined Indian meal has lost three-fourths of its fat, a large proportion of its mineral matter and also a very considerable portion of its protein, due to the separation of the bran which is extremely rich in protein and the germ which is rich in oil and protein."

The color of cornmeal and flour depends on the color of the variety of corn used, white or yellow. It is coarse or fine according to the process employed in milling.

Uses.—I. *Food for Man.*—Indian corn is the leading cereal of this country. It is grown in all kinds of soil and under favorable conditions produces a large yield. Maize is lower in protein than wheat and oats, but fully equal to other cereals in that respect and contains a larger proportion of fat than most of the grains. It is a food well adapted to those engaged in hard, manual labor, as it yields a comparatively high amount of energy. Throughout the country it is used as food, but more extensively in the South where Indian corn is served in some form daily at one or more meals.

As a garden vegetable, it is raised in large quantities for the market to be eaten on the cob or boiled with beans as succotash. The canning of corn is an important industry in some states, especially Maine and New York.

Popcorn is used largely throughout the states as a delicacy. It is a specially hard variety which has the property of the complete turning inside out of the kernel on the application of heat.

Corn is also used as before stated, either cracked or crushed as hominy and finely ground, either bolted or unbolted as meal or flour. On account of the inability of the nitrogenous constituents to form gluten, corn flour cannot be utilized for bread-making unless it is mixed with a large proportion of wheat flour.

II. As food for cattle, corn silage is extensively used as well as the green and dried grain.

III. Cobs furnish a fuel and are also used in the manufacture of tobacco pipes.

IV. On account of its porosity and its power of absorption, pith of corn is used in the construction of war vessels, compressed blocks of it being placed behind the outer armor, where in case of its being pierced during battle the water will be quickly absorbed. Pith is also used for making varnishes, gun-cotton and other explosives.

V. The husks are used in many country places for the making of mattresses.

VI. It is largely used in the preparation of alcohol and alcoholic beverages.

VII. The kernel which contains the starch in comparatively large amounts furnishes the source of supply for most of the American Starch Industry. For further information on this subject see Chapter IX, Starch and Allied Industries.

Adulteration.—Practically no adulteration of corn products has been found by the United States Department of Agriculture.

RICE.

Origin.—Rice has been cultivated from times immemorial, but it is supposed to have originated from the wild variety. Mention is made of its cultivation in China as early as 2800 B. C. It is undoubtedly of Eastern origin, for we find it early appearing in India and Japan as a staple food and allusion is made to its use in the Talmud. It is supposed to have been introduced into Persia from Southern India and later carried by the Arabs into Spain. Although it was raised in Southern Europe in the fifteenth century it was not introduced into the United States until 1694 when the captain of a sailing vessel from Madagascar presented a bag of "paddy" rice to a Charleston merchant. It soon became an important industry of South Carolina and continued as such until the breaking out of the Civil War.

Geographical Distribution.—It is now grown extensively in India, China, Japan, Southern Europe and in our own Southern States, particularly the South Atlantic and Gulf Section. Carolina produces the best rice, large amounts being also grown in Louisiana and Texas.

Composition.—Rice is rich in starch, poor in protein, fat and mineral matter. In the East the deficiency of protein is supplied by the addition of leguminous plants, a combination of rice and legumes being a cheaper complete food than wheat and meat. South Carolina and Japanese rices are richer in fat and are, therefore, highly prized among rice eating nations.

Cultivation.—Rice is the most extensively cultivated of the grains, furnishing the principal food cereal for over one-third of the human race. Where dense populations are dependent upon an annual crop, rice has been chosen wherever the climate permits, as it is the most prolific of all crops. It will grow best on soil ill adapted for any other grain. Sub-tropical rather than tropical climate gives the largest yield. It requires a moist soil artificially flooded at certain seasons. The fields are often so wet that workmen may sink to their knees. It grows most freely on lowlands, especially on land which can be flooded, but it can also be raised on upland fields. Japan grows large quantities of rice on terraces of hills and mountain sides by flooding from reservoirs built on a higher elevation.

Milling.—Primitive methods for milling rice were very simple and are still in common use in many of the oriental countries. Rough rice was placed in a hollow stone and pounded with a pestle until the hull and cuticle were sufficiently loosened to be removed by the process of winnowing. A hollow block of wood was afterwards substituted for the stone, a wooden pestle or pounder as it was called being so arranged above the block that the pounder would fall into the rice tub when operated by the miller. Water power in time was used and finally modern machinery and methods were introduced.

The object of modern milling is to produce from rough or "paddy" rice, a rice for the market which has been not only thoroughly cleaned and the husk and cuticle removed, but having the inner surface polished. To accomplish this, rice must pass through a long and complicated process.

I. Rough rice is screened to remove dirt and foreign material of all kinds.

II. Chaff is loosened by rapidly revolving mill-stones and removed by screening. This sifting also causes a separation of whole and broken grains.

III. The outer skin is removed by pounding in a huge mortar with a pestle. By screening a separation is made of the clean rice and flour.

IV. The clean rice has become heated through friction so must remain in cooling bins for 8 or 9 hours. After passing through brush screens to remove the last of the rice flour, rice is ready for the final process of polishing.

V. Polishing is done by friction with moosehide or sheepskin. This process gives to rice its pearly appearance and satisfies the demands of fashion. It is a blunder; however, from the standpoint of food value as much nourishment is lost in the removal of nearly all of the fat during the polishing process. Unpolished rice is more economical, has greater food value and has a richer taste which makes the rice served in oriental countries so much superior to the grain here.

Adulteration.—The adulteration of rice is confined to coating the grains with paraffin, talc or glucose. The object is to give a better appearance to the grain and protect it from insects.

Uses.—I. Rice as a food furnishes a starch supply which is easily digested and is useful in disordered conditions of the digestive tract when many solid foods cannot be borne. In rice-growing countries it is used as a substitute for wheat bread and potatoes. Rice flour cannot be used for bread-making and is seldom used for cake but mixed with wheat-flour it gives whiteness to bread.

II. A large proportion of the rice taken to Europe is used for starch-making, rice starch being used in laundries and muslin factories.

III. It is the source of a drinking spirit in India and the national beverage of Japan is prepared from the grain by means of a ferment. In both Europe and America rice is used by the distillers of alcohol and it is often employed in beer-making.

IV. Rice straw is used as a cattle food and as a material for bonnets.

V. Rice polish or the fine flour resulting from the polishing process is utilized as a food stock especially for cows and pigs.

VI. Rice hulls are used as fertilizers and also for packing around breakable articles.

OATS.

Oats furnish a more important food material for human beings in Europe than in America, the largest amount being consumed in the British Isles. Their chief use, however, both abroad and here is for cattle food especially for horses. The plant furnishes green forage, hay and straw as well as the milling products.

Composition.—Unlike rice, oats are particularly rich in nitrogenous constituents and mineral matter. They are highly esteemed as a food for the building and restoration of tissue. Oats contain more fat than any other cereal closely resembling Indian corn in this respect.

Oatmeal.—As a human food, oats appear on the market as oatmeal or "groats." Many varieties are cultivated for the preparation of oatmeal but in general character they bear a close resemblance to one another. The outer husk is closely adherent to the grain and cannot be entirely separated from the kernel by the ordinary method of grinding. Old fashioned oatmeal, therefore, consisted of not only the kernel but a great deal of cellulose in the form of small, sharp particles. These acted as a stimulant to the intestines, irritating to some people.

On account of the large amount of fat, oatmeal is often spoken of as a "heating food" and its use is discouraged during the summer months. In the American diet, however, oatmeal is not eaten often or in large amounts so this cannot be a serious consideration. Oatmeal is probably the most nutritious of the cereal foods, but it seems to have a peculiar heating effect on some people, causing skin eruption. The cause of this is not certain, some claiming it to be caused by the protein, others attributing it to a special constituent found in oatmeal.

Milling.—In the manufacture the grain is thoroughly cleaned to remove foreign material of all kinds, kiln-dried to loosen the outer husk and to develop flavor, then screened to remove husks. The kernel thus freed is called groats. All forms of oatmeal are produced from these groats. For further information see Chapter VI. Breakfast Foods.

Adulteration.—The adulteration of oatmeal is not frequent, as the price of this cereal is so low that the substitution of other grains would not be profitable.

BARLEY.

Origin.—Barley is generally supposed to have originated from the wild species native to Western Asia. According to Pliny it is one of the earliest of cereals in the diet of mankind. It has been found in the lake dwellings of Switzerland, in deposits belonging to the Stone Age and in the earliest Egyptian monuments. It is spoken of in the Books of Moses and early Greek and Roman writers make many references to it. The Greeks are supposed to have trained their athletes on this cereal and the sacred barley of antiquity figured on many of the ancient coins.

Cultivation.—The cultivation of barley is somewhat similar to that of wheat so far as soil is concerned. It is, however, considered the most hardy of all the cereal grains, its limit extending farther north than the others and reaching as far south as the sub-tropics. It has been grown successfully in Ireland, Norway and Alaska and in Egypt, India and Algeria.

Composition.—Barley contains all the nutritive properties of the other cereals. It contains less protein and carbohydrate than wheat, but has more fat and mineral matter.

Use.—Until comparatively recent years, barley formed an important article of diet in most of the northern countries and it is still largely used in Northern Europe among the peasantry. In England it was the leading cereal of the early days, the traditional goose-pie and bag-pudding of the Christmas feast being made of this cereal. It was used until very recently by 90 per cent. of the laboring class, but wheat has gradually taken its place throughout Great Britain although barley cakes are still to some extent eaten.

In Japan rice is generally supposed to be the only cereal, but barley is largely used among the poorer classes, a social line being drawn between the rice-eating and barley eating natives. It is also much used among the Hebrews as a breakfast food and pudding.

Medically barley is rated as the mildest of the cereals and in various forms it is found often in invalid dietaries.

In the Old World it is grown extensively for horses, cattle and pigs, the hay and straw being utilized. In the United States it is grown in the northern and western parts to some extent for hay, but its chief use is for making fermented beverages. It is not utilized to any extent as a human food, although it is sometimes used in domestic cookery as an ingredient of soups and broths.

Mill Products.—About the only products milled are meal and pearl barley. Barley meal is the whole grain cleaned, deprived of its outer husk and ground. In this form it is sometimes sold to the manufacturer of beer. Pearl barley has the outer and inner husk removed, is ground to a round form and put through a polishing process. As a food it is used mostly in this form for thickening soups, making cool drink for invalids and for infant feeding.

CHAPTER VI.

BREAKFAST FOODS AND COFFEE SUBSTITUTES.

A canvass of our markets would reveal to-day an endless variety of cereals listed under the name of breakfast foods. In the early days of America, the only cereals utilized to any extent were wheat as wheat flour and corn as samp, hominy, cornmeal and hulled corn. In New England the custom prevailed of using popcorn as a breakfast food. Bread crumbs were also frequently toasted and used for that purpose. Oatmeal was later introduced by the Irish and Scotch immigration and finally barley, rye and rice, but their use has always been more or less limited to the foreign born population.

It was not until the latter part of the 19th century that a new interest was awakened in this class of foods. Much experimenting was done on the cereals, new methods of manufacture were developed and many new products were placed on the market listed under the name of "The Cereal Breakfast Foods." Probably no class of foods has ever been so extensively and ingeniously advertised. In a comparatively short time a bewildering variety could be purchased in the local markets; many appeared to remain indefinitely, but a far larger number soon could be found only in forgotten places. This constant and ever increasing variety of breakfast foods is giving to the cereals an important place in the dietary which was not known in the past history of our country.

Classification.—Although the list of these foods is so long and varied, they fall very readily into four classes.

I. Uncooked
- Whole grain.
- Part of grain.

II. Partly cooked.

III. Cooked.

IV. Malted.

The grains commonly used in this country are oats, wheat, corn and to some extent barley and rice. In the majority of breakfast foods, only one variety of grain appears, at other times two or more are mixed. Breakfast foods are prepared directly from these cereals, either by mechanical manipulation, culinary processes or malting. Many times such changes are brought about in order to make the product ready either for immediate consumption or for serving after a moderate amount of cooking. These changes in composition usually consist in the more or less complete rupturing of the starch granule and sometimes bring about its conversion into more soluble forms. Other substances of the nature of condiments are often added as maple-sugar, cane sugar and salt. Particular methods of preparation are usually trade secrets.

I. *Uncooked.*—The whole grain variety is best represented by oatmeal. This is practically the old-fashioned cereal with modern methods of preparation. Ingenious devices have been invented for the removal of foreign seeds, dirt and other substances of an undesirable nature. The roller process is now used instead of the old idea of crushing but the roller is supposed only to take off the outer husks. They are removed now quite thoroughly so the amount of cellulose left is much smaller than formerly. Sometimes there is a gradual reduction of the kernel so oatmeal may be in the granulated form. This is more common in Canada than in the United States.

Varieties consisting of parts of grain may be found in farina and cream of wheat. They are prepared from the hard, granulated particles of wheat usually taken from the first or second break in the manufacture of flour. It is the part of wheat from which patent flour is made. This class of breakfast foods is usually made from hard spring wheat as soft winter wheat is apt to break down too finely.

The uncooked cereals are sold at a lower price as there has been less manipulation by the manufacturer. They require, however, a longer cooking in the home.

II. *Partly Cooked.*—By far the largest number of the breakfast foods of to-day belong to this class; 90 per cent. of the oatmeal consumed in the United States is in this form, on account of its easy preparation in the home. The first of these cereals to be introduced was the rolled oats. The preliminary treatment of cleaning, kiln-drying and hulling is practically the same as with the uncooked varieties. The "groats" then pass through a process of steaming and while still wet go to heated rolls which flatten them into flakes. Additional cleaning processes are sometimes used to loosen and remove the fine particles of floury matter before the flakes are put into packages. Almost all of the grains are now being flaked, while peas and beans are also found in the Canadian market.

Originally this process of steaming was thought to cook the grain so thoroughly that only a few minutes were necessary in the home. It is now known that the heat has not been applied long enough and such cereals need to be thoroughly recooked before serving. Less water is needed as much has been absorbed in the steaming process. On account of the flattened condition of the grain exposing more surface it is not necessary to give as long a time as in uncooked cereals. More time, however, should be allowed than is stated on the package.

III. *Cooked.*—The ready to serve varieties are numerous and are prepared in various ways. The most common forms are:

1. The flaked cereals closely resembling the rolled variety, but heat has been continued for a longer time. They sometimes consist of one cereal as flaked rice or they may be combinations of grain as wheat and barley. Other substances such as syrup and salt are frequently added and some flaked varieties have passed through an additional process of parching or toasting, thus giving them a darker color and producing a flavor which is relished by most people. Several of these flaked varieties as Cranose Flakes and Force were patented at Battle Creek, Michigan, the center for the development of breakfast foods, and were among the earliest of the ready-to-eat foods.

2. The puffed variety, as Puffed Rice, is made by placing the grain in sealed cylinders which are kept revolving at a temperature of approximately 550 F. for an hour. The moisture within the grain turns to steam, which on being released suddenly from

the cylinders causes an explosion of the starch granule and a puffing up of the cereal grain.

3. There is but one example of the shredded variety, but so popular is it among Americans that it stands in a class by itself. "Shredded Wheat Biscuit" as it is called, was the first breakfast food to appear on the market made from wheat. Its manufacture dates from 1895. The whole wheat kernel appears in the product and special machinery is needed for its preparation. After a thorough cleaning the cereal passes through some twenty to twenty-five different processes, the most important of which are the following: 1st. the whole wheat is steam-cooked for about thirty-five minutes without being flavored then dried to remove excessive moisture; 2nd. by special machinery the grains are drawn into shreds which are piled in layers, cut into miniature loaves and baked.

4. Variety resembling crumbs, as Grape-Nuts. This breakfast food is prepared from wheat and barley ground together, made into a flour, kneaded into bread dough and baked. The bread is then toasted and crushed. Grape-Nuts has had a very large sale in the United States, Canada and England for a number of years and is now gradually being introduced in the commercial centers of foreign lands.

IV. *Malted Preparations.*—The cereal grains are all rich in starch and on account of the hard impervious nature of the walls of the starch granules such food is not easy of digestion in the raw state. A long slow cooking is necessary not only to rupture the granule, but to make the starch more soluble. The digestive fluids under ordinary conditions can then readily take care of such a product. To further aid digestion it was suggested several years ago that the cereal starch be subjected to the action of malt. Malt contains an enzyme called diastase which has the power of rapidly liquifying starch after the cell walls have been ruptured and then converting it into dextrin and maltose. Maltose is soluble and several steps nearer the completion of the digestive process. The amount of starch which has been changed to dextrin and maltose depends upon the thoroughness with which the malting process has been conducted. Manufacturers of these products claim that the process has been thorough and these cereals are highly recommended for people with weak digestion. It is a question whether this claim is always true or whether malt has simply been added to give flavor after the cereal has been cooked with dry heat. Heat would readily change starch to dextrin without the aid of diastase and is a much quicker process than that of malting. For information as to the malting process see Chapter XI, Alcoholic Beverages. Such a cereal has a pleasant taste relished by many people and adds variety to the diet, but it is not predigested.

Experiments along this line have been carried out at the Iowa Experiment Station on a number of malted breakfast foods. It is difficult, however, to decide whether the malting process has actually been carried out or whether malt has been added, but there are strong evidences to make scientific men feel that in many cases the cereal has been cooked by dry heat. The term malted is often used when malt has simply been added, as malted milk. Milk cannot be malted in the sense of adding diastase to it; it can only be reduced to the powdered form then mixed with ground barley malt. Much has been said of the advantage of using predigested foods in order to relieve the digestive tract of much of its normal work. It is a question, however, as to the wisdom of taking habitually artificially digested foods. The human body under normal conditions is well fitted to perform this work for itself and the digestive organs need a certain amount of exercise to keep them in proper condition. It has often been quoted "A well man has no more need of predigested food than a sound man has of crutches." These cereals, therefore, should be taken more for their pleasant taste and to give variety than for their so called predigested value.

Adulteration.—While in advertising much has been said greatly over-estimating the virtues of the breakfast foods, the experiment stations and pure food examiners have discovered very little adulteration. Manufacturers as a rule use good wholesome material, processes are modern and conditions at the factories most sanitary. Goods are protected while in the dealers' hands and are so packed that they can easily be taken care of by the householder.

Comparison of Old and New Cereals.—The old-fashioned cereals were much more economical. Manufacturers did not charge for extra manipulation. They were bought when dry, so consumer was not paying for water which had been added during manufacturing processes, and as they appeared on the market in bulk the box was not included in the weight.

Uncooked cereals which have been thoroughly cooked in the home digest just as easily as predigested kinds and are equally nutritious. In these respects they are superior to some varieties of partly cooked. There is no reason to believe that a prepared food is more favorable to health than cereal itself properly cooked.

On the other hand, much can be said in favor of the use of prepared breakfast foods for they are usually palatable, wholesome and nutritious. They save much time, labor and fuel in the home and are well suited for the use of the housekeeper, who must depend upon the use of kerosene, gas or electric stove. From a sanitary standpoint there has been a great improvement; being sold in cardboard boxes well lined with air-tight paper, they are protected from air, moisture, dust and micro-organism. Unless carefully packed a cereal will not keep well. Moist climate makes it liable to be attacked by mold growth and it is apt to become infested with insects. The chief point against the modern cereal is the excess cost. The cost of cereal per pound is 2 to 3 cents; cost of prepared cereals 10 to 15 cents. The cereals, nevertheless, pound for pound, are the cheapest complete food that can be found on the market and they form a legitimate and valuable food.

COFFEE SUBSTITUTES.

For several years past another cereal product has been found on the market known under the name of coffee substitutes. They are in many cases put up by the same manufacturers as the breakfast foods and like them seem to be gradually increasing in number. They are as a rule made of parched grains of wheat and barley sometimes mixed with wheat middlings, pea-hulls and molasses. Some of the first products also contained a low grade coffee added to give flavor. Experiments made at the Connecticut Experiment Station, however, show that the present day coffee substitutes are as a rule made from the cereal grain as claimed by the manufacturers and that there is now very little adulteration of this kind.

It is claimed that they are harmless, unstimulating, have a flavor resembling coffee and yield much greater nourishment at lower cost. The color and flavor resembling coffee are largely due to the fact that the carbohydrates present are caramelized; this also occurs in the roasting of coffee. See Chapter XX, Tea, Coffee and Coco. Few coffee lovers will agree that the flavor strongly resembles coffee as the coffee bean also contains certain volatile bodies which give that beverage the much desired aroma and taste. Substitute coffee where coffee has not been added is perfectly harmless, unstimulating, and furnishes a beverage for those who cannot take coffee. There is little truth, however, in the extravagent claims made in advertising matter as to the nutritive value of the beverage. This value is hardly worth considering, since experiments have shown that skim milk is from three to twenty times as nutritious.

CHAPTER VII.

UTILIZATION OF FLOUR. BREADMAKING.

By far the oldest and most important product made from flour is bread. The art of breadmaking dates back to the remotest ages of mankind and so important is this world's food-stuff that it is known almost universally as "The staff of life." With the possible exception of milk and eggs, there is no article of the diet that is more generally used by human beings and that is so well able to sustain life. It is to its constant use that we owe the wonderful development along the lines of the cultivation of wheat and the equally marked progress found in its milling operations.

In a broad sense bread includes all forms of baked flour, whether leavened or unleavened, but our common use of the word refers only to those forms in which leavening agents are used, other products being spoken of as pilot bread, crackers, passover bread and biscuit. Originally all bread was eaten without leaven for the savage after crushing or grinding his meal, baked it in the ashes of his camp fire. The result was a bread of hard, tough material not easy for the digestive fluids to act upon. This evidently was only the custom among the most primitive people, for the use of leaven is very ancient. The Israelites while in Egypt used leavened bread, the Greeks were known to have cultivated the yeast plant and in the ruins of Pompeii an oven was found containing 81 loaves of bread not unlike our own. With the use of leaven, a type of bread was produced, more easily masticated, better in flavor and more easily digested.

Primitive Breadmaking.—Crude methods of breadmaking can be studied not only by the earliest historic records but among some of the more primitive nations of to-day. Evidently bread was used in the stone age for burnt specimens have been recovered among the Swiss Lake Dwellers; the pyramids of Egypt bare testimony to its early use and again we find evidences of it in the mound tombs of North Africa and Asia. The method of preparation was undoubtedly very simple, probably much like that used by some of the wild tribes that inhabit parts of Africa at the present time. It is their custom to simply grind grain between two stones, make it into a paste with water, then bake it in the ashes of a camp fire.

In different parts of the world similar products can be found. Natives of some of the West Indies prepare a thin round cake of meal which is obtained from the cassava root; it is known as cassava bread and furnishes the principal food among the common people. In Mexico and Central America, a bread known as "tortillas" is prepared by the natives from Indian corn by first parboiling the grain to soften it, then crushing it by means of a stone rolling pin. The paste is baked on a plate of iron. The "tortillas" is sold at many of the market places by native women and as it is more highly relished when served hot, it is usually baked on a small portable, charcoal stove at the market. Among the well-to-do classes of India, a round, flat cake of unleavened bread called "chapatties" is prepared from wheat flour and baked on a griddle or on the coals. A similar product is made by the poorer classes from cornmeal, millet, barley or a coarse, hard grain known as raggy. In Palestine and Syria women are still the millers and bakers, grinding the meal in small stone hand-mills after the same custom as was used long before the beginning of the Christian era. The coarse meal obtained is made into flat cakes and baked on a hearth, which consists of two stones raised on end over which an iron plate is laid to hold the bread. Bread made in other parts of the Orient as Egypt and Turkey has quite a different appearance. Here the material is rolled or pounded into a flat dough similar to our pie crust; two layers are then put together united at the edges and baked in a very hot oven. The expansion of the air between these layers puffs up the dough and gives the appearance of a large loaf. A flat bread of coarse barley meal is also made in the northern part of Europe, particularly among the Norwegian peasants.

The evolution from these primitive breads to the modern white loaf used by the civilized world has needed much study and experimentation as in the development of all other industries. Probably the most marked change was the use of leaven and it is generally supposed that it is to the Egyptians that the world owes this important step. They seemed to have carried the art of breadmaking to a high state of perfection, as did also the ancient Greeks, who are known to have had at least 62 varieties of bread. From the days of these ancient civilizations, mechanically there seemed to be little progress for centuries and it has been left to the modern scientist to develop the art and science of breadmaking.

Leavened Bread.—So far as the ingredients are concerned, the present day bread might be considered a very simple food, for there are only four materials needed in this operation—flour, water, yeast and salt. Other materials as butter, lard, sugar, milk, fruit or spices might be added to give flavor and variety, but they are not essential to breadmaking. Although the ingredients are so simple, scientists tell us that the chemical changes taking place in the preparation of the loaf are very profound. In order to understand at least a small part of these changes it is necessary to consider the raw material to be used.

Flour.—At the present time our first-class bakers are using a standard flour for breadmaking. It is high in the gluten forming proteins so will absorb more water and gives a larger, lighter and better flavored loaf. For milling processes see Chapter IV.

Water.—The hardness or softness of water does not seem to make any great difference in breadmaking, but it should be free from dirt or contamination of any kind. See Chapter II, Water. In the household many prefer to use milk in part or altogether as the liquid. It makes an equally light loaf, contains a larger amount of protein and fat, is equally digestible, but the dough is slightly longer in rising.

Salt.—Salt is used in breadmaking principally for the flavor it imparts, for without it the dough would be insipid. The amount varies according to the type bread and in different localities even with the same variety. It should never be used, however, in such quantities as to be readily tasted or the delicate aroma and taste of the bread will be destroyed. It is believed that salt added in small quantity stimulates the capacity of the palate for recognizing flavors of other substances. This accounts for the importance of salt as a flavoring agent.

Another reason has been given for the use of salt, but it is not now believed to be important. It has the power of controlling some of the chemical changes which take place during fermentation, so was considered a preservative. It checks alcoholic fermentation and also the ropy ferment, but it does not influence the lactic acid and many other bacteria from working so its influence as a preserving agent is very limited and can hardly be important enough to be considered.

Yeast.—Yeast was the first leavening agent in the world's history and is still by far the most important one. How it first came to be used is not told us in history, but the knowledge that wild yeast is always present in the atmosphere leaves but little to the imagination. Its use might easily have been discovered by accidentally exposing dough to the atmosphere and afterwards finding that it made a lighter loaf. From this simple custom of exposing dough to the air we might easily trace the practice of saving a small amount of raised dough from day to day to act as a leavening agent for the next baking. Gradually the art of cultivating yeast became the practice among the civilized nations.

Although yeast has been used as a leavening agent for many centuries very little was really known about it until the time of Pasteur. It is now believed that yeast, molds and bacteria belong to a class of substances known as ferments. Until quite recently these ferments were divided into two classes: 1st, enzymes, such as diastase and ptyalin or unorganized ferments; 2nd yeast, molds and bacteria, known as organized ferments. Recent research has revealed that micro-organisms cannot do their work as ferments without the presence of enzymes within their cell-walls so that classification no longer can be used. Yeast, molds and bacteria are now known to be living organisms.

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They are microscopic forms of plant life which in their desire for food can act upon substances, bringing about many profound changes. Although the nature of these changes may not be known to the average house-wife, with the effects of many she is quite familiar. Milk after standing for a time, particularly in a warm place changes in its nature; it develops acid qualities and is spoken of as being sour. Butter under certain conditions becomes rancid. Cider when fresh has a decidedly sweet taste which in time gradually disappears and is replaced by an unmistakable taste of alcohol. It is quite common to speak of this product as hard cider and every house-keeper knows that should hard cider be kept long enough it will change to vinegar. These changes and many others modern scientists have traced to the fermentative actions of micro-organisms.

In the fermentation brought about by the yeast plant two very important products are found, alcohol and carbon dioxide, which are used throughout the world whether the races are civilized or still in a semi-barbarous condition. Alcohol is particularly desired by all industries preparing stimulating beverages and carbon dioxide is needed for the lightening of bread. It is to the manufacturer of alcoholic beverages that we owe the scientific study that has been given to the yeast plant.

When viewed through a microscope yeast is found to consist of a single cell round or oval in shape. It is perfectly colorless, belonging to a class of plants without chlorophyll—the fungi. Each cell is an individual plant consisting of an outer wall of cellulose filled with protoplasm. In this condition yeast is usually spoken of as in the resting state.

Being a living organism yeast is capable of reproducing itself should conditions be favorable. The normal reproduction is through a process of budding. If a little of this resting yeast is put under conditions favorable for growth, a daughter cell or bud is formed within the cell. The bud pushing its way through the wall rapidly develops, separates from the parent cell, and in its turn is able to become a parent cell. When growth is very rapid the cells sometimes fail to separate, and adhering, form a chain of cells which can easily be seen in the microscope. Pasteur states that on one occasion he watched two cells for two hours; during that time they multiplied into eight.

Under unfavorable conditions some yeasts are reproduced by the formation of spores. These spores can resist many adverse circumstances, such as lack of moisture, insufficient food and marked changes in temperature. It is to their hardy nature that we owe the constant presence of yeast in the atmosphere. In this state it has been discovered yeast can live in the ground for some little time, until wind carrying them into the air, gives an opportunity for settling amid favorable surroundings and again growth and reproduction take place. The favorite home for the yeast plant is on the skin of grapes and other fruit, a fact well appreciated by those engaged in the wine industry.

The rapidity of the growth is much influenced by surrounding the yeast with favorable conditions of temperature, suitable food, oxygen and moisture.

The temperature found to be most favorable is 77°-95° F. Below 77° F. the growth is slower and a little below 49° F. it is practically arrested. The vitality of the cell is not destroyed by a low temperature for even after exposure to 32° F. yeast will grow if the conditions are once more favorable. Above 95° F. yeast will become gradually weakened by heat until it is finally killed at a temperature of 140° F. if the yeast is moist. Dry yeast can stand a much higher temperature, 200° F., without destroying life. Although yeast grows most rapidly between 77°-95° F. it is sometimes advisable to keep the temperature lower to prevent the action of undesirable micro-organisms. Brewers in the United States and on the continent are now using a lower temperature although none but the largest and more scientific bakers seldom, if ever, take advantage of this fact.

Food for yeast growth must contain carbohydrate, nitrogenous compounds and appropriate inorganic matter. The last two food principles are necessary for the healthy development of yeast for they constitute as in human life, the building material of the cells.

Pasteur discovered that unless these substances are given to yeast they act like cannibals, the stronger cells existing on the weaker. From our standpoint the carbohydrate is the most important food for the yeast as it is to these compounds that we look for the production of alcohol and carbon-dioxide. All forms of carbohydrate cannot be utilized by yeast but should the compound not be available as food, yeast carries its own enzyme, much as we do, which can convert it into a form which can be utilized. There are two important enzymes in yeast—invertase and zymase. The function of invertase is to convert such compounds as starch and dextrin into glucose by the process of hydrolysis:

$$(C_6H_{10}O_5)_n + H_2O \rightarrow C_6H_{12}O_6.$$

Glucose being an available food for yeast it is attacked by zymase which breaks down the sugar into alcohol, carbon dioxide and a number of other substances in small quantities such as fusel oils, succinic acid and glycerine.

$$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2.$$

Micro-organisms also need oxygen, some taking it in the form of atmospheric oxygen O_2 and others from their food. Yeast needs atmospheric oxygen. Pasteur discovered that an abundance of air caused the plant to develop rapidly, but the evolution of alcohol and carbon dioxide was very slow, while in a limited amount of oxygen fermentation proceeded rapidly and the cell growth was arrested. This idea has been of great benefit to brewers and to scientific bread bakers who now know when to limit the supply of oxygen.

Yeast needs also for development a certain amount of moisture. In fact one of the largest and best known breadmaking concerns in the United States make their bread under a process patent, based on the idea of mixing the dough in such a manner as to inject into the dough an unusual amount of atmospheric oxygen.

Leavening Effect of Yeast.—With these facts in mind the leavening effect of yeast can easily be seen. A mixture of flour and water readily supplies the moisture and food, flour containing all the necessary compounds—carbohydrate, protein and mineral matter. If this material be kept exposed to the atmosphere and at a suitable temperature, yeast will multiply very rapidly and will spread throughout the dough. As a result of its action much carbon dioxide is developed, which in forcing its way through the dough becomes entangled in the gluten. The latter being elastic stretches, thus giving porosity and lightness to the dough.

Yeast Preparations—Breadmaking.—The oldest method of preparing yeast was very probably that used by the ancient Egyptians, who succeeded in obtaining wild yeast and growing it in dough. A portion of this dough or "leaven" was always saved for the next baking and as it contained yeast cells, again yeast could be grown when needed. This simple custom has been used more or less from those early days to modern times and in some parts of the world it is still practiced. The home brew used by our ancestors and which can still be found in isolated districts is a preparation of this kind. The leaven saved from the last baking is mixed with suitable material for the rapid growth of yeast. A decoction of hops or potatoes and water were used and when the yeast had developed, part of this material was added to the dough. A similar practice can be found in Scotland at the present time. The "barm" as it is called is prepared by allowing yeast to grow in malt extract and flour before adding it to the bread dough. In some parts of the continent this ancient method is still used by bakers and in many places by the poor country people, particularly in France and Switzerland. The bread has a sour taste due to the development of lactic and butyric acid bacteria, which is relished by many people. Some authorities consider bread made in this way more healthful as the acids developed are supposed to assist in digestion. The taste, however, is disagreeable to the majority of people and the best authorities of our country consider that a high grade commercial yeast is more reliable and much more convenient.

Brewer's Yeast.—One of the earliest commercial yeasts was obtained from brewers. During the fermentation of beer, especially where a high temperature is used, much of the yeast is carried to the top of the vats by the escaping carbon dioxide. It is called by the brewer top yeast. This yeast was skimmed from the top of beer and was sold in the liquid form. Little care was given to sanitary conditions and the product was thoroughly unreliable. It was dark in color and carried with it the flavor and aroma of the hops. Bread made from it was somewhat smaller in volume, due to slow fermentation, dark in color and had a faintly bitter flavor. It has now almost entirely been superseded by distillers' yeast, which at the present time is sold in the form of the compressed yeast cake.

Compressed Yeast Cake.—Distiller's yeast is lighter in color and possesses a rather pleasant taste. At the time that fermentation is most energetic the yeast is skimmed off the surface and is conveyed by wooden drains to sieves. All foreign matter is removed and the strained liquid passes on to the settling cisterns. Here the yeast settles and the liquid is drawn off. The yeast is generally mixed with starch and put into presses which squeeze out much of the moisture, leaving a dough-like paste. The starch is said to be added because it permits more water being removed, which greatly aids the keeping quality. In recent years, however, the foremost yeast manufacturers of our country have discovered that by strict laboratory control and the development of pure culture, compressed yeast of great strength and uniform quality and flavor can be successfully and commercially made without the addition of starch. The latter, in fact, is now looked upon as an adulterant. Yeast is then partly dried, made into cakes, and carefully wrapped in metal or waxed paper to protect it from bacteria. This is the best all-around yeast that is used at the present time. It is more expensive, but will work evenly and quickly and will give a finished loaf of bread with a good volume and texture and having an agreeable taste, odor and color. A good quality should be slightly moist, possess a creamy white color and should break with a fine fracture.

Dried Yeast.—There is one great disadvantage to compressed yeast; even under favorable conditions it will only keep fresh for a comparatively short time. The yeast begins to die and other forms of micro-organisms begin to develop, giving rise to undesirable flavors in bread. For people who live in isolated districts, another type of compressed yeast called dried yeast is put on the market. More starch has been added and more water removed. Although a low temperature is used to dry the yeast some of the cells are undoubtedly killed, so it is not as satisfactory a form to use as a fresh yeast. On account of the dryness, however, decomposition cannot set in and some of the yeast and spores will remain alive for a considerable length of time, and when mixed with water and a soluble carbohydrate will slowly begin to grow.

Object in Breadmaking.—Given the necessary ingredients, it is the baker's object to produce a result which will be pleasing to the sight, agreeable to the taste, easy of digestion and nutritious.

Steps in Breadmaking.—1. FERMENTATION.—The methods of fermenting dough are somewhat varied, but there are only three in common use:

I. Straight or off-hand dough.
II. Ferment and dough.
III. Sponge and dough.

No matter which method is chosen the best material possible to procure should be used; the ingredients should be thoroughly mixed and in proper proportions, and the greatest cleanliness should be observed throughout the entire operation.

I. *Straight or Off-hand Dough.*—With this method all of the ingredients while luke-warm are thoroughly mixed. Care should be taken that the proper proportions are used; too little yeast will give a badly raised dough and too much will cause excessive gas which stretches the gluten beyond its limit, causes it to break open and the gas to escape, thus making a heavy, soggy loaf of bread. The dough is then set aside to rise in a moderately warm temperature (77°–95° F.). It should be kept as free from drafts as possible and should be left exposed to the atmosphere or lightly covered, as the presence of oxygen aids the growth of yeast. As fermentation proceeds the dough increases in bulk and becomes light and porous. When sufficiently aerated with gas it is thoroughly kneaded by hand or machinery. This operation causes the escape of waste gases, incorporates fresh air, revives the activity of the yeast, has a toughening effect on the gluten and assists its elasticity. The dough is shaped into loaves, allowed to ferment again and then baked. Bread made in this way takes from 3 to 10 hours according to the amount of yeast and the temperature used. There are several distinct advantages to this method—all labor of sponging and extra manipulation is saved and bread is produced in less time. It is far more convenient when bread is made at home.

II. *Ferment and Dough.*—Among many bakers the first step is the preparation of the ferment; that is, the cultivation of the yeast by giving it appropriate food. Potato mash is still largely employed for food, also raw and scalded flour, malt extract and commercial yeast foods. The ferment takes about 5 hours, but is still used by bakers for two reasons: first, it enables an originally small amount of yeast to do much work; second, the young yeast cells are very vigorous. This yeast is then incorporated with water, flour and salt and a dough is made similar to the straight-dough method.

III. *The Sponge and Dough Method.*—In this process the dough is made in two stages by allowing the yeast to work for a period in a portion of the flour and water. Several different sponges are used—the quarter, the third, the half and the three-quarter, according to the amount of flour added. Fermentation proceeds from 2 to 12 hours and the remaining material is incorporated. Care should be given to mix the second portion of flour thoroughly with the sponge or the bread will contain lumps on which the yeast has had no opportunity to work. The dough as it is now called is allowed to rise again, is kneaded into loaves and baked. Although it takes longer and requires more manipulation the sponge method has many advantages: first, on account of its slackness, it requires much less yeast—this is a considerable saving where bread is made in large quantities; second, hard wheat flour on account of its absorbing power does not produce a desirable loaf of bread when made by the off-hand method—a sponge gives a lighter and more elastic loaf; third, bread made with a sponge is usually finer in texture and has a better flavor; fourth, it keeps better; fifth, some believe that less work is involved in mixing as the sponge softens on standing.

2. Baking.—The dough should be evenly baked in an oven ranging from 450° to 550° F. according to the variety of bread. The heat should not be too great at first or the bread will harden too quickly. The gas in the interior will not have a chance to expand the gluten and the result will be a heavy bread. In some bakeries the temperature is gradually raised during baking. The effect of this heat is to rapidly expand the gas which in its turn expands the gluten and swells the loaf. As gluten is protein in nature it very shortly coagulates and thus holds the loaf in shape after the escape of the gases. The surplus moisture, the alcohol and acids volatilize. In time the starch granules are ruptured and become suitable for human food. On the outer portion or crust on account of the intense heat, most of the starch is dextrinized and a small portion is converted into glucose. The inner part or crumb is not subjected to as intense heat, since dough is not a good conductor of heat. The interior is not heated above the boiling point of water so the changes in the carbohydrate grow less as it approaches the center of the loaf. The yeast and bacteria are killed during baking and all enzymes present in the yeast and flour. This sterilizes the bread.

3. Cooling.—As soon as completely baked, bread should be placed on sieves or bread-racks so that the air can circulate around them until they are thoroughly cool. This gives the gas and steam within the loaves an opportunity to escape and prevents the bread from becoming damp.

A Modern Bread Factory.—In strong contrast to the old-fashioned cellar bakery with its dingy and many times insanitary surroundings, the modern bread factory has arisen. Here can be found bread being manufactured on a large scale in a well ventilated, sun-lighted building equipped with facilities as nearly perfect as modern science can suggest. An electric plant for lighting the building and running the machinery, a cold storage plant and hot water system for regulating temperature, elevators, conveyors and slides for carrying material from one part of the building to another, can be seen. Many curious devices in machinery have been invented, so that the human hand needs scarcely to touch the product from the time that the raw materials enter the building until the finished loaf is ready to be carried

Fig. 18.—Flour Sifter and Blender.
(Courtesy of Ward Baking Co.)

out for delivery. Conditions insuring thorough cleanliness are carefully sought and the bread is made amid thoroughly sanitary surroundings. Only a high grade flour, good yeast, distilled water and the best available material for shortening are used. Before being utilized the flour is passed through a sieve containing rotary brushes and a surprising amount of wood, lint, dust and other foreign material are removed. When needed, the sifted flour passes automatically to electric bread mixers, as does also the required amount of water, dissolved yeast, salt, etc. As the bread mixer revolves, filtered air is fed to the dough in order to hasten the action of the yeast and give whiteness to the product. The mixing operation requires some 25 minutes. The mixer is then turned over and the dough drops into the raising trough, where it is allowed to rise in a sunny, white-tiled room

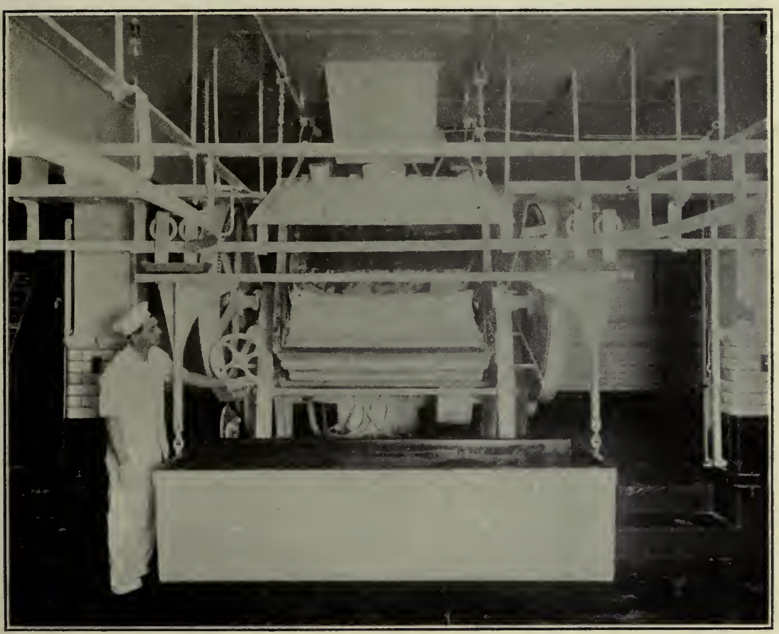


Fig. 19.—Mixing Machine with Dough About to be Lowered Into Raising Trough. (Courtesy of Ward Baking Co.)

for 3 hours. As soon as the dough is in proper condition, the bottom of the tub is removed and the dough proceeds by gravity through an opening in the floor to an apartment below, where it is automatically carried to a machine which weighs and cuts it into uniform pieces. It passes on a moving platform in separate loaves to a number of kneading devices which roll and press it into shape. The loaf travels forward and backward on a conveyor, where it is allowed to rest before it drops into a pan ready for the second rising. The pans are removed to an apartment heated to 110° F., and the bread is allowed to rise. It is then baked at a temperature of 450-550° F. On being removed from the oven, the bread falls on racks from which place it proceeds on an incline to the floor below where after cooling, it is wrapped and sealed in paraffin paper.

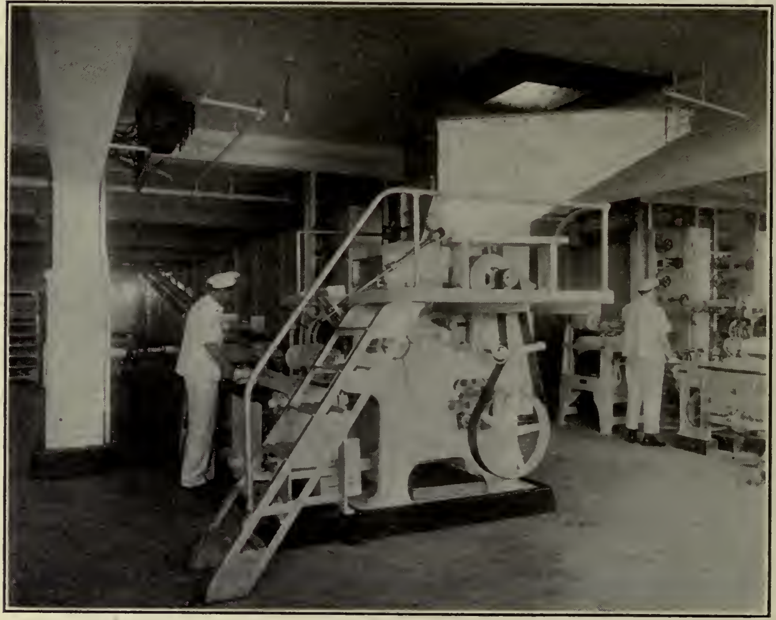


Fig. 20.—Machine for Dividing Dough Into Equal Parts of Equal Weight. (Courtesy of Ward Baking Co.)

Souring and Its Prevention.—The souring of bread is due to the development of lactic and butyric acid ferments. This may be caused by a poor grade of yeast which is apt to contain undesirable bacteria; by a poor flour which on account of the presence of certain nitrogenous bodies gives a medium particularly suitable for bacterial growth; by dirty vessels; by allowing the sponge to proceed too far thus giving the acetic ferment an opportunity to develop. It may be prevented by using a high grade flour, a good yeast and by thorough cleanliness. Too high a temperature during fermentation and prolonged raising of the sponge and dough should be avoided. Sudden changes in temperature should be guarded against.

Adulteration of Bread.—Alum has been largely used and evidently for a long period. English history speaks of Henry VIII

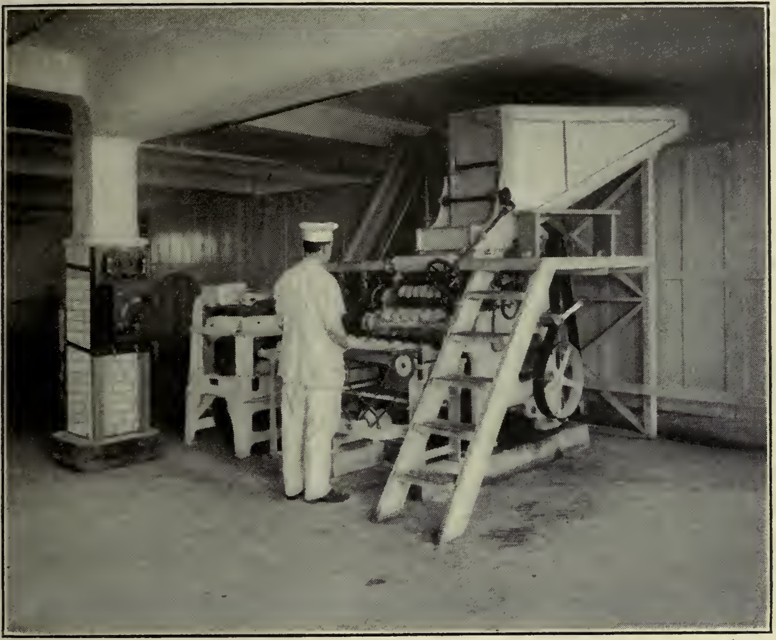


Fig. 21 —Front View of Dough Divider.
(Courtesy of Ward Baking Co.)

ordering his baker to be hanged for using alum in bread intended for the King's table. This subject has been much discussed of late years and its use has been finally prohibited by the Pure Food Law. As a rule alum was used with a poor grade flour or with a flour that had been kept for a long time under unfavorable conditions. When flour deteriorates the protein sometimes changes, becoming more soluble and will not make a good dough. Alum will cause it once more to become insoluble and a better gluten will be formed. The loaf is larger, less sodden, whiter and gives the appearance of a better grade flour.

Losses in Fermentation.—In the preparation of bread by means of yeast, appreciable losses of dry material must necessarily take place. This is caused by the formation of volatile matter during fermentation, such as carbon dioxide, alcohol and acids. They

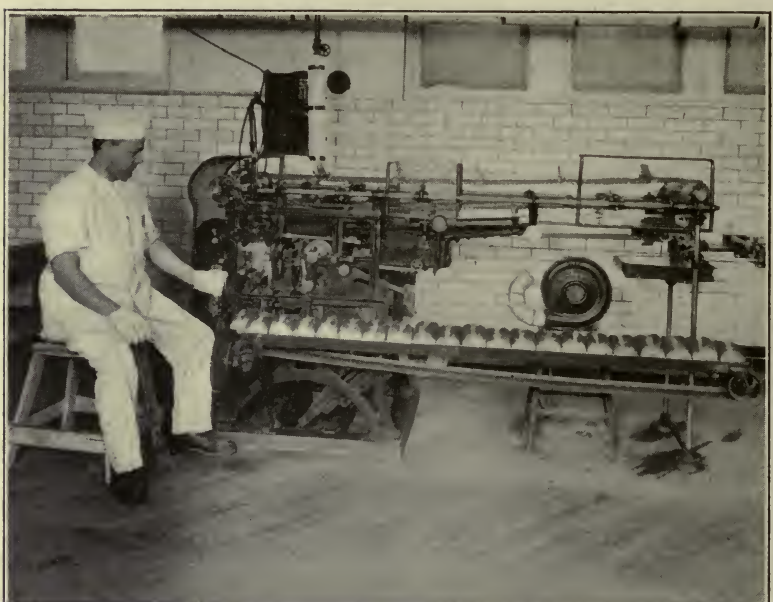


Fig. 22.—Machine for Wrapping Bread with Paraffin Paper. (Courtesy of Ward Baking Co.)

are driven off, to a large extent, at the temperature of baking, so have no nutritive effect. Estimates of this loss have been taken and as a rule it has been found to be approximately 2 per cent. although it may be much higher under unfavorable conditions. Liebig calculated that the loss in Germany daily would supply 400,000 persons with bread and it has been estimated that 300,000 gallons of alcohol are annually wasted in the bakers' ovens in London. There has been much experimenting and large sums of money expended in trying to recover this alcohol, but without success from the baker's standpoint; the bread was found to be dry and unpalatable. This inevitable waste has led to attempts to convert dough into a porous form by other methods than that of fermentation. Many mechanical and chemical processes of aerating dough with CO_2 have been invented, but in

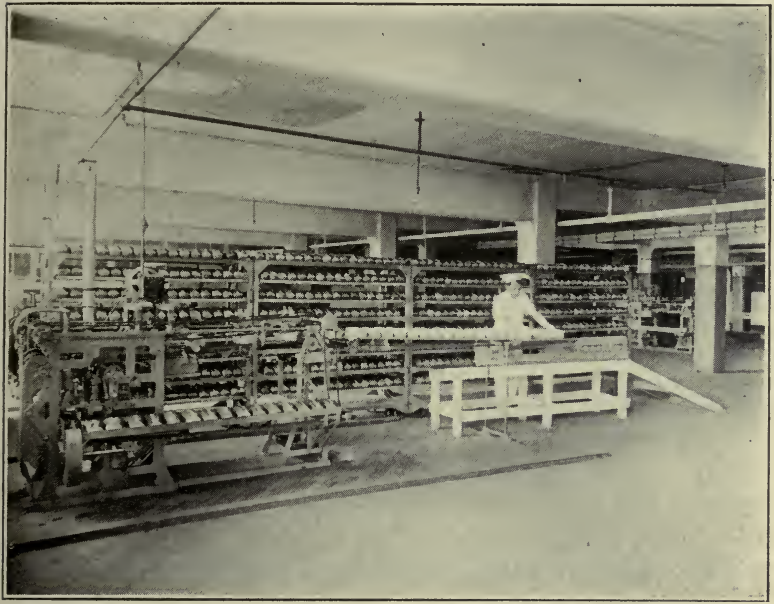


Fig. 23.—Bread After Leaving Wrapping Machine.
(Courtesy of Ward Baking Co.)

England and the United States, only two have met a slight success.

I. *Chemical Process.*—Use of baking powders. See Chapter VIII.

II. *Aerated Bread.*—In this process water is saturated with CO_2 prepared by chemical reaction. This highly charged water is then mixed with flour under pressure in air-tight chambers.

When the pressure is lowered the dough is forced out and blown up by the expanding gas. It is cut into loaves quickly and baked. This bread is very light, porous and involves no waste of material but unfortunately it has an insipid taste due to the absence of the by-products of yeast, so has never met with great success.

THE CRACKER OR BISCUIT INDUSTRY.

Those products formerly known in the United States as crackers and in England as biscuit originally included only varieties of unleavened bread, such as the commonly known pilot bread, ship's biscuits and water crackers, but the march of progress in the last half century has greatly enlarged the field of this industry until it now includes many articles formerly considered cakes, pastry and confectionery.

In both this country and in England the manufacture of biscuit has been greatly improved and the output tremendously increased, one American firm alone manufacturing some four hundred or more different varieties. Great manufacturing concerns have been attracted by this field of business and have by their efforts to produce a perfect product brought about improvements resulting in cleanliness and sanitation in the manufacture of these products. The dirty and insanitary cracker bin and barrel of the grocery store, such as was fomerly used when crackers and biscuit were sold only in bulk form, the chance for the small dealer to deceive, the many varieties of cheap scales, and such numerous handlings as were necessary to deliver the goods to the purchaser are all things of the past. The public now receives its biscuit in air-tight, moisture and dust-proof packages, packed and sold under the best possible conditions and free from the touch of human hands on their journey from the factory to the table of the consumer.

Raw Material.—For the most part, flour made from winter wheat is used in the preparation of biscuit, although different varieties will contain Graham, whole wheat and cereal flours. Butter, lard and specially prepared, refined fats from vegetable sources shorten the goods, and pure water or high grade milk furnishes the moisture, while yeast, bi-carbonate of soda, baking powder or aeration, assisted by the presence of eggs and fatty matter, serves as a leavening agent. There are many varieties of fancy biscuit in which are used refined sugar, fruits, spices, cheese, eggs, chocolate, nuts and confectionery. The ingredients, as above set forth, are carefully measured and weighed, then placed in a mixer, usually a large steel receptacle with revolving arms, and are thoroughly mixed by machinery for a definite time. If the leavening agent be yeast, a period of incubation at a properly fixed temperature must follow. The dough, now

Fig. 24.—A Baking Floor showing Ovens. (Courtesy of The National Biscuit Co.)

thoroughly mixed and having been allowed to rise the proper length of time, is wheeled in its clean steel car to the dough-breaks where, by being rolled and folded between great rollers, it is kneaded into the proper thinness and ready for the machine which further shapes and stamps it into the form in which it is baked with the design and trade mark impressed on the dough.

The ovens used to bake biscuit are generally direct heat with rotating shelves and are kept at a temperature approximating 500° F. After being baked and taken from the oven, the biscuits are cooled and immediately packed in their moisture and dust-proof packages, in which they start their journey, often the same day they are packed, to the ultimate consumer (Fig. 24).

MACARONI.

In the world's food products made from wheat, macaroni has occupied an important place in the diet of several nations. The Japanese claim to be the original manufacturers but whether this be true or not, the Europeans first heard of it from the Chinese who had been using it for a long period. Although the Germans were the European discoverers of macaroni, it was the Italians who early learned to appreciate its virtues and to adopt it as a national food. By the 14th century, Italy was the only European nation that understood its preparation, and for nearly four hundred years she held the secret of the method of manufacture.

The Italian macaroni industry had its birth in Naples from whence it spread throughout Italy and finally to other parts of Europe, but it was not until the latter part of the 19th century that this product could be equaled in any other country. It was finally introduced into France where it has become an important industry. Although the United States is still a large importer of macaroni, there has been a great growth in the macaroni industry since the cultivation of durum wheat in our own northwestern states.

In the preparation of macaroni a hard, very glutenous wheat is used, called macaroni wheat. The early Neapolitan manufacturers won their fame on account of the excellent quality of the Italian wheat. Unfortunately the cultivation of native wheat is now sadly neglected in Italy. Russia for a long period has produced some of the finest varieties. They were grown extensively for macaroni-making long before Liebig started his experimentation on hard wheat as a breadmaking material. Algerian durum wheat, the wild goose wheat of Canada and Argentina macaroni wheat are also largely exported for this industry.

Manufacturing Processes.—In the macaroni manufacture the first step is the preparation of a coarse meal called "semolina" or "semola." Wheat is cleaned by steeping in water, dried by heat, ground and sifted. The husks and much of the starchy flour are separated out leaving the light amber, glutenous part resembling a meal rather than flour. As a rule manufacturers of macaroni buy their semola from millers, rather than do their own grinding. The best macaroni is made by blending various grades of semola much as flour is blended for breadmaking. The semola is then put into an iron mixer, moistened with the smallest possible quantity of hot water and thoroughly mixed by machinery for about 7 minutes or until the dough has a smooth and tough appearance. The mass is kneaded for a few minutes and is transferred to a cylinder. Pressure descends upon the dough, forcing it in strings slowly through the perforated plate which forms the bottom of the cylinder. The form of this plate fixes the character of the macaroni. If the holes contain a steel pin or conical blade the dough takes the form of a pipe-stem and is known as tube macaroni. Holes without pins give solid macaroni and smaller holes produce spaghetti and vermicilli. A flat opening sometimes takes the place of a round hole and ribbon forms are made. When the strings of paste are the proper length they are cut either by hand or by automatic rotary knives. The macaroni is then thrown over reed poles to dry. When the weather is fine it is left exposed to the sunlight for about two hours. When partly dry, it is put into underground vaults and kept in this damp place for about 12 hours or until the dough has lost some of its brittleness and is once more pliable. The poles over which the macaroni hangs are then carried to storehouses where they remain until the strings have a horn-like toughness. They are now ready to be inspected, sorted, weighed and packed for shipment. In case of bad weather the macaroni is dried under cover for a longer period. The yellow color is produced by the use of saffron or of a coal tar dye.

Domestic Macaroni.—There is a constant increasing demand for macaroni made in the United States. The hardest variety of wheat is used especially the hard wheat of Kansas and that grown in the semi-arid land. The drying, especially in the eastern states is done entirely indoors, the lengths being hung over wooden rods in heated apartments through which currents of air are driven. The product is very satisfactory and the sanitary conditions connected with the manufacture are largely in advance of those under which many imported brands are produced.

Judging Quality.—A good quality of macaroni should have a soft yellowish color, should be rough in texture, elastic, hard, and should break with a smooth, glassy fracture. In boiling it should double its original size and should not become pasty or adhesive.

As a Food.—Macaroni is a very palatable and nutritious food. It can be kept for a length of time without deterioration and is comparatively inexpensive. Being high in protein it can readily replace meat in the diet.

CHAPTER VIII.

LEAVENING AGENTS.

Early in the history of the human family, it was found that in order to make bread easy to masticate and more readily digestible, it must be puffed up before it was baked. This could best be accomplished by a gas with heat to expand it. CO_2 was the first gas used, obtained through the agency of yeast, and nothing has ever been found that can equal its action as a leavening agent.

ADVANTAGES.—I. CO_2 is generated by the action of the yeast enzyme on the carbohydrate of the meal or flour, so no foreign substance is introduced into the dough.

II. The slow liberation of the gas causes it to have its full effect as a leavening agent.

III. The by-products produced during fermentation give a pleasant taste.

IV. Bread made by yeast is more easily digested.

DISADVANTAGES.—I. The time required for leavening is long.

II. Careful watching and studying of favorable conditions for the growth of yeast are necessary or the result will be sour or sodden bread.

III. It involves a loss of carbohydrate in the formation of products which are volatile at the baking temperature.

IV. As yeast is a living organism, it is impossible to calculate the amount of gas produced.

Chemical Agents.—The necessity of sometimes raising bread quickly has led to a study of chemical agents which will produce CO_2. With this method the gas is liberated in the presence of water by the action of an acid or acid salt on a carbonate, usually in the form of a bicarbonate. The salt resulting from the chemical action of the acid and base remains in the dough.

ADVANTAGES.—I. The time is shortened. In a few minutes a light, spongy dough can be prepared which would require hours by the use of yeast fermentation.

II. No loss of the carbohydrate is involved.

III. It is possible to calculate the amount of gas which may be produced if the composition of the chemical reagents is known.

Disadvantages.—I. The taste is not as good as that of bread raised by yeast.

II. The product is not as readily digestible.

III. The residue resulting from the chemical reaction remains in the loaf. As these residues have no nutritive value, they can only be regarded as waste products.

Early Use of Chemical Agents.—Long before the scientific investigation along the line of these reagents was begun, the housewife was making use of the same principle in the utilization of sour milk and saleratus to lighten dough. Although this method was very effective, it had two serious drawbacks: 1. The acidity of the milk was apt to be over-estimated. Lactic acid is caused by the action of bacteria in milk on the lactose or milk sugar.

$$C_{12}H_{22}O_{11}.H_2O \rightarrow 4C_3H_6O_3.$$

When 0.9 per cent. is formed the action is stopped, the lactic acid acting as a preservative. In sour milk as used for cooking purposes, the acidity rarely exceeds 0.4-0.5 per cent. As a rule too large an amount of saleratus was used thus giving an excess of alkali. This affected the taste and interfered with protein digestion. 2. The saleratus of to-day is not $KHCO_3$, but a cheaper and stronger compound $NaHCO_3$, approximately four parts of which according to the molecular weight, will do the work of five parts of the potassium compound. Old recipes should, therefore, be reduced to 4/5 of the amount suggested.

Baking Powders.—The introduction of baking powders some fifty to sixty years ago was a great advantage although the early powders were very crude. The first one prepared had for its ingredients Na_2CO_3 and H_2SO_4, but this proved too troublesome to be practical. Liebig suggested the use of the $NaHCO_3$ and HCl which would give a residue of NaCl, a perfectly harmless product. The bicarbonate was found to be so satisfactory that its use has continued to the present time, but experimentation soon proved that the acid could not be used. Commercial HCl almost invariably contains traces of arsenic, minute quantities of which could be found in the dough. Another acid was sought, one which could be effective, comparatively cheap, with good keeping qualities and which would give a harmless residue. Tartaric acid was finally chosen. It was expensive and difficult to keep but it was effective and harmless. Bicarbonate of soda and tartaric acid were tried, both in the powder form. For the sake of convenience these powders could be mixed together. When dry, they did not exert any effect on each other but atmospheric moisture was so quickly absorbed, that chemical action took place and much carbon dioxide was lost. An early improvement was the addition of starch or some other substance having hygroscopic property. Starch absorbs moisture readily and will also tend to keep apart the particles of the acid and base. Another improvement was soon made. Tartaric acid was found to be harmless and efficient but it was expensive and objectionable from a practical standpoint. On account of its great solubility, too rapid evolution of gas occurred. The acid potassium salt, cream of tartar, was less expensive, very effective and perfectly harmless. As it was not so soluble, less loss occurred. These were known as the tartrate powders.

Tartrate Powders.—The first powder of commercial importance contained three ingredients, bicarbonate of soda, cream of tartar and starch as a filler. Much advertising led to a rapid growth in the use of these powders and in a short time they became very popular. The method of manufacture was simple and the profits were enormous. Chemistry was searched for other combinations which could be used for leavening bread. Two acid salts were soon discovered which could be substituted for cream of tartar.

1. *Phosphate and Alum Powders.*—Calcium acid phosphate, a salt of about the same strength as cream of tartar, but cheaper in price.

2. Potash alum, a salt of great leavening power and very low in cost.

Formulae were devised by chemists which made possible the use of either, one or both of these salts in combination with bicarbonate of soda, starch being added as a filler. The powders were known as the phosphate, the alum phosphate and the straight alum powders.

The introduction of less expensive salts and the simplicity of the process of manufacture led hundreds of individuals and companies into the baking powder business and great competition followed. Until the passing of the law prohibiting their use, there were many straight alum powders on the market. They contained starch as filler, bicarbonate of soda and potassium, sodium or ammonium aluminium sulphate. They were very effective but were found so objectionable on account of the amount of alum present that their sale has been practically abolished.

The powders on the market at the present time are tartrate, phosphate and alum phosphate. There has been much controversy as to the relative merits of these powders, the chief point of discussion being the residue, "What is it?" "What amount is present?" "Is it harmful?" A glance at the following reactions and table will give some idea of the relative value.

TARTRATE POWDER.

$$\underset{188}{KHC_4H_4O_6} + \underset{84}{NaHCO_3} + \underset{54}{3H_2O} \longrightarrow \underset{282}{NaKC_4H_4O_6{,}4H_2O} + \underset{44}{CO_2}$$

20 per cent. filler.

1 level T. of powder weighs 3.00 grams and contains 20 per cent. of starch. This yields approximately 0.4 gram CO_2 or 200 cubic centimeters at 0° C., which becomes 273 cubic centimeters at 100° C. the highest temperature of the oven. The residue of crystallized Rochelle Salts amounts to 2.5 grams.

PHOSPHATE POWDER.

$$\underset{234}{CaH_4(PO_4)_2} + \underset{168}{2NaHCO_3} + \underset{180}{10H_2O} \longrightarrow$$
$$\underset{136}{CaHPO_4} + \underset{358}{Na_2HPO_4{,}12H_2O} + \underset{88}{2CO_2}$$

$CaHPO_4$ is insoluble in water; it requires free acid for solution.

1 level T. of powder weighs 4.4 grams and contains 25 per cent. of starch. This yields approximately 0.72 gram CO_2 or

355 cubic centimeters at 0° C. which becomes 485 cubic centimeters at 100° C. the highest point of the oven. The residue of phosphates weighs 4.05 grams.

ALUM PHOSPHATE POWDER.

$$\overset{475}{(NH_4)_2Al_2(SO_4)_4} + \overset{234}{CaH_4(PO_4)_2} + \overset{336}{4NaHCO_3} +$$
$$\overset{144}{8H_2O} \longrightarrow \overset{245}{Al_2(PO_4)_2} + \overset{192}{CaSO_4,2H_2O} +$$
$$\overset{132}{(NH_4)_2SO_4} + \overset{644}{2Na_2SO_4,10H_2O} + \overset{176}{4CO_2}$$

1 level T. of powder weighs 2.85 grams and contains 33⅓ per cent. of starch. This yields approximately 0.32 gram CO_2 or 160 cubic centimeters at 0° C. which becomes 218 cubic centimeters at 100° C. the highest point of the oven. Residue weighs 2.17 grams.

	Weight of 1 T. of powder	Weight of 1 T. of powder less the filler	Weight of CO_2	Volume of CO_2 at 0° C.	Volume of CO_2 at the oven temperature	Weight of the residue	Remarks
Tartrate . .	3 grams	2.4 grams	0.4 gram	200 c.c.	273 c.c.	2.5 grams All soluble in water.	Residue contains water of crystallization.
Phosphate	4.4 grams	3.3 grams	0.72 gram	355 c.c.	485 c.c.	4.05 grams 27.5% insoluble in water.	Residue contains water of crystallization.
Alum phosphate	2.85 grams	1.9 grams	0.32 gram	160 c.c.	218 c.c.	2.17 grams 36.6% insoluble in water.	Residue contains water of crystallization.

Relative Efficiency.—I. Alum phosphate powders are the cheapest, but they do not keep well. They contain alum which is supposed to have a deleterious effect on the system and leave a residue which is partly insoluble in water.

II. Phosphate powders are cheap, but they do not keep well and leave a residue which to some extent is insoluble.

III. Tartrate powders are expensive, but they keep well so are effective when old. They yield a residue of Rochelle Salts which is soluble in water.

Tartrate powders may be prepared at home by thoroughly mixing ½-pound of cream of tartar, ¼-pound of bicarbonate of soda and ¼-pound of starch or lactose. Lactose has been found to be very effective as a filler. It has great lasting power but is more expensive.

Ammonia Powders.—Bakers are now using ammonia carbonate very effectively as a leavening agent. It has the great advantage of leaving no residue, but must be used in very small quantities or the product will taste of ammonia.

$$(NH_4)_2CO_3 \rightarrow 2NH_3 + CO_2 + H_2O.$$

Cream of Tartar.—Almost all of the cream of tartar and tartaric acid used in this country is imported, the largest amount coming from Germany and France. They are by-products of the wine industry being obtained from a certain kind of sour wine. Cream of tartar or potassium bitartrate is a normal constituent of grapes, occurring in comparatively large amounts. When the fruit is crushed and pressed in the preparation of wine, most of the tartrate salts being soluble passes out with the juice. There is no tendency for it to become insoluble and precipitate out in crystalline form until the grape juice reaches 5-6 per cent. of alcoholic strength. This occurs during the fermentation process. It is customary to float branches of the grape vine in the fermenting vats. As the alcohol increases, gradually cream of tartar is deposited upon the sides of the vat and on the floating branches. The crystals carry down with them the color of the wine. They are known commercially as "argol." There are usually from one to three inches of a dark deposit at the bottom of a full barrel of new wine after it has stood long enough to settle, called the "lees." From argol, cream of tartar is made. "Lees" contains a larger amount of calcium tartrate and is used more extensively for the production of tartaric acid.

Argol is not pure cream of tartar as it carries down in precipitating, other constituents of the grape. These impurities must be removed. In the process of refining, the crystals of argol are powdered, dissolved in boiling water and filtered to remove dirt and other foreign matter. The color can be removed with egg albumin or by filtering while hot through bone-black. The solution is then run into shallow receivers and as the clear liquid cools, cream of tartar separates out and is deposited in thick masses of crystals. These crystals may be further purified by again dissolving in hot water and recrystallizing. When all the impurities are removed, the crystals are powdered in a mill and are then ready for the market.

Tartaric Acid.—Tartaric acid may be prepared from the lees by the action of sulphuric acid. The calcium is removed in the form of a sulphate.

$$CaC_4H_4O_6 + H_2SO_4 \rightarrow H_2C_4H_4O_6 + CaSO_4$$

Tartaric acid is used largely in pharmacy and in the textile industry, either as the acid or as tartar emetic in certain dyeing processes and in calico printing.

Acid Phosphate of Lime.—Acid phosphate of lime occurs in different forms. The soluble acid phosphate as used in the baking powder industry does not occur in nature, but must be manufactured. The skeletons of animal life are largely employed for this purpose. Here calcium phosphate $Ca_3(PO_4)_2$ appears in a form insoluble in water, but which can be readily made soluble by treatment with an acid.

$$\underset{\text{insoluble}}{Ca_3(PO_4)_2} + 2H_2SO_4 \rightarrow \underset{\text{soluble}}{CaH_4(PO_4)_2} + 2CaSO_4$$

The material utilized in this industry is usually obtained from certain sections of the country where large deposits of phosphate of lime have been found. This has been caused by sharks and other forms of animal life having been deposited in past ages, and through the process of weathering all organic matter has disappeared, leaving only the material which has constituted the frame work. This material is dug up and changed to a form which can be utilized in the baking powder industry.

Bicarbonate of Soda.—The preparation of soda constitutes to-day one of our largest and most important industries. An alkali has been used for cleaning purposes by the housewife, for many centuries, but this represents only about one per cent. of the soda manufactured. It is also needed in many industries such as soap-making, glass manufacture and in the bleaching of cotton and linen goods.

The original alkali used was potassium carbonate obtained from potassium salts which are widely spread throughout plant life. The early housewife obtained her supply from the ashes of her wood fire. Boiling water was poured over the dead embers of the fire, and the solution was boiled down giving a lye which could be used for cleansing purposes. For many years, the manufacturer was forced to depend, also, on the leaching of wood ashes or on natural deposits of potash which have been found in certain parts of the world. The largest deposits occur on the western coast of South America and in the region of North Germany which has Starsfurt as the center.

It was not until the 18th century that another alkali was found to take its place. This was discovered by the Spaniards who prepared it by burning to ash a sea-weed found along their coast. It contained a sodium compound which yielded a carbonate on heating. The soda compound, being stronger and cheaper than potash, was readily received by the manufacturers and used by them, until the early days of the 19th century. Warfare at that time interfered with commerce and Spain being hostile, the French manufacturers were cut off from their source of supply. Napoleon was determined to get some means of replacing this alkali and as France was poor in mineral deposits, he offered a reward for the discovery of a practical process for making sodium carbonate. Everything used in the manufacture, however, must be obtained in France. Many chemists worked at this problem and a process was finally discovered by Le Blanc which is used in many places at the present time.

Le Blanc Method.—Le Blanc used in the preparation of soda, dry salt which he obtained from the sea, by the process of evaporation. He then mixed together salt and sulphuric acid.

$$2NaCl + H_2SO_4 \rightarrow Na_2SO_4 + 2HCl$$

Na_2SO_4 was known as the salt cake. It was broken up and mixed with powdered coal and limestone and was then treated in a reverberatory furnace.

$$Na_2SO_4 + 2C \rightarrow Na_2S + 2CO_2$$
$$Na_2S + CaCO_3 \rightarrow Na_2CO_3 + CaS$$

Na_2CO_3 an impure form, known as soda ash, could be dissolved out and the water afterwards evaporated. To obtain pure Na_2CO_3, the soda ash must be again heated with coal and other soda compounds be changed to the carbonate form.

Bicarbonate of soda can be easily obtained from sodium carbonate.

$$Na_2CO_3 + H_2O + CO_2 \rightarrow 2NaHCO_3$$

Hydrochloric acid was practically unknown commercially until the invention of the Le Blanc process of soda manufacture. At first it was allowed to escape into the air and being washed down by rain it found its way into neighboring streams. This soon caused the destruction of animal and plant life and was also a waste of a valuable by-product. Later it was discovered that HCl could be run into water and sold. This opened up a new industry and did much toward making the Le Blanc method a commercial success.

When more HCl was produced than was needed, it was soon found that from it chloride of lime could be prepared, and a valuable disinfectant and bleaching agent was placed upon the market.

Value of the Le Blanc Process.—I. The raw materials salt, coal, limestone and sulphuric acid are common and inexpensive.

II. The furnace and plant can be put up at a fairly low price.

III. The by-products are important and have done much toward keeping this process in existence.

Solvay Process.—The Solvay method of preparing sodium carbonate was invented in 1860 by a Belgian named Solvay, and is a serious rival of the Le Blanc process. Scattered throughout the world are large deposits of salt, sometimes in the dry state as in the salt mines of Germany and England, at other times in the form of brine. Brine wells occur more extensively and as the Le Blanc method required dry salt, it was found very troublesome to evaporate the water. The Solvay process can make use of the brine. This has been a great benefit to America for brine wells are abundant in Michigan, Louisiana and New York State. Syracuse is an important center in the American soda industry. Brine is also much easier to handle. It is pumped to the surface, saturated with ammonia, and then with carbon dioxide.

$$NaCl + H_2O + NH_3 + CO_2 \rightarrow NaHCO_3 + NH_4Cl.$$

$NaHCO_3$ is separated out by filtration.

If sodium carbonate is wanted the bicarbonate is heated.

$$2\ NaHCO_3 \rightarrow Na_2CO_3 + H_2O\ CO_2.$$

The ammonium chloride obtained in this process can be decomposed by heating with quicklime, and the ammonia given off is again used for the treatment of another batch of brine.

This process is cheaper than the Le Blanc and furnishes a purer product.

Niagara Process.—By the use of electricity, a method of preparing soda has been discovered, which is a serious rival to both the Le Blanc and Solvay processes. Brine is here run into partitioned tanks containing electrodes. When the current is turned on ionization of the salt occurs.

$$\overset{+}{Na}\overset{-}{Cl} + H_2O \rightarrow NaOH + HCl.$$

NaOH passes to the negative pole in one partition as it carries a positive change and HCl goes to the positive pole in the other partition.

Caustic soda can readily be utilized in the preparation of the carbonate and the bicarbonate.

$$2\ NaOH + CO_2 \rightarrow Na_2CO_3 + H_2O,$$
$$Na_2CO_3 + H_2O + CO_2 \rightarrow 2\ NaHCO_3.$$

In this industry HCl can again be used as a by-product for the preparation of chloride of lime or can be utilized in the acid form.

CHAPTER IX.

STARCH AND ALLIED INDUSTRIES.

Starch is one of the most widely diffused substances in the vegetable kingdom. With the exception of the fungi, it has been found in varying amounts in every plant that scientists have so far examined. It occurs in relatively large amounts in different parts of the plant as in the seed (cereals), the root (cassava), the tuber (potato), the fruit (banana), the stem (celery, rhubarb, sago), and in the leaves (spinach).

Composition and Formation.—See Chapter I, Food Principles.

Physical Characteristics.—To the naked eye, starch has the appearance of a glistening white powder. It is neutral to litmus, has no odor or taste, does not crystallize and has a harsh feeling when rubbed between the fingers. When seen through a microscope, it consists of granules of various forms, round, oval, etc., differing greatly in size, according to the source. This has served as a valuable means of identifying starch. Although the size and shape may differ, all starch granules have a characteristic appearance. They are arranged in layers around a central nucleus. The outside consists of a substance closely resembling cellulose and within the granule or package is found the true starch.

Physical and Chemical Properties.—I. Insoluble in cold water.

II. With iodine, starch gives a characteristic blue color.

III. Starch absorbs moisture from the atmosphere until it contains approximately 18 per cent. In very damp weather, it has been found to absorb a much larger quantity.

IV. When heated dry to 200° C. or more it is converted into dextrin.

V. When heated in the presence of water, the contents of the granules swell enormously owing to a large absorption of water, and cause the rupture of the outer wall. The starch freed from the package, forms a viscous liquid known as starch paste.

Uses.—While its place in the diet would alone make starch an important article of commerce, the manufacturer finds many another market for his product. It is used:

In laundries.

For food such as puddings, sauces and jellies.

For candies such as gum drops and lozenges.

In baking powders.

In the textile industry for stiffening and finishing fabrics.

In wall paper manufacture as a filler, finisher and size.

For cosmetics, asbestos, soaps and adhesives.

In brewing beer, ales and in the manufacture of alcohol.

For the manufacture of dextrin and glucose.

Source of Supply.—While starch is so widely distributed in the vegetable kingdom, there are comparatively few plants that can be utilized as a source of supply for the manufacture. In looking for his raw material, the starch producer must consider several important points: 1st, the ease with which the plant can be grown in his locality; 2nd, the amount of starch yielded by the plant; 3rd, the ease of extraction; 4th, the presence of other constituents such as protein and oil, which makes the process difficult.

With these points in mind, the European manufacturer chooses the potato, wheat and rice. The American uses corn and to a limited extent the potato and wheat. In the East and West Indies the cassava furnishes the chief source of starch. The arrowroot is utilized in the West Indies and parts of South America, and the sago in the East Indies.

POTATO STARCH.

The potato is a valuable source of starch on account of the great ease of extraction. The starch content is comparatively low as compared with corn and wheat, but protein, mineral matter and oil are present in such small amounts that they do not interfere with manufacturing processes. As a rule only about 20 per cent. of starch is found in the potato, although in certain parts of Germany the starch content has reached from 25-29 per cent.

Potatoes can be grown very easily in temperate climates such as Germany, England, Scotland and Ireland. In the United States, Maine is noted for the production of a high quality potato and Wisconsin and Colorado grow the potato largely for the starch industry. The following demonstration may be used to illustrate the simplicity of the method used:

Extraction of Starch.—Clean and remove the skin from a small potato. Rub it on an ordinary grater, collect the gratings in a beaker of cold water, strain and allow the cloudy liquid to stand until the starch settles. Pour off the liquid. The starch can be purified by the addition of water, thoroughly mixing and allowing the starch to again settle. Remove the water by filtration and dry the starch with low heat.

Although the manufacturer uses more or less complicated machinery to carry out these operations, the commercial processes are practically the same.

Processes in Manufacture.—I. *Cleaning.*—The washing of potatoes must be thorough or the quality of the starch will suffer. The adhering dirt and sand are carefully removed by washing in revolving wooden drums, so constructed that the water carrying dirt and other impurities can escape through narrow openings. Inside the drums, devices such as bristle or wire brushes, or revolving arms which rub the potatoes together, are sometimes used to assist in the cleansing.

II. *Rasping.*—The potatoes are reduced to a pulp in machines called raspers. These are usually revolving cylinders containing saw blades or knife edges to assist in the pulping process. Water is added at the time of rasping and the starch pulp is fed to a sifting machine.

III. *Sifting.*—Shaking tables covered with gauze separate the starch grains from the potato pulp. The pulp can be pressed and dried. It is sold as a low grade cattle food. The starch suspended in water passes through the sieves to settling tanks. When it has settled in a firm mass, it can be broken up and sent at once to a drying kiln or can be further refined.

All root starches follow the same principle in the extraction of the starch.

TAPIOCA.

Tapioca is an important food product prepared from the starch of the cassava, a plant grown largely in Brazil and other tropical countries. The extraction of the starch is carried out by the processes of grinding and washing with water, similar to those described under potato starch. The product is sometimes known as Brazilian arrowroot. In the manufacture of tapioca, the starch while still damp is placed in shallow pans and subjected to low heat. As the moisture is driven off, the tempera-

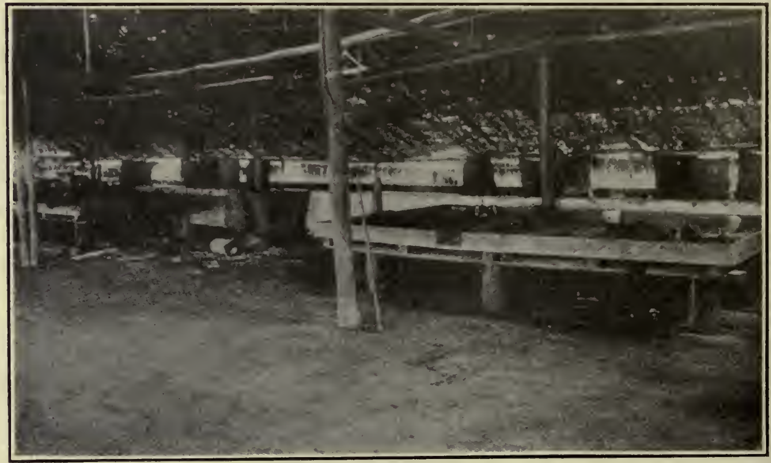


Fig. 25.—Sheds and Board Used for Drying the Tapioca. (Courtesy of The Spice Mill Publishing Co.)

ture is gradually raised until the starch granules burst and adhere together, forming the mass into small irregularly shaped translucent kernels. A similar product may be obtained by making a starch paste, subjecting it to heat, and forcing it through metal screens from which it is dropped and cooled. Tapioca is placed on the market in various forms according to the amount of heat used and differences in mechanical operations.

Starch derived from other sources may be subjected to the same treatment and an equally nutritious product be obtained. As genuine tapioca, however, is always prepared from cassava starch, other imitative forms must be classed as substitution products.

Outline of the Corn Products Industry.—

I. Cleaned.

II. Kernel softened by steeping.

III. Crushed.

IV. Separated by gravity.

(1) Germ flows off from the top with the raw starch liquor, screened from the latter, dried, ground, pressed.

(2) Hulls flow off from the bottom with the raw starch liquor, screened from the latter, then ground in burr mills and become part of gluten feed.

(3) Endosperm (raw starch liquor) separated by gravity on tables into
- Starch.
- Gluten, which with corn solubles obtained from steeping water, becomes part of the gluten feed.

Starch is purified and sold as

I. Starch—laundry lump, crystal, pearl powder etc.

II. Dextrin
- 1. By process of roasting.
- 2. By use of a dilute acid.

III. Glucose by process of hydrolysis
- Boiled with dilute acid 0.06 of 1%
- Neutralized.
- Filtered.
- Decolorized.
- Concentrated.

CORN PRODUCTS INDUSTRY.

The abundance of the growth of corn in the United States and the many by-products obtained, make it an important source of starch, although the composition of the kernel involves elaborate methods for the extraction.

The kernel of corn consists of an outer coating called the hull, the germ which contains a comparatively large amount of oil, and the endosperm, where are found starch and protein.

When received at the factory, the corn contains some impurities and the kernel is in a dry, hard condition.

Fig. 26.—Steeped Corn Running to Crushers. (Courtesy of Corn Products Refining Co.)

Processes in Manufacture.—I. *Cleaning.*—Corn like other cereals contains a certain amount of foreign matter such as bits of corn cob, pieces of wood, lint, dust and dirt. These are removed by screening, while magnets are used for drawing out bits of iron, nails and the like.

II. *Steeping.*—In order to separate the kernel into its component parts, the hard, dry grain must first be softened. This is accomplished by steeping it in water for approximately 40 hours at a temperature of 110° F. Steam is injected to maintain the circulation and to keep the temperature at the desired degree A very small amount of acid, 0.005 per cent. H_2SO_3, is added to prevent fermentation. This is afterwards removed by thorough washing. When the grain has absorbed sufficient moisture to cause a loosening and softening of the various parts, the water is drawn off, leaving the kernel of corn in a moist, soft condition.

Fig. 27.—Crushers. (Courtesy of Corn Products Refining Co.)

The steepwater is evaporated and the solubles of the corn are incorporated with the gluten feed. The steeped corn is run to the crushers (Fig. 26).

III. *Crushing.*—The softened grain is passed through a mill called the crusher (Fig. 27). It consists of two large disks set face to face having projecting teeth and rotating in opposite directions. It is supposed to grind only to a coarse meal, thus leaving the germ and hull intact.

Fig. 28.—Separators. (Courtesy of Corn Products Refining Co.)

Fig. 29.—Hydraulic Presses for Oil. (Courtesy of Corn Products Refining Co.)

IV. *Separation.*—The resulting mass is fed to a long, narrow tank about 25 feet long, 4 feet wide and 8 feet deep, where taking advantage of the difference in the specific gravity, a separation of the various parts is effected. The germ being the lightest rises to the top and floats over the weir at the end of the tank; the hulls sink to the bottom and flow off with the starch liquor (Fig. 28). The germs are passed over screens or shakers. They are then washed to free them from adhering starch, dried, ground fine, heated, wrapped in cloth and pressed (Fig. 29). The pressure causes the oil to flow out, leaving the oil cake which is sold for cattle food. The oil is cleared of foots by settling and passing through a filter press. It may be used for the manufacture of soap, soap powders, oil cloth, leather, paints and varnishes. By further refining with a treatment which removes the free fatty acids and other impurities, corn oil can be used for edible purposes as a salad oil, for frying and cooking and as a shortening for bread and cake. In this form, it is also utilized for pharmaceutical purposes. By a vulcanizing process, corn oil yields a substance called "paragol," which can be used as a rubber substitute in the preparation of such articles as shoes, rubber specialties and automobile tires.

V. *The Hulls and the Endosperm.*—The hulls flow off from the bottom of the separator together with the starch liquor (endosperm) just as did the germs from the top of the separator. They then pass over screens, the starch liquor uniting with the starch liquor of the germs. The hulls being coarse are ground in burr mills, passed over screens, the starch liquor unites with the starch liquor of the germs and of the hulls, and the ground hull becomes part of the gluten feed, being mixed with the gluten and corn solubles.

The starch liquor (endosperm) contains the starch and protein matter, which is spoken of as gluten by the manufacturer. These must next be separated. This is effected by running the starch liquor from the germs, hulls and ground hulls, directly upon tables from 60-120 feet long, 3 feet wide with a decline of about 4 inches. As there is a difference in specific gravity, the starch settles while the liquid containing the protein flows over the end of the run and is caught in a tank below. The crude corn protein is mixed with the hulls, filter pressed, mixed with the corn solubles, dried, ground and constitutes gluten feed. The starch which settles to the bottom of the run is removed by being shoveled while in a solid, moist condition. The purification can be effected by the addition of water and again passing over the runs on which the starch settles. This process can be repeated, until all foreign matter such as traces of fat and

Fig. 30.—Dripping Boxes. (Courtesy of Corn Products Refining Co.)

protein, are removed. Pearl starch, that to be used for baking powder and for certain classes of food starch, is prepared by breaking up the starch from the table and placing it on trays which are put into iron wagons, run into kilns, and dried. The lump starch and crystal forms are prepared by mixing the starch from the tables with water, then running it into boxes with perforated bottom lined with cloth (Fig. 30). The boxes are allowed to stand until the water runs off, then turned over and the thick slab of starch is broken up into cubes (Fig. 31). These are either wrapped in paper or put in trays and placed in drying ovens, where after ten or more days they are drawn out.

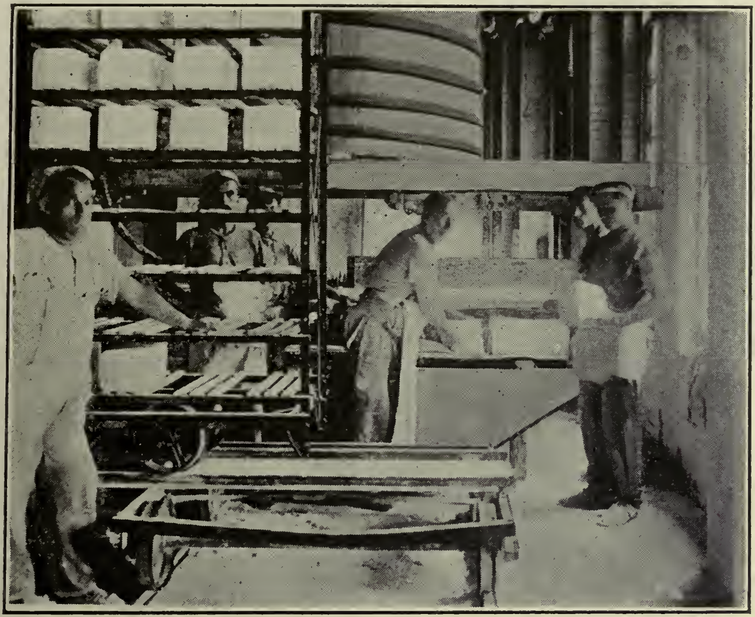


Fig. 31.—Emptying Starch from Drip Boxes. Breaking into Cubes. (Courtesy of Corn Products Refining Co.)

DEXTRINS.

Dextrins are produced in the same factory usually by the simple process of roasting. The different varieties depend upon the time and heat applied.

Uses for Dextrins.—For the manufacture of gums, glues, mucilage and other adhesives.

For cloth, carpets and twine.

For leather dressings, paper and ink.

For food sauces.

In the textile industry, in sizes for strengthening the fiber and finishing the fabric. Also for thickening colors for calico and other printing.

CORN SYRUP OR GLUCOSE.

On account of its source commercial glucose is known in the United States as corn syrup. The term glucose is derived from the Greek word "Glykos" meaning sweet. It is a carbohydrate of the monosaccharid group, $C_6H_{12}O_6$, and is found in nature in the juice of many plants such as grapes, cherries and sweet corn. Although it exists at times in relatively large amounts, the commercial source of glucose is always starch on account of the cheapness of that material, and the comparatively simple process of manufacture. In Europe glucose was first prepared from the potato starch during the early part of the 19th century, and has long been looked upon as a nutritious food. It was not until after the Civil War, however, that American manufacturers started experimenting with corn starch as a source of supply for glucose. As grape sugar and corn syrup, it was soon placed upon the market. The products from corn compared very favorably with those made abroad from potato starch and so rapidly has the manufacture grown, that it is now one of our most important industries.

Glucose is sold in the liquid form, either white or colored, with or without flavoring, and as a solid in the powdered and crystalline form, all under various trade names.

Uses for Glucose.—For confectionery, syrups, jams, jellies, pie filling, puddings, preserves and mince meat.

In the brewing of beer.

In chewing tobacco.

In silvering glasses for mirrors.

In liquid soaps, hair tonics, blacking and shoe polishes.

In food sauces and in the canning of meats.

For pastes and sizes.

In the tanning of leather and in rice polishing.

Processes of Manufacture—Whether in Europe or America, whether from potato or corn starch, the manufacturer must use the process of hydrolysis to obtain glucose. This is accomplished by heating starch in a closed digestor, with a minute quantity of muriatic acid. The amount of acid used represents proportionately about a fifth of the same acid contained in the gastric juice.

The heating is continued until the starch reaction with iodine has disappeared. At the present time, a pressure of 35 pounds is maintained and the operation at that pressure is finished in about five to ten minutes.

On the continent and in England H_2SO_4 is the agent used for hydrolysis. This is afterwards neutralized with marble dust which with the acid forms an insoluble precipitate. During the process of refining this precipitate is removed.

$$H_2SO_4 + CaCO_3 \rightarrow CaSO_4 + H_2O + CO_2.$$

The American manufacturer prefers the use of HCl, although it is more expensive. With soda ash as a neutralizing agent, common salt is obtained as a residue, and being perfectly harmless, the manufacturer is saved the trouble of removing it. American glucose, therefore, always contains sodium chloride.

$$2\ HCl + Na_2CO_3 \rightarrow 2\ NaCl + H_2O + CO_2.$$

After hydrolysis, the glucose solution is filtered to remove small amounts of fat and protein occurring in the starch, and is then decolorized by passing through bone-black, a similar process to that used in the cane sugar industry. It is then evaporated to various degrees of concentration.

If hydrolysis has been continued until the dry substance in the liquid consists of at least 86 parts of glucose, the product after concentration instead of being a syrup, crystallizes and hardens into a sugar after it has been run into barrels or pans.

CHAPTER X.

THE SUGAR INDUSTRY.

Source.—The disaccharid $C_{12}H_{22}O_{11}$, known as sucrose or saccharose, is found in a large variety of plants. It is so apt, however, to be accompanied by a characteristic taste of the plant, or other carbohydrates such as starch, glucose or invert sugar, that unless it appears in relatively large proportions and can successfully be freed from the taste, it does not pay commercially to extract it. For the supply of raw sugar the world is largely dependent to-day, on the sugar cane and the sugar beet. Sugar-producing plants of lesser importance in commerce are the maple tree, the date palm, the sorghum and the maize.

History of the Sugar Cane.—The sugar cane is by far the earliest plant from which sugar was extracted. Prior to its discovery, many centuries before the Christian era, mankind was largely dependent upon honey as a sweetening agent, and the European nations knew little of its use until the 13th and 14th centuries. The original home of the cane was undoubtedly in the east, for mention of it is made in many of the sacred books of the Hindoos and Chinese. Its cultivation was gradually carried westward, by the Persians and Arabs, and at the time of the crusades, sugar factories were found in operation in Syria and Palestine. Carried still further westward by the Saracens and Moors, it was finally introduced into Sicily and Spain. The discovery of America shortly after this period led the Spaniards to carry the plant to the New World, where it was found that it could be successfully grown on the mainland and on adjacent islands. This opened a new field for the growth of the cane and laid the foundation of a great industry.

History of the Sugar Beet.—The history of the sugar beet industry dates only as far back as the early days of the 19th century. A half century before its introduction, the German chemist Margraff had called the attention of the Berlin Academy of Science to the fact, that sugar could be extracted from the beet. This discovery, however, lay dormant until an important historical event cut off the European nations from their supply of cane sugar. South-western Europe, at that time, was involved in warfare and a great continental blockade was established by the English fleet. The nations of Europe deprived of cane sugar searched for another supply to take its place. Sugar from the maple and glucose from the juice of grapes, were used but could not supply the demand. A former pupil of Margraff, Achard, finally turned the attention of scientists to the beet, and a long series of investigations followed which had for its final outcome the birth of the beet sugar industry. It was first established in France by a decree issued by Napoleon, January 15th, 1811 and was greatly fostered by him until the disastrous Russian campaign. Although the fall of that dynasty interrupted, it did not destroy the industry, and in the course of twenty years it had become of great commercial importance. Undoubtedly, the great progress in this industry was largely due to the invention of the polariscope, which greatly assisted in a rapid determination of the amount of sugar present in the beet.

About this period German scientists became interested, and through their experimentation, marked progress was made in the cultivation of the beet and in the methods of manufacture, which in time placed Germany at the head of the sugar producing countries of the world. While the beet sugar industry has reached its highest development in Germany, it is rapidly becoming an important source of sugar in the United States.

Comparison of Cane and Beet Sugar.—Since the time that beet sugar began to assume commercial importance, there has been much discussion in regard to the relative merits of these sugars, for use in the household. Scientists claim that chemically they are the same, both having the formula $C_{12}H_{22}O_{11}$, yet it has often been said that beet sugar is not as sweet as cane sugar, and that it cannot be used successfully for canning, jelly-making and preserving. Experiments along this line were carried on at the California Experiment Station by Prof. G. W. Shaw. The conclusion drawn from his experimental data was that sugar derived from these two sources give equally satisfactory results, both in the household and for commercial purposes. Any differences occurring seemed due rather to processes of manufacture such as degree of fineness in granulation, rather than to the composition of the sugars.

Properties of Sugar.—From the manufacturer's standpoint, there are three important properties to be considered in preparing the raw material for the market; 1st, solubility in water; 2nd, crystallization; 3rd, production of invert sugar.

THE CANE SUGAR INDUSTRY.

The manufacture of cane sugar as a rule is divided into two distinct industries: 1st, the plantation where the plant is grown, the juice extracted and made into raw sugar, the form in which it is exported; 2nd, the refinery where the raw sugar is received, impurities removed and the sugar recrystallized, in which form it is placed upon the market.

At the Plantation.—GROWTH.—The sugar cane belongs to the family of grasses. It can be grown in a variety of climates, but thrives best where it is moist and warm with intervals of hot, dry weather. Such conditions are found near the coast in tropical and sub-tropical countries. Cuba, Hawaii, Porto Rico, the Philippine Islands, all raise the sugar cane extensively. In the United States this industry is confined to the Gulf States especially Texas and Louisiana.

OUTLINE OF THE PRODUCTION OF RAW SUGAR.—

I. Cane cut in the green stage.

II. Cane crushed { begasse. / crude juice.

III. Crude juice screened { woody fiber. / juice.

IV. Juice treated with milk of lime; residue removed.

V. Juice concentrated.

a. Boiled down in open kettles.

Drained in hogsheads or casks { molasses. / muscovado sugar.

b. Boiled down in vacuum.

Separated in centrifuge { molasses. / raw sugar.

Cutting.—The sugar cane, when the crop is ready, is harvested by cutting the stalks as close to the ground as possible. Considerable care must be given that the plant be cut at the right time, for should it reach maturity, much sugar would be lost to the manufacturer. The sugar cane contains a substance known as pectose which in time changes to pectic acid. The presence of this acid rapidly converts the sugar into invert sugar which is not crystallizable. The sugar planter knowing well the damage this acid will do to his product, cuts the cane while it is still green.

Fig. 32.—Cane Mill, Philippines.
(Courtesy of the School of Mines Quarterly, Columbia University.)

At the "green stage," the plant contains the maximum amount of sugar and the minimum of undesirable substances. After stripping the leaves from the stalk and removing the green upper portion, the cane is taken to the mill for the extraction of the juice.

Extraction of the Juice.—The most common method used with the cane is the crushing process by means of heavy mills. The cane-mills of to-day are of various types ranging from the crude ox-driven mill of primitive countries (Fig. 32) to a high power steam-driven roller mill where the most modern machinery can be found. As the cane is received at the mill, it is delivered by carriers to high crushers (Fig. 33), which reduce the stalks to a pulpy fiber and extract much of the juice. This mass then passes to a mill composed of three rollers of the same size, set in such a way that the first and second are not so close together as the second and third. The rollers draw the cane within their grip, subjecting it on its passage to great pressure, and causing the rupture of the cells and the escape of more of the juice. A second and third mill are sometimes used, more and more of the juice being extracted by each roll. It is customary to spray the pulp

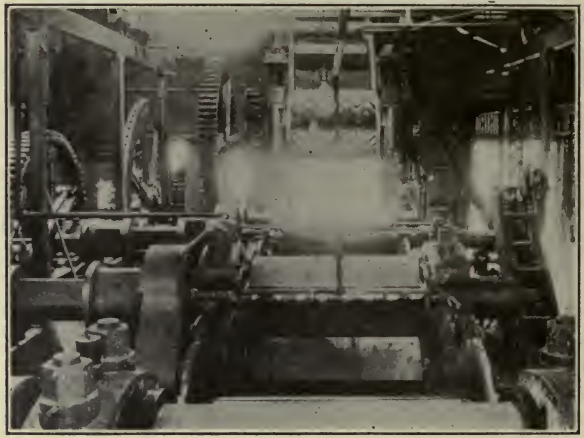


Fig. 33.—Cane Crusher, Hawaii.
(Courtesy of the School of Mines Quarterly, Columbia University.)

as it passes between the rolls to secure a greater degree of extraction. From the roller-mill two products are obtained, the exhausted cane which is called begasse, and the extracted juice which must be purified before it can be converted into raw sugar.

Even with modern machinery, the extraction of juice by this method is by no means perfect,—only from 75 to 80 per cent. of the weight of cane in juice is obtained. As the sugar cane contains approximately 88 per cent. a considerable portion of the sugar is lost in the begasse. Much experimenting has been done to remove the juice from the cane by a method which will involve less loss. The diffusion method used so largely in the beet sugar industry has been tried, but at present is being used in but few of the large plantations in the United States.

Purification of the Raw Juice.—The second important step is the purification of the raw juice by straining, to remove bits of cane, and the addition of a clarifying agent. Milk of lime is the agent most commonly used and the mass is heated to boiling. This prevents fermentation, neutralizes the free organic acids

Fig. 34.—Open Pan Evaporators, Philippines.
(Courtesy of the School of Mines Quarterly, Columbia University.)

of the juice and assists in the coagulation of the dissolved matter. A thick scum of impurities rises to the top of the kettle. This consists of lime salts and albuminous matter and is known as "the blanket scum." The impurities are removed by skimming and by sedimentation and passage through a filter press.

Evaporation.—The concentration of the juice may be carried out in two ways: 1st, the old-fashioned method of boiling down in an open kettle; 2nd, by the use of the vacuum pan. Large open pans or kettles usually made of copper and heated over direct fire are found now, only in primitive countries or on isolated plantations (Fig. 34). Their use has been found to involve a great loss of sugar, although the product obtained had an agreeable aromatic taste much preferable to the refined sugar of to-day. It was customary to boil down the sugar juice until the mass began to crystallize. This necessitated a rise in temperature from 212° to 240°-250° F. and resulted in the formation of caramel and invert sugar which must be looked upon as waste, from the standpoint of the manufacturer. After crystallization had reached the desired point, the mass was freed from the syrup by simply being run, while hot, into hogsheads having fine perforated bottoms, through which the molasses gradually drained out.

Fig. 35.—Vacuum Pans, Hawaii.
(Courtesy of the School of Mines Quarterly, Columbia University.)

The light brown sugar obtained as a result of this process was known as "muscovado" sugar. The molasses was very dark in color but of excellent quality and without further treatment could be used as a table syrup.

In all modern sugar mills, evaporation is carried on in vacuum pans where concentration can be brought about with a lower temperature, 160°-180° F., thus avoiding the losses always occurring in the open kettle method. The vacuum pan invented in England in 1813 is a large closed vessel usually made of copper containing steam-coils for heating, the vacuum being maintained by a pump (Fig. 35). Suitable openings are made in the side for the entrance and exit of the juice, a window is inserted where the operation can be watched, and an opening from which samples can be taken and tested. When the vacuum pan was first introduced into this industry only one was used. It has been found of great economic value, however, to use the vacuum evaporators in series of two, three or more, known as the multiple effect vacuum (Fig. 36). When arranged in series, a low

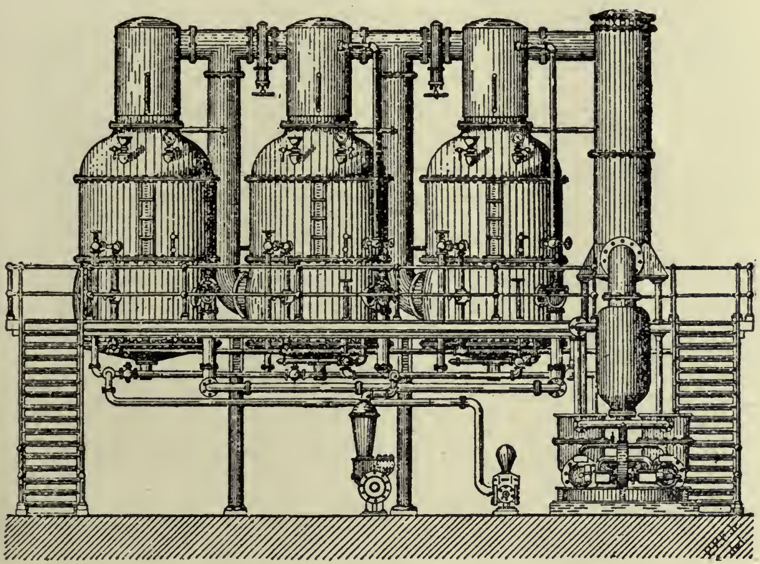


Fig. 36.—Multiple-effect Evaporating Apparatus.

vacuum is maintained in the first vessel, a little higher in the second and still higher in the third and so on. The boiling point for each succeeding vessel is thus reduced. When the system is in operation, the steam arising from the juice in the first vessel passes to the coils of the second vessel and serves as a heating agent. The steam from the juice of the second vessel in turn serves as a heating medium for the third vessel. After the clarified juice has been evaporated to a syrup, it is run into a single vacuum pan known as "the strike pan" when a high degree of vacuum is maintained (Fig. 37). There it is concentrated until the sugar begins to grain. Crystallization is allowed to continue until the pan is full of crystals the desired size. The

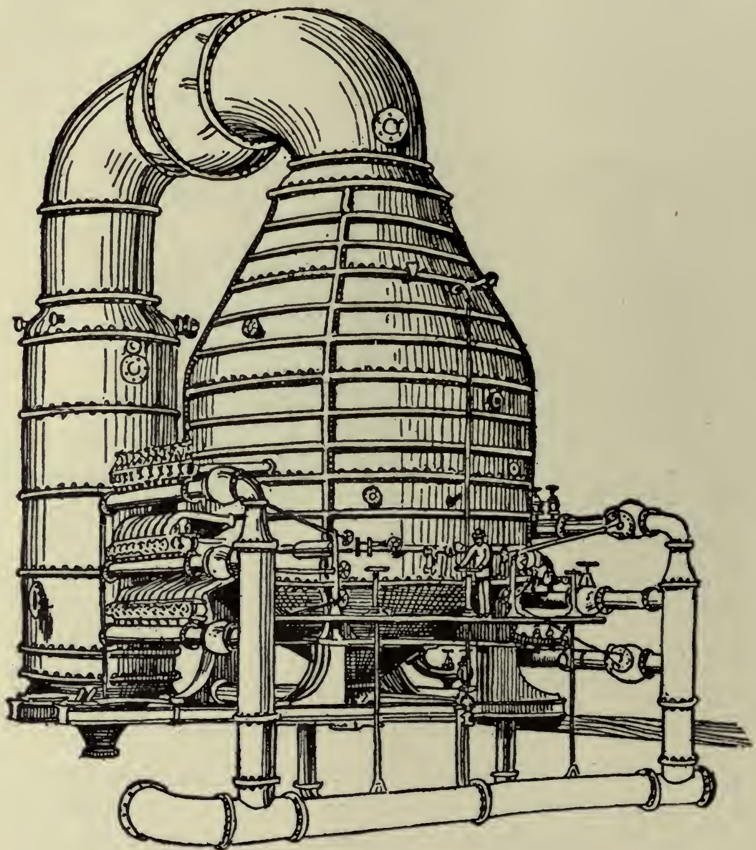


Fig. 37.—Vacuum Strike Pan.

mixture of crystals and syrup is known as "massecuite." The vacuum is then broken, air is admitted and the bottom of the pan is opened so the contents can be transferred to a mixing apparatus where the massecuite is kept in gentle motion. While still warm, the mixture is passed to a centrifugal machine which causes a separation of the crystallized sugar and the molasses.

Centrifugal.—The centrifugal or centrifuge is a hollow iron drum containing a perforated basket (Fig. 38). It can be rapidly rotated during which the sugar mass is thrown against the sides of the basket and the molasses passes through the perforations. The sugar is then bagged and shipped to the country where it is to be refined.

Fig. 38.—Centrifugal Machines. (Courtesy of *Sugar*, Chicago, Ill.)

This is known as "the first sugar" and the molasses drained from the sugar is called "the first molasses." This molasses may be sold for household use or as it contains much sugar, it may be again worked over. This is accomplished by boiling it down in vacuum and again centrifuging. By this means a second sugar and a second molasses are obtained. The second molasses may again be boiled down for a third sugar and molasses. While the third molasses still contains about 30 per cent. sugar, it contains so many impurities that the sugar will not crystallize out.

THE BEET SUGAR INDUSTRY.

GROWTH.—Unlike the cane, the sugar beet reaches its highest

Fig. 39.—The Wild Beet. (Courtesy of *Sugar*, Chicago, Ill.)

development in a north temperate climate, although where the soil has exceptionally good qualities, it has been grown successfully in sub-tropical regions. It is not apt, however, to contain as much sugar. Moisture also plays an important part in the

Fig. 40.—The Sugar Beet of To-day. (Courtesy of *Sugar*, Chicago, Ill.)

production of a normal crop. The sandy soil, temperature, and moisture near our western rivers in Colorado, and neighboring States, furnish satisfactory farm land for this industry. Beets

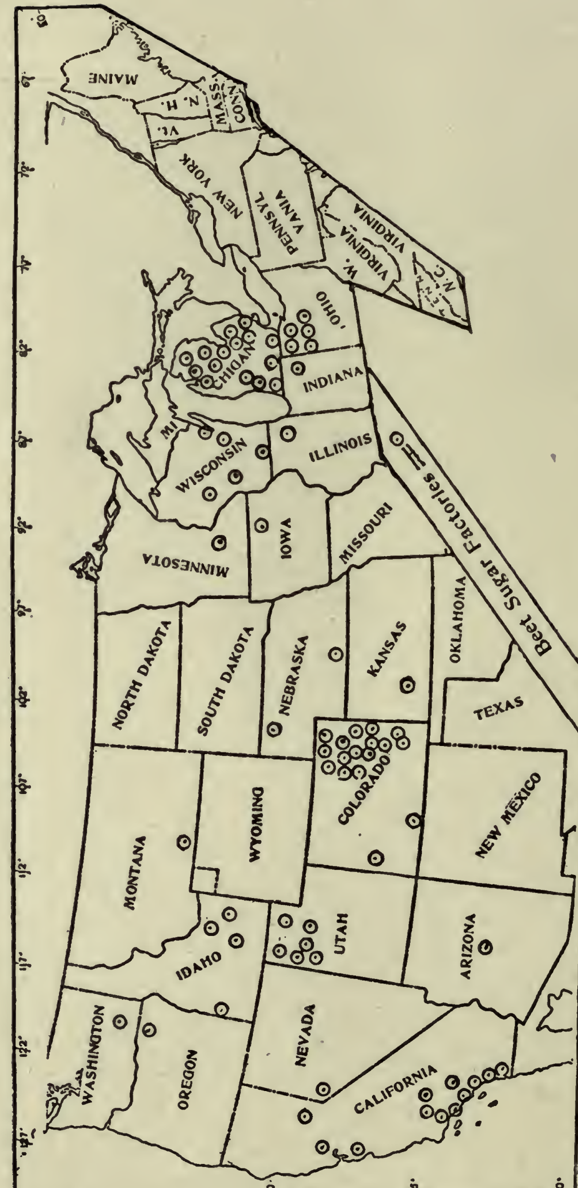


Fig. 41.—Distribution of Beet Sugar Factories. (Courtesy of the U. S. Dept. of Agriculture.)

can also be grown successfully in irrigated areas and much waste land, it is hoped, may be utilized in this way. Much experimenting is being done in regard to the cultivation of the beet, and great improvement has been made especially in increasing the sugar content (Figs. 39 and 40). The average percentage of the sugar is 13-14 per cent., while on the irrigated area it has been increased to 16-18 per cent. The yield per acre is still low, however, not exceeding eight tons, while in Europe twelve to thirteen tons are obtained (Fig. 41).

OUTLINE OF THE PRODUCTION OF RAW SUGAR.—

I. Beets are grown, harvested, topped.
II. Washed.
III. Sliced.
IV. Diffused $\left\{\begin{array}{l}\text{pulp.}\\ \text{crude juice.}\end{array}\right.$
V. Crude juice is screened.
VI. Defecated.
VII. Filtered $\left\{\begin{array}{l}\text{albuminous matter, etc.}\\ \text{juice.}\end{array}\right.$
VIII. Concentrated in vacuum.
IX. Centrifuged $\left\{\begin{array}{l}\text{molasses.}\\ \text{raw beet sugar.}\end{array}\right.$

Topped.—After harvesting, it is necessary to remove the tops with a small part of the neck of the beet. The object of removing this portion is to prevent the large accumulation of mineral matter at the top from entering the factory, as it interferes with the crystallization of the sugar. This work is done in Europe as a rule by women and children. In the United States, foreign labor is gradually replacing the custom of sending whole families into the field during the harvesting season.

Washing.—On entering the factory, the beets are first washed to remove adhering soil, sand and pebbles. This work is accomplished in long troughs, each containing a revolving shaft which carries pins set in the form of a screw. These push the beets along the trough against a stream of water, and the rubbing against one another loosens the dirt, which is carried away by the water.

Extraction of the Juice.—In considering the method of extraction of the juice from the beet, the composition plays an important part. In the beginning of this industry, the crushing process was used similar to that employed with the sugar cane, but was found so unsatisfactory that it has been almost entirely replaced by the diffusion process.

	Composition of the sugar cane	Composition of the sugar beet
Water	67–75%	75–85
Fiber, etc	10–15	4–6
Sucrose	11–16	12–16
Invert sugar	0.5–1.5	0.0–0.3
Mineral matter	0.5–1.0	0.8–1.5
Nitrogenous matter	0.4–0.6	1.5–2.5
Germs, acids, etc	0.2–0.5	0.4–0.8
Wax, fat, etc	0.4	0.2

A comparison of these two important sugar yielding materials will reveal marked differences in composition, which make necessary the employment of different processes, for the extraction of the sugar. The cane which contains a relatively large proportion of fibrous material yields very readily to crushing by rollers, while the beet containing more water and less fiber is reduced to a pulpy mass very difficult to handle. It may also be noted that the beet contains more nitrogenous and mineral matter and less invert sugar than the cane.

Slicing.—In order to obtain the best results with the diffusion method, the beets are sliced into thin pieces by a machine containing revolving knives. These slices are known as chips in English, corsettes in French and schnitzel in German.

The chips after being weighed are run into vessels in which a current of warm water displaces the juice in the beet by the process of osmosis. Foreign matter which is colloidal cannot pass through the cell walls of the beet; the sugar being crystalline, however, passes out into the water.

The Diffusion Battery.—The vessels in which the sugar is extracted are known as diffusion batteries (Fig. 42). They are usually arranged in a series of 10-12 upright iron cylinders called cells which are connected by pipes, the outlet from the top of one cell passing downward into the bottom of the next, and so on through the entire series. The cells can be placed in a row or in a circular position.

When ready for operation, the chips are fed by means of a swinging trough into the cells through a manhole at the top, and warm water about 140° F. is passed through the system. The

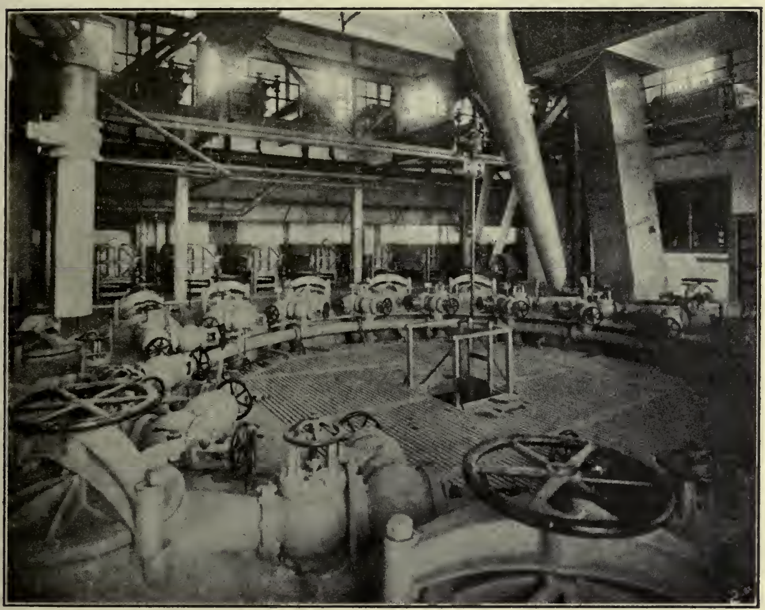


Fig. 42.—The Circular Diffusion Battery. (Courtesy of *Sugar*, Chicago, Ill.)

circulating liquid remains about twenty minutes in each cell, removes sugar from the beet chips and is passed to the next cell. Heaters or "juice warmers" are placed between the cells to again raise the liquid to the desired temperature. As the juice passes from battery to battery, it grows stronger in sugar content. When it has become sufficiently concentrated it is sent to the defecating room and fresh water is passed through the batteries. The process is continued until practically all the sugar has been removed from the beet chips. There is rarely more than 0.5 per cent. loss of sugar with this method of extraction.

During the sugar season, the battery is constantly in use. Being arranged in series, it is possible to circulate liquid through from 8 to 10 cells while two are being emptied and refilled with fresh chips.

Clarification of the Juice.—The sugar solution known as "the diffusion juice" is almost as black as ink as it comes from the batteries, and must, therefore, be clarified. This is usually accomplished by adding an excess of lime, heating, and treating with CO_2. The lime is converted into the carbonate form and in precipitating carries down much of the impurities which are removed by a filter press. The process is usually repeated two or three times or until the liquid is clear. The first carbonation is stopped when the greater part of the lime has been precipitated, but while there is still about 0.1 per cent. of lime in solution. The impurities precipitated with the carbonate of lime are insoluble in an alkaline solution, but redissolve in a neutral solution. After the first carbonation, the juice is filter-pressed to remove the precipitated carbonate of lime and impurities, and then carbonated a second time to precipitate most of the remaining lime, this time to an alkalinity of 0.02 or 0.03 per cent. The second filtration is usually through gravity filters where only a very gentle pressure is applied.

The clear juice is then concentrated in vacuum and separated by the centrifuge into molasses and raw beet sugar, the processes being similar to those used for cane sugar.

Raw beet sugar contains substances of decidedly unpleasant odor and taste, due to nitrogenous matter and mineral salts being taken up from the soil by the roots of the beet. It must, therefore, always be refined even when modern machinery and up-to-date methods have been used. The molasses obtained can be worked over until most of the sucrose has been obtained. It is very impure, however, from mineral salts and nitrogenous compounds, which give it so disagreeable an odor and taste that it is never fit for table use.

REFINING OF RAW SUGAR.

Raw sugars, with the exception of maple, are now refined before being placed upon the market. The refining of sugar was not practiced until about 500 A. D. It first appeared in Mesopotamia and gradually traveled westward, refineries being erected in many of the European countries in the 15th and 16th centuries. In 1689 the first refinery of the Western Continent was built in New York City. This industry has gradually grown until public taste now demands a pure white sugar. As before stated, so far as the beet sugar is concerned, refining is a necessity since the raw product has a disagreeable odor and taste. Cane sugar, however, possesses in the raw state a more fragrant odor and agreeable taste than in the refined product.

Refining sugar is in theory a simpler process than the preparation of the raw product, but it requires great care and attention to details. Experience has shown that it can only be done economically in very large establishments, which are usually located on a navigable river, where the cargoes can be readily received and unloaded. Refineries are built many stories high so as to take advantage of gravity in passing the solution from one process to another. An abundant water supply is also a necessity.

The process consists essentially in dissolving the crude material, separating the impurities and recrystallizing the sugar.

Outline of the Refining Process.—

I. Raw sugar washed.

II. Centrifuged $\left\{\begin{array}{l}\text{wash syrup.}\\ \text{washed raw sugar.}\end{array}\right.$

III. Washed raw sugar melted.

IV. Defecated.

V. Filtered through bags $\left\{\begin{array}{l}\text{mud, etc.}\\ \text{liquor.}\end{array}\right.$

VI. Liquor bone-blacked.

VII. Boiled down in vacuum.

VIII. Centrifuged $\left\{\begin{array}{l}\text{syrup} \left\{\begin{array}{l}\text{syrup.}\\ \text{yellow sugar.}\end{array}\right.\\ \text{sugar}\end{array}\right.$

Washing.—The raw sugar after being weighed is mixed with a low grade sugar solution. This process assists in removing soluble impurities.

From the mixing tank, the magma of raw sugar and syrup is fed into a centrifuge which is rapidly rotated. The purified raw sugar remains on the sides of the basket and the syrup containing most of the coloring matter, dirt, glucose and gum passes through the perforations. The purified raw sugar is left 99-99½ per cent. pure.

The Melter.—The washed raw sugar is dissolved in a melting tank, which contains steam coils and a revolving arm for stirring. When the density of the liquid is about 30° Bé., it is pumped into defecators or "blow-ups."

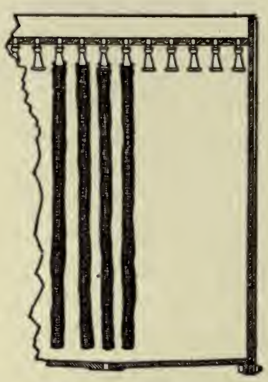


Fig. 43.—Filter Bags.

Defecators.—Here the solution is treated for the removal of such impurities as organic acid and fine suspended matter. Different clarifying agents can be employed, such as alum or blood albumin. To a large extent now a treatment with calcium acid phosphate or phosphoric acid and milk of lime is used. The mixture is heated and agitated for about twenty minutes. Soon a flocculent precipitate separates out, carrying with it suspended matter and some of the coloring.

Filtration.—The impurities are removed by a mechanical filtration through cotton-twill bags enclosed in coarse, strong netting sheaths. They are 6-7 feet long and 5-6 inches in diameter. The open end is tied tightly around a metallic nipple by which the bag is suspended (Fig. 43). The first run of liquor is often muddy and must be refiltered. When the filter bags have become exhausted, they are rinsed in several waters. The mud washed out contains about 20 per cent. of sugar, part of which can be recovered.

Bone-black Filters.—These filters are large cylindrical iron tanks filled with bone-black, a material obtained by the charring of bones and reducing them to a granular form by a crushing process. Bone-black has the power of decolorizing. About one pound is used to one pound of sugar. In passing through these filters, the sugar solution loses most of its color, a small amount of ash and organic impurities. It is collected in storage tanks according to its color and purity. The char in time loses its power of removing color, and must be revivified. It is washed, drained, dried, put in a kiln and highly heated to expel organic impurities.

Vacuum Pan.—The decolorized sugar solution passes to the vacuum pan and is then boiled to grain.

Centrifugal.—After cooling, the separation of the sugar and syrup is accomplished by means of centrifugal force. At this stage, blue water is sometimes used to give a white appearance to the sugar.

The sugar is dried and passed through screens to separate it into grades. It is bagged or barreled to appear on the market as granulated sugar.

Block sugar may be made in two ways.

I. The boiled mass from the vacuum pan containing syrup and crystals of sugar may be drained into conical moulds and allowed to stand for about two weeks. It is occasionally washed by means of a pure sugar solution. The uncrystallized sugar slowly drains off through a small hole opened at the point of the cone. The dried sugar is then cut into cubes. A modified form of this process, which greatly shortens the time, is now being used in Europe and to a slight extent in America. By centrifugal force, the cones can be freed in a few minutes from the syrup, and the sugar after drying can be cut into blocks.

II. Granulated sugar while still moist can be pressed into blocks by an ingenious machine, and gently dried in an oven.

Powdered Sugar.—Granulated sugar can be reduced to a powder. When very finely ground it is placed upon the market as confectioner's sugar.

Sugars are coarse grain or fine grain according to the length of time allowed in crystallizing. When the operation is slow, the crystals are large; rapid crystallization yields small crystals.

Yellow Sugar.—The syrup obtained as one of the final products in the refining process, contains much sugar and can be worked over for a second sugar and second syrup. Sugar obtained by the treatment of syrups usually appears on the market as light brown sugar; darker colors are largely low grade sugars.

Utilization of the By-Products.—Wherever primitive methods for the extraction of cane sugar are used, little thought is given to the by-products. This is not true, however, in progressive countries where modern machinery and methods are employed. Under such conditions, the utilization of waste matter is being carefully considered. Such material is obtained as follows: 1st, refuse of the beet and cane; 2nd, impurities removed in the clarifying processes; 3rd, molasses. The beet tops make an excellent food for cattle. They may be dried by the sun or with mechanical means or they may be converted into ensilage. The beet pulp remaining in the diffusion batteries, may also be utilized as cattle food in the form of wet pulp where it can be used immediately, in the dried state, or after conversion into ensilage. In the cane sugar industry, the leafy portion of the cane top is fed to animals, while the begasse has been utilized mainly, in the past, for fuel purposes. In recent years, it has been discovered that an excellent quality of paper may be manufactured from begasse. While very little is being done along that line at present, the development of paper manufacture in connection with this industry, may prove of great importance.

In both the cane and beet sugar industry, the filter cakes obtained during the clarifying processes are rich in mineral matter, and may be successfully used as fertilizer.

Molasses constitutes the most valuable by-product. As it contains a large percentage of sugar which cannot be crystallized out with ordinary methods, chemical means are being devised for its extraction. Beet sugar molasses contains 50 per cent. of sucrose. By treatment with calcium, strontium or barium hydroxides, it is possible to precipitate the sucrose as insoluble saccharate which, after filtration, may be decomposed and recovered as sucrose. Beet sugar molasses being rich in nitrogenous and mineral constituents may be utilized for fertilizing material with certain kinds of soil. It is also useful as a cattle food and for fuel purposes.

Molasses from the cane industry, may be used as a table syrup or for feeding cattle, after being mixed with begasse or such material as bran meal or similar products. In both the beet and cane sugar industries, the molasses is used largely for the manufacture of rum and alcohol. Lesser products obtained through fermentation of cane sugar molasses are acetic, butyric, caprylic and other fatty acids. Many valuable by-products of a nitrogenous nature may also be obtained from beet sugar molasses.

Maple Sugar.—A sugar and syrup highly prized for confectionery and table use can be obtained from the maple tree. In the United States, they are made almost entirely in Vermont, New York, Ohio and Indiana. The process is comparatively simple. In the spring, when the sap begins to run, the trees are bored and the sap escapes into receptacles. It is usually evaporated in open kettles and allowed to crystallize. The sugar is sold in the raw state, as the delicate flavor so much desired is lost in refining processes.

Date Palm Sugar.—In India, the date palm yields a low grade crude sugar known as "jaggary." Much of this sugar is shipped to England for refining.

Sorghum.—The sorghum cane belongs to a family of grasses resembling the sugar cane. It has been known and valued in China for many centuries. Many attempts have been made in this country in recent years to extract sugar from the sorghum, but without great success. The juice contains dextrin bodies which prevent crystallization of part of the sugar. It is used largely, however, for the production of syrup. The stalks can be utilized for the manufacture of coarse wrapping paper and the seeds for fodder.

Cane Syrup.—Cane syrup is prepared largely in small mills in our own Southern States by the use of primitive methods. The juice of the sugar cane is extracted, clarified, partly inverted and evaporated until 25-30 per cent. of the water remains, which is sufficient to prevent the crystallization of the sugar.

Adulteration of Sugar.—With the exception of pulverized sugar very little has been found in the United States on account of the cheapness of the product. Sugar sold in the powdered form, however, has been adulterated from time to time with flour, glucose, chalk, silica and gypsum.

CHAPTER XI.

ALCOHOLIC BEVERAGES.

Alcoholic beverages may be classified as follows:

- I. Malted fermented
  - Beer.
  - Ale.
  - Porter.
  - Stout.
- II. Malted distilled
  - Whiskey.
- III. Wines
  - 1. Sweet or dry.
  - 2. Color
    - Red, Claret, Burgundy, etc.
    - White, Sauterm, Rhine, etc.
  - 3. CO_2
    - Still, most of the natural wines.
    - Sparkling, Champagne and Sparkling Moselle.
  - 4. Alcohol
    - Natural, containing not more than 15%. Most of the natural wines.
    - Fortified, Sherry, Port and Maderia.
- IV. Distilled Wines
  - Brandy.
- V. Cordials, Liqueurs and Gin.
- VI. Sophisticated Wines.

Historical.—The use of alcoholic beverages dates back to the earliest historic times; hardly a race of men is known even among savage tribes which has not its fermented drink. The process of beer brewing is of great antiquity, but undoubtedly that of wine making is of still earlier origin. It may well be imagined that primitive man stumbled upon this process by accident. A vessel containing crushed fruit juice, set aside for future use, may have been found to contain a drink far more exhilarating than the ordinary fresh fruit juice. Early we find that in all countries where fruit could be readily grown, a fermented drink of this kind was used. Through this simple art of wine making, aided by the development of human intelligence, the discovery was finally made of how a fermentable sugar could be obtained by the treatment of a grain. From that time fermented grains were used, during seasons when fruit could not be obtained, and in regions not adapted to the growing of fruit. The art of beer making must have been discovered in early times, for references are made to the beverage in Egyptian records dating back to 3000 B. C. It is related that an attempt was made by their government to suppress beer-shops over forty centuries ago. The Egyptians taught the ancient Greeks and Romans the art of brewing, and beer was used as a beverage by the soldiers of Caesar's army. Latin authors show that the drink was in their time extensively used in Western Europe. The Saxons became accustomed to its use before they settled in Britain, and for centuries it was used as the national beverage by all English people.

Beer was prepared from barley, which could be readily grown in the British Isles, and was indulged in at every meal by men, women and children. A housewife was judged as much by her skill in brewing as by the bread that she baked. Families became noted for making exceptionally fine beer and recipes were handed down in verbal form, from parent to child, and the secret most carefully guarded. Beer being a common drink of most of the European people before the establishment of the colonies in America, it followed naturally that the early settlers brought with them to the New World the art of brewing.

Fermentation.—For the production of alcoholic beverages, the manufacturer is as dependent upon the yeast plant as the maker of bread. The baker desires carbon dioxide only, while the brewer needs for his product, alcohol principally and, in some beverages, carbon dioxide also.

Even under the most favorable conditions, there is a limit to the amount of alcohol that yeast can produce. When the alcoholic strength reaches 14-15 per cent., yeast can no longer propagate itself and fermentation ceases. Conditions for its growth, such as temperature, food, oxygen and moisture, have been carefully studied in connection with this industry, and modern scientific research has placed at the disposal of the brewer of to-day, a wealth of knowledge which was not known to his predecessors. Most conspicuous among the scientists who made investigations along these lines was Louis Pasteur, the father of modern bacteriology. It was from the study of the phenomena of brewing that he finally gave to the world the theories of fermentation. The study of brewing has contributed much to science, for research work has also been done along the lines of: 1st, processes of germination in seeds; 2nd, the chemistry of carbohydrates and protein compounds; 3rd, the action of micro-organisms and enzymes.

Yeast for the brewer's purpose is divided into two groups, namely, top yeast and bottom yeast. For its growth top yeast requires rather a high temperature—60°-80° F. Fermentation is very active; the rapid evolution of CO_2 causes the liquid to bubble violently, and as the CO_2 escapes to the surface much of the yeast is carried to the top of the vat. This type of yeast is used for heavy ales and beers, for alcohol, whiskey and high wines. Bottom yeast acts at a lower temperature—40°-50° F. Fermentation is very slow, the evolution of CO_2 is gradual and the yeast remains on the bottom of the vat.

In fermenting at a high temperature yeast generally dies. At a low temperature, it can be kept for a considerable time and can sometimes be used as a starter for the fermentation of the next liquid. Above 86° F., the alcoholic fermentation readily passes into the butyric and other forms of decomposition. It is also subject to the lactic and acetic ferments. Much study has been given to the temperature of fermenting beer.

Temperature for growth:

Yeast	32°–120° F.
Lactic ferment	50°–130° F.
Acetic ferment	50°–122° F.

With these facts in mind the brewer on the continent and in America uses a low temperature, possibly 48°-50° F. This allows the growth of yeast and prevents the development of lactic and acetic ferments.

THE BREWING OF BEER.

Raw Material.—For the manufacture of beer, water, yeast, hops and a malted grain are necessary. The water should be free from organic impurities and in general should be moderately hard. Continental brewers use a soft water, but in England and

America, the presence of gypsum is preferred. Water containing sodium chloride, calcium and magnesium sulphates has been found to be very satisfactory. A soft water has a greater solvent power on protein, which is likely to undergo decomposition. Hops are the catkins of the hop plant. They contain several bitter principles which give a desirable flavor to beer. Hops also act as an antiseptic. In the early days of brewing, beer was always prepared from wheat and barley; later oats, millet and anise were sometimes substituted. At the present time, barley stands foremost among the cereals used in this industry, on account of its flavor and yield of diastase. Rye also occupies a prominent position and in Russia and Austria wheat is still largely used. In some parts of the United States, corn under the name of grits plays an important part, while rice is used largely in the Orient and by American brewers. In Germany, beer is often prepared from potatoes.

Processes in the Manufacture of Beer.—

I. Malting
   1. Steeping.
   2. Couching.
   3. Flooring.
   4. Drying.

II. Preparation of the wort.

III. Boiling

IV. Cooling

V. Fermentation.

VI. Preservation

Malting.—In the classification of the carbohydrates, we find the disaccharid maltose $C_{12}H_{22}O_{11}$. This substance is never found in nature, in large amounts, as is sucrose and lactose, but must always be prepared by allowing the enzyme diastase to act upon starch. Here by the process of hydrolysis, starch passes through the dextrin stages to maltose. Maltose is, therefore, a partially digested carbohydrate and since much of it occurs in beer, that beverage contains material of food value, as well as stimulating principles.

Except in very large breweries, malting is now generally done by a separate industry. This process of changing barley into malt is divided into four stages: steeping, couching, flooring and drying. When the barley is received at the malting house, dust, dirt, broken kernels and foreign seeds must first be removed. This is accomplished by revolving sieves and strong currents of air. It is now ready for the processes of malting, during which period, the production of diastase is the chief aim of the maltster. The mode of formation is not yet known but it occurs during the sprouting of the grain.

In order to soften the grain, it is soaked in water in large wooden vats for two or three days, fresh water being added from time to time. During this period any imperfect grains remaining, will float and can easily be removed by skimming; perfect grains gradually sink. This process is stopped when the grains have softened so the skin can easily be removed. A test is usually made by piercing the grain with a needle. By this time, the grain should have absorbed sufficient moisture to allow germination to begin so the water is drawn off. The swollen, softened grain is couched by being piled in heaps about 24 inches deep, on a cement floor, in rooms moderately light. The temperature is very important, about 60° F. is maintained, as a high degree often causes mold growth. In the olden times, it was necessary to carry on this process in the spring and autumn. Now malting plants are artificially controlled in temperature, so couching can be carried on in any part of the year. The grain is kept moist by a frequent sprinkling with water, a good circulation of air is maintained to supply sufficient oxygen, and it is turned from time to time. It gradually begins to "sweat," the temperature rises, and an agreeable odor is given off. At the end of twenty-four to thirty-six hours, tiny rootlets have appeared and sprouting has begun.

By means of wooden shovels it is next spread out on the floor in layers of about 10 inches. This is called flooring. To prevent its heating too rapidly, every few hours it is turned over so new grains are exposed; frequent sprinkling keeps it moist. From six to twelve days, the tiny rootlet called "the acrospire" is allowed to grow. During this time, two important ferments, diastase and peptase, have been formed. The production of diastase increases as germination proceeds until it reaches a maximum, then it begins to decrease. It is at the maximum stage when the sprout has grown three-quarters of the grain. The pro-

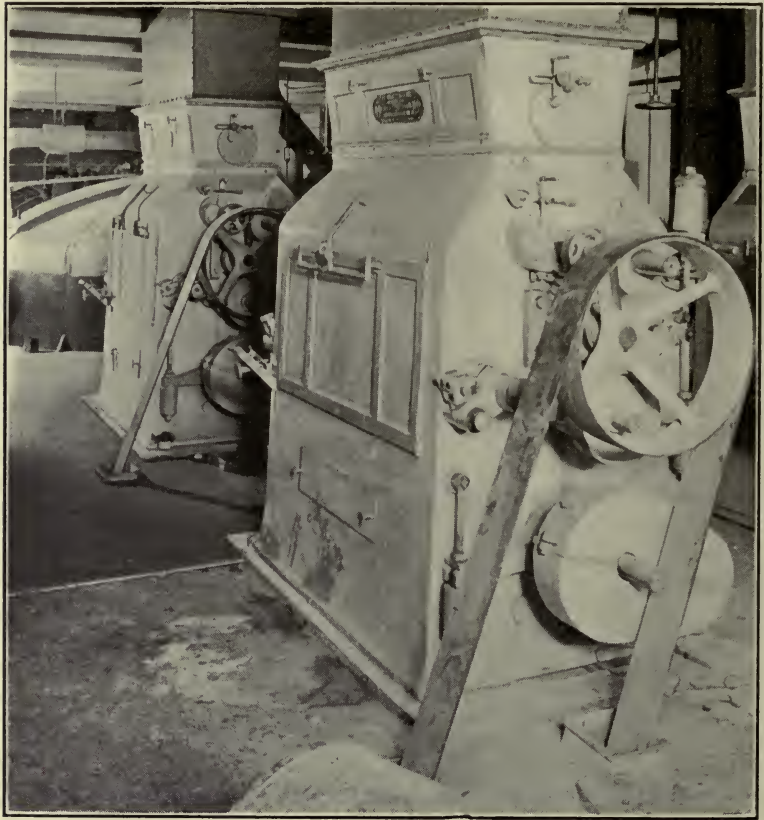


Fig. 44.—Roller Mill for Grinding Barley Malt. (Courtesy of United States Brewers' Association.)

cess is then stopped. As soon as the diastase is formed it begins to act on the starch of the barley, gradually changing part of it to dextrin and maltose.

Germination is stopped by drying.. This may be accomplished by air-drying or in a kiln. The character and odor of the beer are much influenced by the method of drying. A low temperature produces a pale malt, higher heat gives yellow, amber and brown. After drying, the rootlets are brittle and can easily be removed by passing the grain through sieves containing rotary brushes. The grain is now called barley-malt.

The Wort.—The preparation of the wort or the mashing process is the second stage in the making of beer. The malt is

Fig. 45.—Filter Presses for Clarifying the Wort. (Courtesy of United States Brewers' Association.)

cleaned and coarsely ground in a roller mill (Fig. 44), and a water extract is made. Another cereal such as corn or rice may be added. This process is intended not only to extract the dextrin and maltose already formed, but to allow the diastase to act upon any starch present so it may be converted into dextrin and maltose. Peptase is also active, converting protein matter to the more easily digested form of peptone. Great care is given that the temperature be kept at the point where the diastase and peptase can do the most effective work. Tests are made from time to time with iodine. After a certain length of time the watery extract is drawn off and fresh water is added. This is called the second extract. Again a third extract may be made. These extracts when mixed are passed through a filter press (Fig. 45). They are known as the wort. The wort contains dissolved material which has been acted upon by ferments.

Fig. 46.—Copper Boilers. (Courtesy of United States Brewers' Association.)

Boiling.—The wort is run into copper kettles where it is boiled from one to two hours (Fig. 46). Hops are added during this time. The boiling accomplishes several desirable changes: 1st, Unchanged protein coagulates and separates out. This change is assisted by tannic acid dissolved from hops. 2nd, The wort is concentrated and sterilized. 3rd, The constituents of hops are taken up by the wort. They give taste, aroma and keeping quality to beer.

Cooling.—After boiling, the temperature must be dropped rapidly to prevent undesirable fermentation from starting. This is accomplished by running the boiling hot liquid into cooling tanks, then passing it quickly over pipes through which brine is being circulated. It is cooled down to a temperature of 40° F., the point needed for the fermentation by yeast.

Fermentation.—For a long period, fermentation of the wort took place in great open vats made of oak It was left for spontaneous fermentation or more often yeast was added. Recent experimentation has proved that fermentation is far more satisfactory when carried on in closed iron vats lined with porcelain, through which filtered air is forced. In the use of the closed receptacle, pure yeast cultures may be utilized with great efficiency. As bottom fermentation is used in America, the temperature is kept below 50° F. This method produces less alcohol but the flavor of the beer is considered better. In England, top fermentation is more popular. It requires a higher temperature, 65°-80° F., the action is rapid and more alcohol is developed.

I. Main fermentation lasts from 4-8 days, when a high temperature is used; and from 9-10 days in bottom fermentation. During this period, new yeast cells are constantly forming and in their desire for food are breaking down sugars into alcohol, carbon dioxide, glycerine and succinic acid. As the action goes on, there is a tendency for the temperature to rise. It was customary in olden time to float in the vats, cans containing ice. As most modern breweries have a cooling plant, brine is circulated through coils in the bottom of the vats. By these means the desired temperature can be maintained. At the end of this process, it is called the "new beer."

II. For the after fermentation the new beer is drawn from the vats into casks containing beech wood shavings, which have been passed through a sterilizing process. Isinglass can also be used. These assist in clarifying the beer. The temperature is kept low, the yeast cells gradually cease growing and in settling, become attached to the shavings, leaving the beer clear.

III. The storage fermentation takes place in casks and lasts from three to six months. During this time flavor is developed. Fresh beer is added to give the product its head and fermentation goes on slowly at a low temperature, after which the beer is ready to be filtered and bottled or barreled (Fig. 47).

Preservation.—Pasteurization is sometimes used and is a perfectly legitimate method of preserving beer. The temperature is raised to 140° F., which is high enough to kill any ferment present.

Fig. 47.—Filter Presses for Clarifying Beer before Bottling. (Courtesy of United States Brewers' Association.)

Great care must be given to the bottling and barreling process. The barrels are usually coated on the inside with pitch and are regularly inspected. They may be disinfected with SO_2 or thoroughly sterilized with live steam and rinsed with filtered water.

Any carelessness at this stage causes the souring of beer. The keeping qualities depend on absolute cleanliness in barreling or bottling, purity of the water and yeast, and the quality of the grain and hops. Sanitary conditions should be maintained throughout brewing.

The use of preservatives such as silicylic acid or boracic acid, is forbidden by many countries.

Composition of Beer.—Beer contains when ready for use dextrins, maltose, peptones, alcohol 3-7½ per cent., and carbon dioxide. The addition of hops gives tannin, volatile oils which give a better flavor, alkaloids which have a narcotic effect, and resins which contain antiseptic principles and protect against undesirable fermentation. Bitter substances have been added to give pungency, as quassia, gentian root and ginger, but their use is now prohibited by most governments.

Adulteration.—The adulteration of beer is of early origin. In 1620 mention is made that cocculas indicus was used in Holland and during the reign of Queen Anne, of England, it was necessary for Parliament to pass a law prohibiting brewers from using this substance, as well as other unwholesome ingredients. One of the earliest books written on food adulteration, exposes the practices of the brewers of the early 19th century. Such substances as ground alum, coloring matter, beans, quassia, capsicum, caraway seeds, grains of Paradise, strychnine and picric acid were frequently used. Beer many times was prepared from chemical preparations, substituted for malt and hops.

While much has been said against the brewer of modern times, it is safe to say that adulteration has practically disappeared in this industry. There is a prevailing belief that beer contains a variety of substances such as opium, belladonna, strychnine and corrosive acids, but these ideas are not true. The only harmful ingredients are preservatives. Sodium bicarbonate is sometimes used to overcome acidity and to increase the head.

Substitution.—Beer is generally supposed to be made from barley malt. This operation is long and involves a certain amount of waste so is expensive. Brewers sometimes substitute glucose. This is practically the same practice that is found in malted breakfast foods. It is not; however, injurious if the glucose is a pure article.

Kinds of Beer.—Lager beer is used in Germany and to a great extent in America. It is always made by bottom fermentation, where the process is allowed to proceed slowly and has, therefore, less alcohol, but a more desirable flavor and better keeping qualities. Lager means stored, so this variety of beer is always stored six months. It is brewed in the winter and stored until the following summer. There is usually the addition of a large amount of hops.

Ale is a light colored beer made by top fermentation. It has, therefore, more alcohol, about 7½ per cent. The bitter flavor is due to the addition of more hops than in ordinary beer. It is practically the only beer made in England, as they use top fermentation.

Porter is a dark colored beer. When a high temperature is used in kiln-drying malt, the carbohydrates present become partially charred and caramel is formed. This gives color and flavor to the beer. Porter contains about 5 per cent. alcohol.

Stout is a porter with a higher percentage of alcohol usually about 7 per cent. It contains more of the extracts.

CHAPTER XII.

ALCOHOLIC BEVERAGES. (Continued.)

THE WINE INDUSTRY.

Wine is the fermented juice of a fruit which contains sugar or its derivative invert sugar. While any sweet fruit may be used, the term wine generally refers to the juice of the grape, for that is the only fruit which is cultivated on an extensive scale for the manufacture of wine. Grapes owe their wine producing value to several important constituents: 1st, the large amount of grape sugar which often constitutes 18-20 per cent. of the weight of the fresh fruit and more than half of the solid matter; 2nd, the organic acids of which tartaric is the most important; 3rd, the proteins which greatly influence fermentation.

The cultivation of the grape for this purpose began in the Orient, and gradually extended into the middle and south of Europe, and into the northern part of Africa along the countries bordering on the Mediterranean. France, Spain and Portugal are now the chief wine producing countries of Europe, although along the banks of the Rhine and Moselle Rivers as well as other parts of Germany, Austria and Italy, grapes are cultivated in large quantities. The islands of the Atlantic and certain sections of America, as California, New York, Ohio and Virginia, are also important wine manufacturing centers. The climatic conditions and the character of the soil greatly influence the quality of the grape. The vine grows on soil containing mineral matter, chalk, magnesia and silica. It appears to thrive best along the borders of rivers and on ground which can attract considerable moisture from the subsoil. The composition varies from season to season due to weather conditions. A warm summer with a moderate amount of rain gives the highest percentage of sugar and tartaric acid. During a cold, rainy, grape growing season, less sugar is produced and a higher percentage of malic acid is developed.

The varieties are very numerous and there is great difference in the cultivation in various localities, but wherever grapes are grown for the wine industry, great care and experience are absolutely essential.

Processes in the Manufacture of Still Wine.—

I. Grapes picked when fully ripe.

II. Crushed between rolls or with the feet.

III. Pressed or centrifuged.

IV. Fermentation $\begin{cases} \text{Active.} \\ \text{Still.} \\ \text{Storage.} \end{cases}$

Picking.—Grapes are taken for wine making either when ripe or slightly over ripe, according to the character of the wine. The harvesting usually begins early in September and continues into November. The early grapes usually contain the largest amount of sugar, but those taken later in the season when allowed to become over ripe, produce a wine having a peculiar bouquet which is much prized.

The grapes are picked by hand or with a fork. Except in certain districts, the common practice is to gather all the grapes carried by the vine and to sort them into grades. The care given in sorting, differs greatly according to the quality of the wine. For the finest wines, all unripe, bruised, sun-burned and rotten grapes are discarded. In the manufacture of red wine, the stems are also removed by causing the grapes to pass through a series of sieves by which the stems are retained. The almost universal practice in white wines is to allow the grapes to remain upon the stems during the pressing, as the separation of the must and marc takes place before the astringent principle which they contain can be communicated to the must.

Extraction of the Juice.—In order to extract the juice, the grapes must first be softened. This may be accomplished by treading underfoot in vats or by crushing between grooved rollers, great care being taken that the pressure be gentle, so that the juice from the pulp only will be extracted. Heavy pressure forces the juice from the skins and bruises the seeds and stems if these have not been removed. This greatly injures the flavor of the wine. Treading with the feet has probably been the most satisfactory method. Wooden shoes are now worn as they are more sanitary and give a gentle even pressure. The softened grapes are pressed or passed through a centrifugal machine. At this stage, for white wines, the skins are removed if the blue grapes are being used. If red wine is wanted, the skins are left on. After pressing or centrifuging, the juice is known as the "must" and the pulp and skins as the "marc." The quality of the wine depends on the "must." The first portion is often collected separately as it is the juice of the ripest and sweetest grapes. That which is pressed from the grapes later contains more acid and tannin, for it is obtained from the unripe grapes and skins.

Fermentation.—The fermentation of red wines usually takes place in large open vats of wood, marble or stone. White wines are generally fermented in barrels with only the bungholes opened for the escape of the carbon dioxide generated. Although the use of yeast cultures has recently been introduced in certain localities, fermentation is still almost always spontaneous in the wine industry. Spores of the wild yeast are always present on the skins of grapes and in the air of grape producing regions, so fermentation begins at once. A temperature of about 50° F. is maintained for bottom fermentation and 70° F. if top fermentation is desired.

Fermentation is divided into three stages.

I. Main fermentation.—During this period the yeast cells are very active, the liquid becomes turbid, carbon dioxide is given off, a scum forms and a sour taste and odor are developed. It lasts from one to three weeks according to the temperature used. When fermentation is completed, the evolution of gas ceases, yeast cells and other suspended matter settle to the bottom and the liquid becomes clear. During this process the proteins are largely consumed by the yeast.

II. Still Fermentation.—The new wine is run into tungs or casks where it remains until the following spring. During this after fermentation the young wine slowly loses its sugar and remaining protein substances. Acid potassium tartrate and calcium tartrate separate out and form deposits known as argol and lees. For further information see Chapter VIII, Leavening Agents.

III. Storage Fermentation.—The storage of wine lasts for many years according to the quality. Very rich wines are held for eight years or more, cheaper varieties from two to four. During this process of ripening the desired bouquet is gradually developed. This is due to the formation of etheral salts, from the alcohols and organic acids present in the wine. Minute quantities of higher alcohols known as fusel oil are developed during fermentation. As they are of a poisonous nature, the formation of these salts not only means the development of desirable flavors but the lessening of the toxic quality of the wine. Tannins and other impurities are gradually precipitated. Sometimes during the ripening process clarifying agents such as gelatin and albumin are added to assist in dragging down suspended matter. The treatment with gelatin is particularly applied to sweet and heavy white wines which frequently remain more or less turbid. Albumin as a rule is used with red wines which contain tannic acid.

Improving Wines.—The juice pressed from the grape varies in composition to a considerable extent from year to year, according to the amount of rain fall, sunshine and temperature. As a result it is usually treated or improved in some way to maintain certain proportions. The must of a poor season can be so treated as to bring it up to the standard of a must of a good year, by correcting the ratio of acid to sugar. Any excess of acidity may be overcome by neutralizing with marble-dust and the addition of a certain quantity of cane sugar. To improve the sweet taste without injuring the keeping qualities glycerine is sometimes added. Wine deficient in alcohol and containing a large amount of acid is frequently improved, by the addition of wine of a succeeding year. The practice of adding gypsum or plaster of Paris has prevailed extensively in the countries of south and south-western Europe. This is known as "plastering," and is supposed to have for its object the withdrawal of a certain amount of water from the must, thus increasing the alcoholic strength. It also deepens the color and adds to the keeping qualities. Public opinion is strongly against the custom, however, as it is supposed to have an injurious effect on the consumer of the wine. The process is now controlled by law.

In certain heavy wines as Port and Madeira, alcohol is added and they are known as fortified wines. The amount of alcohol developed during fermentation never exceeds 12-13 per cent. Alcohol is added to fortified wines until the strength reaches 16-22 per cent.

CHAMPAGNE.

The art of making champagne was discovered by a monk during the 18th century. Both white and red grapes are used and a special treatment is necessary. Great care is given in picking so that the grapes are not crushed, or coloring matter may be added to the juice. The branches are detached one by one and carefully sorted according to their ripeness. In some localities even the individual grape is examined. After picking they are crushed quickly in order to prevent any coloring matter being taken up. The first press only is used for champagne, the second and third being utilized for cheaper wines. After the must has been allowed to stand long enough for impurities to settle, it is run immediately into casks for the main fermentation, which usually takes place in cool cellars. The young wine is allowed to ferment until the early winter, when it is cleared with isinglass and racked off into other casks. At the end of one month this operation is repeated. Before bottling it is mixed with a certain proportion of old wine and cane sugar. The bottles are then placed in a horizontal position in champagne vaults, where they remain six months or longer. New fermentation starts, much CO_2 is developed and a quantity of sediment is formed. This scum can later be removed by first placing the bottles in an inclined position so impurities will gather near the cork, which is then carefully removed just long enough to allow the sediment to be blown off. By chilling the bottles just before the operation, the pressure is reduced and the cork can be liberated with very little trouble. The loss in the bottle is replaced quickly by sugar, fine wine and aromatic essences, and the bottle is again corked and wired. Champagne is usually held for a period in order to allow blending and ripening to take place before it is placed upon the market.

An imitation champagne is sometimes made by forcing carbon dioxide into a sweet white wine to which liqueur has been added.

Sophisticated Wines.—The so-called sophisticated wines are prepared by mixing water, alcohol, tannin, sugar, tartaric acid, fruit essences and the like, closely imitating the composition of a regularly fermented wine.

Composition of Wine.—Wine contains water, alcohol, glycerine, ethereal salts, and other volatile products giving flavor and bouquet, grape sugar, tartaric and malic acids, mineral matter, pectin, gummy matter and tannin.

Adulteration.—The practice of adulterating wine is almost as old as the wine industry. The ancient Greeks and Romans were forced to pass strict laws to prevent such practices, and officials were appointed to detect and punish those who adulterated wine. Substitution and adulteration are still being carried on extensively. Innumerable substances have been added—water, glycerine to give sweetness, coloring agents such as berries, beets, coal tar products and holly-hocks, flavoring to make inferior wines appear older and better grade, cloves, bitter almonds and elderberry juice. In France, on account of the failure of the wine crop in recent years, a wine has been made from dried raisins and prunes and substituted as grape wine. Raisin and prune wine is a perfectly legitimate product only when sold under its own name.

By-Products.—Cheap wines are prepared by adding water and sugar to the marc and fermenting it. This wine is largely used by the poorer people on the continent. The marc may also be utilized in the production of cheap brandy and vinegar, as a fertilizer, for fuel purposes and for cattle food.

In Europe tannic acid is extracted. This is used extensively in the textile industry. The preparation of cream of tartar from argol is another important industry connected with wine making.

Preservation.—Pasteurizing and the use of preservatives are practiced in this industry similar to the processes described under beer making.

DISTILLED LIQUORS.

Distilled liquors differ from malted beverages such as beer, ale, porter and stout, and from products of the wine industry, in two important ways:

I. In the fermentation process, every effort is made to have a maximum amount of alcohol developed.

II. The fermented liquid is distilled and redistilled in order to have a product rich in alcohol.

There are three classes of distilled liquors.

I. Brandy.—The first class of distilled liquors uses as a basis wine which when distilled produces brandy. The product contains much of the flavor and bouquet of the original wine. Fictitious brandy may be made from grain or potatoes, but a true brandy is always manufactured from the fermented juice of a fruit. Apples, peaches, plums, cherries and blackberries may be used, but by far the largest amount is produced from the grape.

The brandy industry has been chiefly carried on in France, particularly in the southwest districts, where the product is known as cognac. The vineyards in this part of France have suffered greatly in recent years and the making of imitation cognac is greatly increasing.

A very inferior grade of brandy is sometimes made by adding water to the marc, fermenting and afterward distilling the product.

II. Rum.—A sugar-containing material such as molasses is always utilized in the production of rum. This industry is carried on very largely in close proximity to sugar cane and sugar beet factories, which readily supply the raw material in the form of molasses and sugar scums. The East Indies and the West Indies, especially Jamaica, use enormous quantities of molasses from the cane in this way. In the West Indies, rum is always flavored with caramel. The beet sugar industry also supplies much molasses for this purpose especially in France and Germany. For the production of rum, the sugar-containing material is diluted, fermented and distilled until the product contains approximately 55 per cent. of alcohol.

III. WHISKEY.—In the manufacture of whiskey a starch-containing material, for example a cereal, is used as a basis. It is malted, fermented and distilled. The cereal used as raw material depends entirely upon the country. England uses barley, wheat and oats and the United States, corn, rye and barley. Scotch whiskey is usually made from malted barley which was formerly dried in a kiln and heated by glowing peat. A peaty flavor was imparted and retained by the final product, which gave to Scotch whiskey a characteristic aroma and taste that were highly prized. Now, peat is scarcely used so creosote is added to give a similar flavor. In Russia, wheat is largely used giving a whiskey known as "vodka." Germany uses the potato almost exclusively for this industry.

Distillation.—In distilling these products, advantage is taken of the different boiling point of alcohol and water. At a temperature of 78°-80° C. alcohol will volatilize carrying with it whatever is volatile. The still may be very simple in construction with the same principle as the water-still or it may be very complicated. A process known as fractional distillation is quite extensively used. The hot vapor is chilled by coming in contact with metallic diaphragms, where a portion condenses and can be separated from the richly alcoholic vapor, which passes on to another compartment. The stills are frequently columnar in shape, and are divided into compartments by horizontal copper plates, perforated with holes, and furnished with valves opening upward. Dropping pipes are attached to each plate, and are connected at their lower end with shallow pans. When the still is in operation, the fermented liquid, heated to the vapor state, is allowed to enter the lowest compartment. As it rises, the vapor comes in contact with a metallic diaphragm which lowers the temperature, thus causing part of the water content to condense and drop back through the pipe into the shallow pan. The alcoholic vapor passes on to the compartment above where the temperature is again lowered, causing more water to condense. The operation is continuous and can be carried on until the percentage of alcohol is raised as high as 95 per cent. This high figure is only used in the production of 95 per cent. alcohol. Higher than this can only be obtained by chemical means. Four per cent. of the water may be removed by lime and the remaining one per cent. by metallic sodium. The product is then known as absolute alcohol. In the distillation of fermented liquids for alcoholic beverages, a strength of about 45 per cent. is usually obtained, although it may vary from 30 to 60 per cent.

Bonded Whiskey.—While the chief constituent of whiskey is ethyl alcohol, when freshly made it also contains small quantities of higher alcohols, fatty acids and other volatile products known as fusel oil. As these products are considered injurious, whiskey is put in storage under government protection for five years. During the process of aging, chemical changes take place. Through oxidation, ethers are formed from the fusel oil which give aroma and bouquet. Whiskey is, therefore, improved in two ways by storing: 1st, it loses toxicity; 2nd, it gains in flavor. As oak barrels are always used for storage, a certain amount of tannin and coloring matter is extracted from the oak by the action of the alcohol.

CIDER.

Cider may readily be regarded as a wine since it is the fermented juice of the apple. It is made extensively wherever that fruit can be readily grown. Cider is manufactured for use as a beverage and as a foundation for what is regarded in the United States as the best kind of vinegar. The fruit is chopped and crushed in a mill, and the extracted juice is run into barrels, where it is allowed to ferment. Where the same care is given as in the preparation of wine from grapes, the product is a superior grade and has good keeping qualities. The greater part, however, produced in this country has a very short life, owing to the poor quality of the raw material and to carelessness in manufacturing processes. The apples used are often those not marketable on account of small size, bruises, greenness or decay, the perfect fruit as a rule being used, only when the crop is so large that it pays better to make cider than to sell the apples at a low price. Poorly made vinegar is frequently adulterated with salicylic acid.

Cider is mildly alcoholic in its nature, containing in the sweet stage about 1 per cent. and as it ages from 3 to 5 per cent. alcohol. In hard cider 8 per cent. alcohol is frequently found. Sugar, organic acids of which malic predominates, salts and extractives are also present, the latter giving odor and taste.

VINEGAR.

Vinegar is a product obtained by the fermentative action of a group of bacteria, on a sugary solution which has undergone alcoholic fermentation, such as cider, wine, malted products and the like. The micro-organisms cause the oxidation of the alcohol into aldehyde and ultimately into acetic acid according to the following equation:

$$C_2H_5OH + O \rightarrow CH_3CHO + H_2O,$$
$$CH_3CHO + O \rightarrow CH_3COOH.$$

In this country cider or wine vinegars are preferred, while in England malt vinegar is largely used. Until recent years, cider vinegar was obtained by allowing barrels partly filled with cider to remain standing in a warm cellar for a number of months, the bungs being left open. This process was so long, however, that it has now been almost entirely replaced by what is known as the "quick vinegar process." Cider is allowed to percolate slowly through perforated casks filled with twigs or shavings, which have been saturated with old vinegar. By this method the product is ready for use in a short time, but the best varieties undergo a process of aging before being placed on the market.

In wine producing sections, vinegar is prepared from cheaper grades of wine and from wines which have spoiled by the acetic ferment having set in. White wine vinegar is usually considered the best. It contains a little more acetic acid than cider vinegar, also tartaric acid and some of the mineral salts of the grape as acid potassium tartrate.

Cider vinegar has 4½ to 5½ per cent. acetic acid and marked traces of malic acid which has come from the apple. Mineral matter, sugar and extractives are also present, the total solids constituting about 2 per cent. of the entire weight.

As England is neither a wine nor cider producing country, it is customary to make vinegar from a malted product as the wort of beer, the addition of hops being omitted as they possess an antiseptic effect. Such a product is dark in color and has considerable extracted matter such as dextrin, maltose, protein, mineral matter and extractives. The percentage of acetic acid is not as high as in wine and cider vinegar, therefore, a small amount of sulphuric acid is frequently added, 0.1 per cent. being allowed by law.

Vinegar may also be made from sugary solutions as molasses or by synthetic processes. Synthetic vinegar is the nearest approach to pure acetic acid, but as it contains less dissolved material, it lacks flavor.

Adulteration.—Vinegar has been largely subject to substitution and imitation. The best varieties on our market are cider, wine and malt vinegar. Substitution may be detected by slowly evaporating almost to dryness 100 cubic centimeters of vinegar and examining the warm residue. That of cider vinegar will give a distinct odor of baked apples and will respond to the malic acid test. The residue of wine vinegar contains tartaric acid and has the aroma of the grape. Malt vinegar gives a malt odor, distilled vinegar that of burnt sugar, while no residue on evaporation indicates a synthetic product.

KOUMISS.

Koumiss is a fermented drink used largely in Russia and by Asiatic tribes. It was originally fermented mare's milk, but for American purposes cow's milk is usually employed. The process is started by adding yeast cultures and a small amount of sugar syrup to milk or by mixing fresh milk with some already soured. Both the lactic and alcoholic fermentation are started and continue for twenty-four hours. The result is a slightly sour milk containing alcohol and carbon dioxide. It is much used by invalids and people with weak digestion.

CHAPTER XIII.

FATS.

For information in regard to the source, composition and properties of fats, see Chapter I, Food Principles.

Extraction.—The methods for the extraction of fats differ according to the physical condition in which they exist, their source and use.

Animal fats are contained in cells composed of membranous tissue, which putrifies soon after the animal is killed, causing the fat to become rancid. It must, therefore, be extracted or rendered immediately to prevent a foul odor from arising. Solid fats like tallow or lard are freed from the enclosing membrane by finely chopping the material, subjecting to low heat and drawing off the fat in the melted state. Great care is necessary that the product is not overheated, lest the neutral fat be decomposed into fatty acid and glycerine. The temperature should not exceed 130° C. The heating may be done in open kettles over direct flame, either with or without the addition of a small amount of sulphuric acid, or by the action of steam under pressure.

The vegetable oils are found to exist in largest quantities in seeds and nuts. In order to extract the oil, they are carefully cleaned, crushed to break the shell or kernel and ground to a fine powder. Crushing is carried out in machines called the oil seed mill, some types of which are of great antiquity. The oil can then be removed by pressure or by the use of a solvent. With pressure, heat may or may not be added. Hot pressing gives a larger yield, but a better product is obtained with the cold method. Many times the cold process is used first for the extraction of the highest quality oil, then heat is added for lower grades.

A larger amount of oil can be obtained by the use of solvents such as naphtha, ether and carbon disulphide, but this method cannot be used for edible oils.

Purification.—The extracted oils are in a very crude condition. containing suspended and dissolved matter of various kinds and must be purified even if the oil is to be used for manufacturing purposes such as soap-making. Purifying can be carried out by filtration through cotton-wadding or bone-black, by the use of Fuller's earth, by chemical treatment or by a bleaching process.

BUTTER.

One of the most easily digested fats is butter. It has been used as a food since the days of the early Hebrews, but during the Greek and Roman civilization it appears to have been utilized only as an ointment.

The original method of making butter was very simple. Whole milk was put in a bag prepared from animal skins and the mass was agitated until the butter appeared. This involved a great amount of labor and a considerable loss of fat, so in time the separation out of the fat by the method known as creaming came into use.

Composition of Butter.—

Water . . .	12 — 16%		
Fat	82.5 + %	1. Soluble 10%	Butyrin. Caproin. Caprylin. Caprin.
		2. Insoluble 90%	Olein. Palmitin. Stearin.
Protein	trace	Caseinogen.	
Carbohydrate . .	trace	Lactose.	
Mineral matter	2%	Sodium chloride. Salts of milk.	

The object in butter making is to extract from milk its fat, which exists in an emulsified form. The United States Standard butter requires at least 82.5 per cent. fat and not more than 16 per cent. water. The fat consists largely of palmitin, olein and a small amount of stearin, mixed, not chemically combined, in about the same proportion as found in lard. In addition to these non-volatile fats, there exists in small amounts, various volatile fats which give to butter its characteristic taste and aroma. The most important are butyrin, caproin, caprylin, and caprin.

Processes in Butter Making.—

- I. Separation of the cream
  - 1. Gravity
    - Shallow pan.
    - Deep setting system.
  - 2. Centrifugal force.
- II. Ripening of the cream.
- III. Churning.
- IV. Washing.
- V. Working.

Separation of the Cream.—The separation of fat from milk, from the earliest times to comparatively recent years, was accomplished by the gravity method. This was called "gravity creaming." As fat exists in the form of an emulsion, by allowing milk to rest, the globules will gather near the surface of the liquid. In so rising, they carry with them certain of the milk constituents such as minute particles of milk sugar, caseinogen and mineral matter. The earliest idea in creaming was the use of the shallow pan, and although rapid changes have been made of late years, a large quantity of butter is still being made by this method. As quickly as possible after milk has been drawn from the cow, it is run into shallow pans, cooled and placed in a clean, well ventilated cellar where it is kept about thirty-six hours at a temperature approximating 60° F. After the fat has gathered at the top, it is removed by a skimmer. With this method the separation is imperfect, as about 20 per cent. of the fat remains with the skim milk.

The use of deep pans for creaming has been very popular in many parts of Europe for the past thirty years. The temperature of the milk is rapidly dropped to 40° F. where it is maintained by ice or cold water from twelve to twenty-four hours. This insures a more perfect separation of the cream, the loss involved under favorable conditions being less than one-half the amount which occurs in the shallow pan method.

In the United States the deep setting system has never been largely employed. This is undoubtedly due to the fact that shortly after its introduction abroad, a machine was patented by which fat could be removed from milk by centrifugal force. Although the cream separators, as they are called, were at first very crude, it is to their development that we owe revolutionizing methods in butter-making (Fig. 48). In separating cream by this method, much labor is saved and less loss is involved. The separator consists of a revolving bowl or drum usually made of cast iron. Old-fashioned types have hollow drums, but modern separators contain contrivances in the bowl to increase the efficiency of separation (Fig. 49). An entrance is made for the whole milk and suitable openings for the removal of the cream

Fig. 48.—Early Experiment in Cream Separator.
(Courtesy of the De Laval Cream Separator Co.)

and the skim milk. When the bowl is rapidly revolved, the heavy liquid is thrown toward the outer wall from where it finds an exit through the skim milk tube. The cream being lighter moves toward the center and is drawn off through the cream outlet. The separation can be carried almost to perfect. The cream separator also assists in clarifying milk, as much dirty material is thrown against the outer wall of the bowl, and can be removed from the skim milk by screening.

Ripening of the Cream.—It is possible to make butter directly from sweet cream, but such a product lacks the delicate flavor and texture of butter which has passed through a ripening process, and it does not keep as well. This process is essentially the holding of cream under favorable conditions for a period, in order to allow bacterial action to take place. Such action may be brought about by bacteria of the air or those natural to milk,

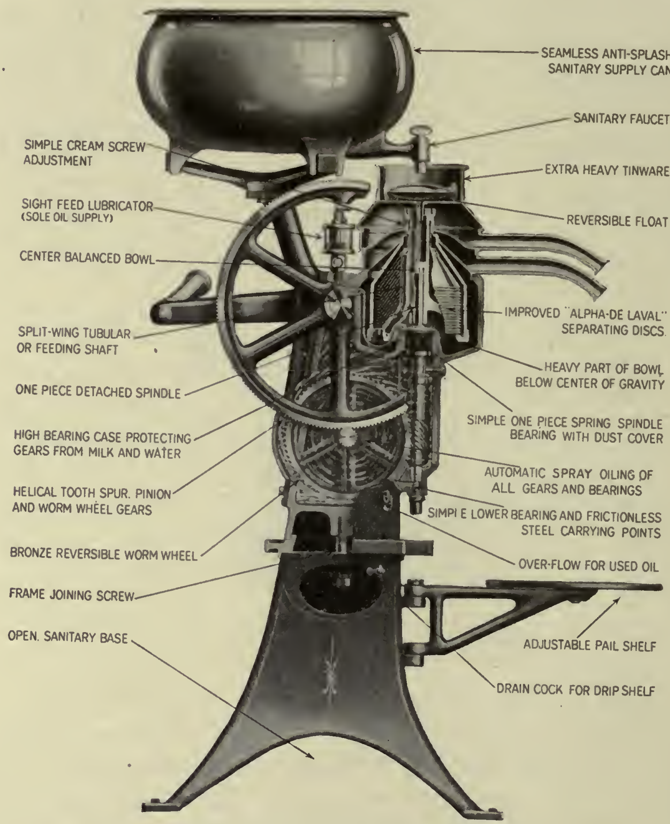


Fig. 49.—Improved De Laval Cream Separator.
(Courtesy of the De Laval Cream Separator Co.)

causing the development of lactic acid. The temperature during this process is regulated from 60°-70° F. and absolute cleanliness has been found to be essential. Any carelessness at this stage is apt to cause other ferments to work upon the milk and undesirable flavors to be developed. In order to have a uniform taste to butter, the cream is sometimes pasteurized, cooled and artificial bacterial cultures are added. Their use was first suggested by the people of Denmark, who now employ this process largely. Professor Conn, of Wesleyan University, also highly recommends their use, but they have never been as popular in America as they have been abroad. The majority of experts prefer the flavor of butter which has been ripened naturally under thoroughly sanitary conditions.

The amount of acid allowed to develop depends on the taste desired. Experienced butter-makers usually judge by the appearance and flavor or tests can be made for acidity by the use of normal alkali solutions. Under-ripening gives an insipid tasting product, while over-ripening causes the development of undesirable flavors and gives a poor texture.

Churning.—By agitation, it is possible to separate out the fat in mass, from the ripened cream, so it can be readily removed from the milk serum. As before mentioned the primitive churns were undoubtedly made from the skins of animals, and the old-fashioned dash churn worked by hand represents another simple form. Now churns are run by machinery and may be rotating hollow barrels, square boxes or more elaborate forms which combine churn and butter worker. The best temperature for the rapid gathering of the fat is 65°-70° F. and under favorable conditions, butter will appear in from 12 to 30 minutes. It can then be easily separated from the butter-milk.

Washing and Working.—In order to prepare butter for the market, it is necessary to subject it to a washing, seasoning and working process. The washing with water removes the remaining butter-milk, but should be carried out with great caution, as much of the desirable flavor of butter is soluble in water. Brine may be used for wash water or dry salt may next be added, and the mass worked into a compact form. The working process also separates from the butter certain non-fatty constituents of the cream, which greatly assist in the keeping quality and give to the butter a finer texture. Salt is added to give flavor rather than for its antiseptic properties. The amount should be small or the butter will be unpalatable. Many prefer the taste without the addition of salt. The product is called sweet butter and is generally considered the highest grade butter on the market.

Coloring.—The coloring of butter with annatto, saffron or coal tar dyes is very largely practiced in the United States. The natural coloring of milk varies with the seasons. When cows are fed on fresh pasture grasses the butter is a clear bright golden yellow, but during the winter months when stall feeding is necessary, it develops only a slight yellowish appearance. Since the demand is for yellow butter, it has become customary to add coloring matter during the working process. Although as a rule, it is harmless, the use cannot be recommended.

Flavor.—The flavor of butter depends largely on the character of food given to the cow, to careful methods of manufacture, to the amount of salt added, and to sanitary conditions during the ripening process and during storage.

RENOVATED BUTTER.

A product known as renovated, process or hash butter has of late years, been placed upon the market. The material from which it is made is gathered from dairies scattered over a wide area. Dairy butter made under different conditions will vary greatly in color, texture and flavor. When taken to a central creamery, these butters are mixed together, melted, purified of the rancidity by washing, coloring matter is added and the resulting mass is rechurned. While the product may be better than a poor quality butter, there is danger of more or less rancidity in renovated butter. This is caused by the purifying process being insufficient, as a prolonged washing would remove the butter-fats which are so essential to the flavor of butter.

OLEOMARGARINE.

The manufacture of substitutes for normal, dairy butter began in 1870 with the experiments of Mège-Mouries, who suggested the use of cheaper fats, as a basis for the preparation of a product to be used in the place of butter. These substitutes have been placed on the market under varying names such as oleomargarine, oleo, butterine and lardine, but all are called oleomargarine by the United States Government.

Oleomargarine has been greatly misrepresented since the early days of its manufacture. It has been said to be made from soap grease, the carcasses of animals which have died of disease, from material extracted from sewage and other unwholesome fatty matter. These statements have been far from the truth, for oleomargarine is made from pure material, in the cleanest possible manner and under the supervision of the Officials of the Internal Revenue. When well made it is equally as wholesome as butter, and is a very valuable article in the diet of those who cannot afford to buy a good quality butter. When sold under its own name, it is a product well worth being on the market. The chief objection has been the enormous amount of fraud practiced. Since the early days of its manufacture, there has been a constant disposition on the part of the manufacturer and local dealer to sell it as butter and in spite of government inspection, this fraud is still largely practiced.

Materials Used.—The fats utilized as a basis for butter substitutes are those which have been in the diet of civilized people for centuries. Mège-Mouries suggested the use of carefully washed beef-suet. Neutral lard, lard stearin, cottonseed oil and cottonseed oil stearin are now also largely used. Milk is added to give flavor and occasionally egg-yolks to give coloring and a firmer structure. Salt and coloring matter may or may not be added. The government requires a tax of ten cents per pound for all oleomargarine colored to resemble butter.

Processes in Manufacture.—Fats are taken from the slaughterhouse, washed and cooled as quickly as possible to remove animal heat. They are cut by machinery into small pieces, heated to separate fat from the tissue, cooled, stearin is removed by presses and the remaining fat is known as oleo oil. To oleo oil a small quantity of neutral lard is added to give body. These fats are melted, filtered and churned with milk which has been ripened, in a like manner to that employed by butter makers in most creameries. When the churning process is complete, the butterine is drawn off into vats filled with ice water which causes the fat to solidify into small masses (Fig. 50). The butterine is removed by cloth covered screens and deposited on trays, with perforated bottoms, where it is allowed to remain until excess water has drained off. After the addition of salt, butter is

Fig. 50.—Chilling Butterine. (Courtesy of Armour & Co., Chicago, Ill.)

worked and finished for the market in a manner similar to the processes used in butter-making.

OLIVE OIL.

Olive oil was the first of the vegetable oils used by the human race, and from the standpoint of the palatability it still holds the first place. It has been known from the earliest historic times and is supposed to have been introduced into Europe from Asia Minor.

Olive oil is obtained from the fruit of the olive tree where it makes up from 40-60 per cent. of the weight of the fruit. The oil is found in both pulp and kernel, but the pulp yields the better quality. The olive tree grows in semi-arid regions, where rainfall is not abundant and where the temperature is fairly high. Spain, Italy, Greece, Southern France and Southern California are the principal regions where the olive tree is grown.

Olives are usually picked when they are three-quarters ripe and for the best grade oils are carefully sorted. For these oils the choicest olives only are selected and are bruised very slightly in a mill. Only the pulp and not the kernel is crushed. The crushed pulp is then gathered up and the oil is allowed to drain away, without heat and either without or with slight pressure. This product is known as "Virgin Oil." It has a yellowish appearance, a very delicate flavor and has excellent keeping properties. Heat and more pressure are applied for a second grade oil. For ordinary lower grade olive oil both pulp and stones are ground into an oily paste, which is packed into woven grass bags and subjected to pressure. The process is continued until all the oil has been extracted. The different grades are refined by heating to coagulate albuminous matter, which is allowed to settle. The lighter colored oils are used for the table, the darker for soap-making, lubricating purposes and the like.

Adulteration.—There has been an enormous amount of adulteration practiced with olive oil on account of the great demand, the high price and the ease of substituting other vegetable oils. Nearly all of the vegetable oils have the same amber tint as olive oil, and when added in certain proportions can scarcely be detected by taste. Abroad peanut oil has been largely substituted for olive oil and in the United States, cottonseed oil has furnished the chief adulterant.

COTTONSEED OIL.

Until comparatively recent years, the cotton plant which is cultivated so largely in the Southern States, was used only for its fiber. The seed, however, has been found to be particularly rich in oil, and rapid development in methods of extraction and purification have opened up a new industry, and have placed upon the market a comparatively cheap and nutritious edible oil.

Processes in Manufacture.—The seeds when taken to the mill are screened, passed over magnetic iron plates and through machines known as linters to remove foreign material such as sand, nails and cotton fiber. The short fiber obtained in the linters can be used for the preparation of cotton batting. The cleaned seeds are hulled, crushed and heated. The cooked meal is enclosed in camel's-hair cloth and subjected to hydraulic pressure, by which means the oil is removed. Crude cotton seed oil is reddish in color and must be refined. This is accomplished by the following processes. After the addition of 10 Bé NaOH, the oil is heated to 80°-85° C. and the mass is constantly stirred with paddles, until fatty acids are neutralized and impurities precipitate out. It is then allowed to remain quiet for many hours in a settling tank, after which the "foots" are removed and sold to soap manufacturers. The clarified fat is bleached with Fuller's earth and the color and taste are removed by secret processes. If it is to be sold as salad oil, it is winterized by dropping the temperature and removing by filtration, any fatty matter which has solidified. The oil must stand eight hours at the temperature of refrigeration before it is bottled.

PEANUT OIL.

Peanut oil is extracted from the peanut by the hydraulic pressure method, and is refined by processes quite similar to those used with olive oil. The first pressing gives an edible oil, used extensively in Europe and to a limited extent in the United States for salad dressing, either alone or mixed with other oil. Subsequent pressing yields a product very frequently employed in France for packing cheaper qualities of sardines and other food products. Peanut oil is also utilized in the making of fine silks as it does not readily turn rancid, and as a lubricant for fine machinery because it does not have the tendency to "gum." Inferior qualities are used in soap-making and as a basis for liniment. The cake which is left after the final pressing is highly prized for cattle food, as it contains oil, protein and mineral matter. It may also be utilized as a fertilizer.

CHAPTER XIV.

ANIMAL FOODS.

The animal foods commonly utilized by man in civilized countries include the flesh and various organs of cattle, sheep and swine, domestic and wild fowl, fish and shellfish, eggs, milk and milk products.

MEAT.

In the United States, the term meat generally implies the edible portion of cattle, sheep or swine. Animals found in the wild state, as the deer, moose, bear, squirrel and rabbit, are frequently highly prized but are used only to a limited extent.

The Physical Structure and Chemical Constitution.—Whether of domestic or wild origin, the muscle of meat is found to have a similar structure when viewed through a microscope. It appears to consist of tiny fibers which have the form of tubes, varying in length in different kinds of meat and in different parts of the same animal. The walls of the tubes consist of a protein substance which in the living animal is very elastic. It is known as elastin or yellow connective tissue. The tubes are bound together in bundles by a thin membrane called collagen or white connective tissue, a substance of great importance since it yields gelatin on boiling. Commercially gelatin may also be obtained from the elastin by the addition of an acid, but in the household elastin is not materially affected by cooking, except that it shows a tendency to harden.

The texture of meat depends upon the amount of connective tissue present, the contents of the tubes and upon the character of the walls of the muscle tubes. In a young, well-fed animal, the wall of these tubes is a thin delicate membrane and there is little connective tissue. The meat is, therefore, tender. The older an animal is, however, and the more work it has been required to do, the denser becomes the membrane and the larger the amount of connective tissue, thus giving a tough texture to the meat.

The value of the meat as food depends largely on the fat and the contents of the muscle tubes, which are chiefly protein. In the living animal within the muscle tubes may be found liquid myosinogen, paramyosinogen, albumin, alkaline salts and extractives. Carbohydrate occurs in the form of glycogen and glucose. As glycogen is not stored in large amounts it disappears very shortly after death. The texture of meat also changes considerably at death, caused by the clotting of the principal proteins, myosinogen and paramyosinogen. The hardening of the muscle tubes known as rigor mortes or the death-stiffening causes the meat to become very tough and it should, therefore, never be eaten in this stage. Either meat should be consumed before stiffening has had time to set in, or it should be hung until further changes take place, which again give it a tender texture. Rigor mortes is succeeded by the first stages of decomposition, during which acids are developed which not only bring about important chemical changes, but develop desirable flavors, fresh meat being very insipid. The contents of the muscle tubes, therefore, differ after hanging. They are found to contain myosin, metaprotein, extractives, mineral matter and sarco-lactic acid.

Fat.—All meat, however lean it may appear, contains fat. Besides that ordinarily visible there is always present more or less, occurring in small particles, embedded in the connective tissue between the muscle fiber. The visible fat varies greatly in amount, being comparatively small in veal, chicken and most game, while in pork, fattened beef and mutton and in the duck and the goose, the amount may reach one quarter to one half of the weight of the entire animal.

Water.—The amount of water contained in meat also differs widely, being regulated to a great extent by the fat content as other constituents are fairly constant.

Mineral Matter.—While protein is the chief constituent of meat, the mineral matter which it contains, particularly the phosphorus compounds, is also important although it occurs in relatively small quantities, constituting about 0.3 to 1.9 per cent. of the total fresh material. Besides phosphorus, meat contains potassium, sulphur, sodium, magnesium, calcium and chlorides. Traces of iron are found in lean beef, bacon and ham.

Meat Inspection.—Since domestic animals are subject to diseases which can be transmitted to man, a more or less rigid government inspection is now carried on by most civilized countries. Chief among these diseases are tuberculosis found principally in cattle and swine, and trachina which occurs exclusively in swine.

Tuberculosis.—Tuberculosis is probably the most frequently occurring disease both in this country and abroad. Among cattle it has probably been the most widespread, occurring not only in animals intended for slaughter but among dairy cows, particularly those of the Jersey and Guernsey herds. Much experimentation has been carried on for many years, to determine at what stage meat from animals affected with tuberculosis becomes unfit for human consumption. Experts still disagree on this subject. Extremists advise the condensing of the entire carcass even though the disease may be in an early stage and localized. Most authorities, however, take a more moderate view and would allow meat to be sold for food where the disease does not exist in a dangerous form, or where it is more or less restricted to certain organs. Where the disease has become generalized, all agree that the entire carcass should be condemned. With modern packing house methods, it has been found that even such animals may be utilized for the manufacture of valuable fertilizing material.

Trachina.—Swine are sometimes found to be infected with trachina, a disease resulting from a minute parasitic worm, which usually invades the muscular tissues. It was long regarded as a harmless parasite, but is now known to cause a disease in the human family somewhat similar to typhoid fever. Fortunately it is killed when exposed to a temperature of 155°-160° F. As it is customary in the United States to consume pork well cooked, there is practically little danger from this disease. Abroad where it is eaten more or less rare, a rigid inspection has been found necessary.

Reasons for Cooking Meat.—In great contrast to the carbohydrate group, protein does not become more digestible on cooking. In fact, meat fiber subjected to high temperature or prolonged heating becomes toughened and more difficult of digestion. It is obvious, therefore, that we must look for other reasons for the almost universal custom of cooking meat. Sterilization is the reason usually given, but this is only true to a limited extent. As meat is not a good conductor of heat, the interior of large portions, such as roasts, frequently does not reach the temperature when all pathogenic bacteria are killed. Neither can we hope that harmful ptomaines will be affected if by any chance such compounds have been developed. Our real reason for cooking is probably the development of desirable flavors, largely due to the extractive creatin, which yields creatinin on heating. This is important as it is now a well known fact, that we do not derive as much benefit from food that we do not relish.

Changes in Cooking.—1st. The structure of meat is frequently changed. Where wet heat or boiling is used, the fibers have a tendency to disintegrate. This is caused by the connective tissue being partially converted into gelatin. 2nd. Certain losses always occur in greater or less amount according to the method of cooking, temperature and use of salt. A loss of water is always involved even when the meat is boiled. Part of the fat is removed, the amount depending on the temperature and the melting point of the fat. Soluble constituents such as albumin, mineral salts, extractive and other organic bodies dissolve, especially in boiling. To prevent these soluble compounds from being lost, some means are taken to coagulate the protein on the outside, thus forming a protective coating. This can be accomplished by searing. The use of salt and the question of solubility are also important. In soup and broth where it is desirable to remove as much of the nutriment as possible, salt should always be added, as myosin as well as albumin is soluble in a dilute saline solution. Where salt is used to saturation, as in pickling or when rubbed on the outside of a roast, myosin is retained in the meat. Care should be given in pickling that saturation be kept up.

The greatest losses in cooking have been found to be in boiling and roasting, protein, mineral matter and extractives being the main constituents lost in boiling, and fat during the process of roasting. According to Jordan* the smallest losses occur in pan broiling and in sauteing.

BEEF EXTRACTS.

The question of solubility plays a very important part in the preparation of beef extracts, which may be regarded as soup or soup stock prepared from beef. The commercial forms are more or less concentrated by the water having been removed in vacuo.

The valuable qualities of such extracts were recognized by old time chemists, but they were not known to any great extent until after the researches of Liebig. In 1865 a company was formed authorized by Liebig, and a factory was established in South America, where cattle could be extensively raised at a lower cost than in Europe. The original method of preparation of these extracts was very simple. Finely chopped beef was treated with eight times its weight of cold water, and the soluble constituents were extracted by heating under pressure. The extract was then filtered, the fat removed to prevent it from becoming rancid, and the remaining liquid was concentrated to a paste in a vacuum pan. Liebig calculated that it would require thirty-four pounds of meat to yield one pound of beef extract, which on dilution would make approximately six or seven gallons of beef tea.

When extracts are made according to this method, they contain besides moisture chiefly mineral compounds 17-25 per cent., as potassium phosphate and sodium chloride, and meat bases 50-60 per cent., as creatin and creatinin. On examination, traces of albumin, proteoses and peptone have been found but they are not present in large enough quantities to add materially to the nutritive value. During the process of manufacture, the major

* Jordan, Principles of Human Nutrition, p. 317.

portion of the beef containing practically all the nutriment is rejected. The value of meat extracts must, therefore, depend on the mineral matter and the meat bases, or as they are frequently termed, the extractives.

These extractives, of which creatin and creatinin are the most important, are nitrogenous compounds but are not able to furnish the body with constructive material, neither do they yield energy. Beef extracts for that reason can scarcely be classed as food. Experiments have revealed that animals fed exclusively on such material died in practically the same time as those that received no food. Notwithstanding the small amount of nutriment present, beef extracts are valuable on account of their flavor and effect on the digestive organs. They are the most powerful exciters of the gastric secretion that we possess, and are important, therefore, as arousing appetite and as an aid to digestion. This is their chief function in sickness and in health. They are also of value as flavoring agents.

Some commercial beef extracts have the addition of protein, but the amount is never very great, although advertising matter frequently gives customers a false impression as to their nutritive value. A series of experiments carried on in 1908, at the Connecticut Agricultural Experiment Station, showed that "Of forty-seven preparations examined, ten only were properly branded and up to the standard, seventeen were found to be misbranded and varying from the standards, and the others were, in general, not up to the standards, though not misbranded." The very high cost of these extracts was also reckoned. It was found that the dry organic matter present cost from $2.68 to $10.18 per pound. The amount far exceeds the cost of home made beef extracts which are as a rule far better in quality.

Beef Juices.—Beef juices may also be found on the market. They contain substances of the muscle-fiber which may be obtained by subjecting finely chopped meat to strong pressure, with or without the aid of heat, and concentrating the extracted liquid in a vacuum pan. Such products are liable to undergo fermentation. They may readily be prepared in the home, by placing finely chopped meat in a jar and surrounding it with water heated to 140° F. The juice may then be extracted from the meat, by pressure with an ordinary lemon squeezer, and flavored with a small quantity of salt.

INTERNAL ORGANS.

In the use of internal organs, the custom differs in various countries. On the English market, quite frequently are seen the heart, the lining of the stomach (tripe), and the kidneys particularly those of the sheep. While tripe and kidney may be obtained in the United States market, their use is limited and the heart is considered of small value. It is disposed of in the canning industry or more generally for sausage making.

Beef tongues are sold largely here and abroad, either smoked or in the fresh state. As they constitute a valuable by-product, they are handled with great care in order to prevent decomposition from setting in and to give the best results in weight and appearance. Short tongues are frequently canned, while lambs' tongues as a rule are pickled.

Beef's and sheep's livers are sold in the fresh state and as they become stale more quickly than any other edible part of the animal, every effort is made to keep them dry and at a low temperature. They are frequently utilized in the manufacture of sausages known as Liberwurst. In the United States, hogs' livers are seldom used for edible purposes. They frequently are utilized as one of the constituents of dog biscuit or as an ingredient of table sauce. In former years, many were shipped to foreign countries where the custom of eating hogs' livers prevails, but more stringent laws in regard to methods of preserving such material during transportation, has greatly restricted the foreign trade.

Calves' brains and sweetbreads are considered delicacies both at home and abroad. In the United States, the thymus gland of young animals is placed on the market as sweetbreads.

FISH.

From the magnitude of the fish industry, both at home and abroad, may be seen the important part that fish and shell-fish play in the diet of the human race. The catch in the United States alone reaches approximately 2,200,000,000 pounds annually, most of which is consumed in this country, a small proportion only being prepared in various ways for export. Salting, smoking, drying, canning and other methods of preservation, have greatly increased the value of fish as a world's product. Modern methods of cold storage have also greatly assisted in the preservation and transportation of fish. A lower temperature than that used with meat has been found necessary, fish very frequently being stored in the frozen state. While 32° F. is sufficient to inhibit the growth of micro-organisms, it will not hinder the action of ferments, which acting upon the tissues, produce disagreeable flavors and make the fish unpalatable. Fish which has been frozen, however, deteriorates rapidly when thawed and decomposition of a very undesirable nature sets in quickly. For this reason, fish should be eaten as fresh as possible; it never improves on keeping as does meat during the hanging process.

Fish living in both salt and in fresh water are generally edible, being, as far as known at the present time, equally wholesome. As a rule those taken from deep, clear and cold water especially where the bottom is rocky or sandy are preferable to those coming from shallow, warm water or where the bottom is muddy. Fish taken from water polluted with sewage are not desirable. It is a well known fact that some land-locked fish are affected with parasites, at certain seasons, which make them undesirable as food.

Nutritive Value.—The nutritive value of fish is chiefly due to the protein and fat content. In protein, fish ranks nearly as high as meat, but it is very much poorer in fat, the majority of species containing less than 5 per cent. High in fat are the herring, lake trout, mackerel and the salmon, ranging from 7.1 to 17.8 per cent. Many of our common varieties, however, such as the bass, bluefish, cod, haddock, perch and the pickerel contain less than 2 per cent. The small fat content of the greater variety of fish is the main difference between meat and fish, when compared as to their relative nutritive value. So far as the protein is concerned, fish resembles meat but great differences occur in the proportion of fat and water, fish having water where meat has fat. Fish contains more gelatin yielding proteins, but has less extractives. This accounts for the lack of flavor and the reason that fish is apt to pall more quickly on the appetite. The mineral matter consists chiefly of calcium and potassium phosphate and sodium chloride.

Edible Portion.—Large proportions of fish are inedible and must, therefore, be considered as waste matter. This includes the skin, scales, bones, head, tail, entrails and fins. The amount varies greatly in different varieties, sometimes reaching as high as 70 per cent. Taking fish of all kinds, according to Dr. Wiley, some 55 to 60 per cent. of the total weight is edible.

Adulteration.—In the fish market very little adulteration occurs except along the line of substitution. Hake and haddock are sometimes sold as cod, and inferior salmon for high priced varieties. This practice of substituting one variety of fish for another occurs especially along the line of canned goods, as in the sardine canning industry, where the herring is frequently used.

SHELLFISH.

Chief among the shellfish on our market is the oyster although the clam, scallop, lobster, crab, shrimp, turtle and terrapin are used at certain seasons, when on account of their cost, they are usually considered great delicacies. As regards general composition, they strongly resemble meat and fish except that certain of the shellfish, as the scallop and the oyster, contain carbohydrate in the form of glycogen.

The oyster has apparently occupied a place in the diet of the human race for over 2,000 years. In very remote ages the Chinese cultivated artificial oyster beds, and as early as 100 B. C. the Italians were engaged in this industry. As civilization advanced oyster farming spread to all the maritime countries of the Old World and eventually to the Western Hemisphere, where it has progressed to such an extent, that the annual crop now exceeds the total production of the rest of the world.

In the United States the oyster is extensively raised on the

Atlantic and Pacific Coasts and in the Gulf of Mexico, especially in the vicinity of Louisiana and Texas. Those of the greatest value come from Long Island Sound, while the largest crop in the world is taken from the Chesapeake Bay.

Oystermen formerly depended almost entirely on natural beds for their product, but wherever the fishing is active and the demand great, the natural beds are rapidly becoming exhausted. This has led to the cultivation of artificial beds in close proximity to public oyster grounds. To promote the oyster industry the Federal Government through the Bureau of Fisheries, has co-operated with the States "In determining the physical and biological character of the oyster grounds, in surveying and plotting those grounds with a view to their allotment for oyster culture, in conducting experimental and model operations, in recommending oyster legislation and in giving disinterested expert advice on the various problems that arise in the development and administration of the osyter fishing."*

The necessity of guarding oyster beds from sewage pollution has been found imperative, through the tracing of typhoid epidemics to the consumption of raw oysters. For a long period a custom has prevailed among oystermen of transferring oysters from salt to brackish waters, for some forty-eight hours before shipping. The rapid absorption of fresh water gives them the appearance of fatness, increases their weight from 15 to 20 per-cent. and enhances their market value. The practice has proved to be unfortunate. Oyster plumping has been frequently carried on in estuaries within range of sewers or other sources of contamination. Where pathogenic bacteria exist in the water, oysters are in danger of imbibing disease germs with their food, and of acting as carriers of typhoid to the human family. Freshening also impairs the keeping quality and alters the flavor through loss of mineral matter by the process of osmosis. Chemical tests have further showed that while increasing the weight, fattening has deprived the oyster of 10 to 15 per cent. of its nutritive value.

* National Geographic Magazine, March 1913.

Deterioration is more rapid after removal from the shell; therefore, while increasing the cost, it is advantageous to ship oysters in the shell. They are, nevertheless, frequently shipped without the shell after having been washed and placed on ice. In this form they can be kept for approximately ten days.

As regards food value, they are frequently compared to milk, as both contain about the same amount of nutritive substances. Comparing the relative cost, it may readily be seen that the oyster cannot be considered as an economical food. The same may be said of the other shellfish, for while all may be classed as valuable foods so far as protein and mineral matter are concerned, their high cost places them among the delicacies rather than among our staple products.

EGGS.

Chief among the animal foods used throughout the world are eggs. In most countries hens' eggs are used to the largest extent although those of other domesticated animals such as ducks, geese, turkeys and guinea-hens are frequently found on the market. The eggs of birds and reptiles are eaten in certain sections of the world, and those of the fish may occasionally be found as delicacies, particularly those of the shad and sturgeon, the latter being extensively pickled and sold as caviar.

Physical Structure.—While the eggs of the wild birds vary greatly in color, tint, and plain or mottled appearance, those of the hen are either brown or white. Through a mistaken idea the difference in hens' eggs has greatly affected the market value, white eggs selling for a higher price in some localities, while other markets give the preference to the brown varieties. Analysis has been carried on at the New York State, Michigan and California Experiment Stations to determine their relative nutritive value. After much experimentation, the conclusion drawn was that there is no basis of fact for such popular belief. "Eggs of one breed whatever the color of the shells, are as nutritious as those of another, provided they are of the same size and the fowls are equally well fed."

Composition of the Shell.—The shell or protective coating of the egg is very largely composed of mineral matter. According to Dr. Langworthy 93.7 per cent. is calcium carbonate while magnesium carbonate and calcium phosphate also appear in small amounts. Organic matter is present only to the extent of 4.2 per cent.

When viewed through a magnifying glass, the shell is shown to be very porous in its nature. This allows the evaporation of water and results in the gradual loss in weight of the egg. The decrease in specific gravity, therefore, furnishes a very satisfactory means of judging the freshness of an egg. Brine may be prepared by dissolving 2 ounces of salt in 1 pint of water. A perfectly fresh egg will sink to the bottom in this solution. According to the experiments of Siebel, "An egg one day old will sink below the surface, but not to the bottom, while over three days old will float on the surface, the amount of shell exposed increasing with age."

In marketing eggs, the freshness is usually told by a process called "candling." In a dark room, an egg is held between the eye and an artificial light; a fresh egg appears unclouded, homogeneous and translucent; a stale egg is cloudy and frequently contains dark spots; a rotten egg appears dark colored. A simple housewife's test may also be made by shaking an egg held near the ear. The contents of the egg should not move. If a slight movement can be detected, it is somewhat stale; if it rattles, the egg is spoiled.

Methods of Preservation.—The porous condition of the shell is to a great extent responsible for the rapid deterioration of eggs. Bacteria can readily enter and bring about such changes as to make the article unfit for human consumption, in a comparatively short time.

In early days eggs were usually marketed near the source of supply, but modern times frequently require the transportation for long distances. As hens lay more plentifully in the spring it is also necessary, in order to secure an even distribution throughout the year, to store eggs for use during the fall and winter months. These facts have led to the study of the best methods of preservation. Cold storage has been found most effective, a temperature near the freezing point being usually employed. Eggs thus protected retain their freshness for several weeks, but when held for months as is frequently the case, the taste and odor are greatly altered. Where decomposition has not set in such eggs can be readily used for cooking purposes.

In order to prevent bacteria from entering, eggs are sometimes coated with a non-porous substance. The most efficient of these has been found to be a 10 per cent. solution of sodium silicate (water-glass). The egg should be carefully wiped with a damp cloth, and either coated or placed in a jar containing the water-glass as quickly after it has been laid as possible.

Eggs may also be preserved by the process of drying. Desication may be accomplished by spreading the egg in a thin film on a dry surface, or by passing the product under pressure through drying chambers. Where fresh eggs have been used, and where the process of manufacture is such as to make the product palatable and care has been given to the storage, such a product is wholesome and may be held for a reasonable length of time. Dried eggs are used largely by bakers, in camps and on long expeditions where fresh eggs are not available.

Composition of an Egg.—As the contents of an egg were intended by nature, to furnish the sole nutrition of the young chick during the process of development, we might expect to find among its constituents, all the elements required for building purposes. In this way it bears a strong resemblance to milk, both being a perfect food for the animal for which it is intended. Water, protein, fat and mineral matter are well represented, while carbohydrate is present only in a small amount. The nutritive parts of the white are chiefly protein, largely in the form of albumins, and a small amount of mineral matter. Only traces of fat are present. The yolk is rich in fat, protein and mineral matter. The fat occurs in the form of an emulsion, held in suspension by vitellin, a phosphoprotein resembling the caseinogen of milk. Eggs are also rich in sulphur, phosphorus and such elements as calcium, magnesium, potassium and iron in the form of salts. Another important food constituent present in the yolk is lecithin, a compound which furnishes the body with phosphorus in a form which can be readily assimilated. The composition of the white and yolk, given by Langworthy is as follows:

	White	Yolk
Water	86.2	49.5
Protein	12.3	15.7
Fat	0.2	33.3
Carbohydrate	—	—

CHAPTER XV.

THE PACKING HOUSE.

Historical.—The packing industry as it exists to-day was founded about thirty years ago, although packing in a very primitive way, has been practiced since the middle of the 18th century. Starting in the eastern United States, it spread westward and in time concentrated in centers near the source of supply of the raw material, thus saving the cost of freight on the live animal, from the ranch to the market.

On account of the large grazing areas, it became possible to raise cattle in the west in larger numbers than in the more settled east, so we find Chicago, Kansas City, St. Louis, Omaha, St. Joseph, Fort Worth and other middle west cities rapidly becoming important packing house centers. The nearness to the corn belt and the water or rail shipping facilities have also played an important part in the development of these cities, as centers in the packing industry.

The growth of this business has been very rapid. Although of comparatively recent origin, it now ranks fifth in importance of the industries of the United States. It is said to be the largest and most important industry which is strictly American in its conception and development. From the States, it is rapidly spreading to most of the new countries of the world.

Growth and Breadth of the Industry.—Important factors leading to the rapid growth of the packing business have been artificial refrigeration, concentration and the utilization of by-products.

In former times, packing could only be carried on during the winter months, as meat cannot be kept in good condition for any length of time after slaughtering, unless the temperature is kept low. The introduction of artificial refrigeration has now made it possible to carry on the business throughout the year. Not only has refrigeration become essential in the packing house, but its use during transportation has regulated the supply of meat at all seasons.

Where animals were driven or shipped to the place of consumption and slaughtered for local demand, the numbers were necessarily very small and little thought was given to the by-products. The fresh beef, the hide, the horns and the tallow were the only products used; the remainder was thrown away. This involved a great waste of valuable material. When the packing business became concentrated, the large amount of waste matter attracted attention. This resulted in the conversion of animal products that were not fitted for food or for manufacturing purposes, into fertilizing material. The fertilizer department once established, soon led to the study of the utilization of all by-products. Assisted by Applied Chemistry, means were in time discovered by which every available part of the animal could be converted into a marketable product. The value of using waste matter which formerly had been an expense to remove is enormous. It has been greatly responsible for the rapid growth and development of the industry.

The large modern packing houses consist of many departments, where frequently the by-products are elaborated to the finished articles, so that they go direct to the consumer from the packer; thus we find the high grades of fat being manufactured into butterine in one department, lower grades into soap in another department. The meat canning industry and the manufacture of such products as beef-extracts, pepsin, sausages, gelatin, glue, lard, sheep skins, feathers and many articles too numerous to mention, are now frequently part of the packing industry.

Processes in the Packing House.—*Inspection and Slaughtering.* On the arrival of cattle, sheep or swine at the stockyards, an inspection is made by a representative of the government and where pathogenic conditions are suspected, the animal is segregated and handled separately. A post-mortem inspection is also made on all animals and on all parts of animals, to be utilized as food (Fig. 51).

As a rule, animals found to be healthy are not slaughtered until the day after their arrival at the packing house, thus avoiding any abnormal conditions such as over excitement and fatigue.

After slaughtering they are bled and the hide, head, feet and internal organs are removed. They are then scrubbed and washed in each part, after which they are removed to the cooler, where they hang until ready for shipment or until they are sent to the cutting room for curing, sausage making or canning.

Beef are hung far enough apart to admit free circulation of air and the temperature is dropped as quickly as possible to

Fig. 51.—Beef Viscera Inspection. (Courtesy of Armour & Co., Chicago, Ill.)

40°-45° F. where it is maintained for twelve hours, after which it is gradually dropped to 34°-35° F. The temperature is seldom allowed to fall to the freezing point.

Hides, Pelts and Bristles.—As the hide of beef constitutes the most valuable by-product, great care is given to the handling and curing, preparatory to delivery to the tanner. It is removed from the freshly killed animals, by skilful workmen, freed from adhering flesh and fat and quickly cooled. A combination of fine salt and rock salt which has been crushed and screened, is spread over each hide and they are piled one above the other. During the curing process, which lasts for 25-30 days, more or less of shrinkage takes place, after which the salt is removed and they are prepared for shipment.

The pelts of sheep are also removed after slaughter. When not disposed of while fresh, they are cured by salting and sometimes treated so that the wool can be easily removed from the skin.

After the slaughter and scalding of swine, the bristles are taken from the back and ham and are cured first by drying, either in the sun or with artificial heat and then by salting They are used for the manufacture of brushes or made into curled hair for stuffing mattresses, cushions and similar articles. At the present time, the best bristles are being obtained from Russia and China.

Fat.—The second important by-product is fat, which is extensively used for the manufacture of edible products and many useful articles. From the bullock, three grades of fat are obtained. The first grade yields oleo stock from which, by further treatment, oleo oil and oleo stearin are obtained. The latter product is largely used in the preparation of compound lard. Oleo stock is frequently called butter-fat as oleo oil is one of the chief constituents of butterine. Oleo oil may be sent to a separate department of the packing house to be made into artificial butter, or as raw material, it may be sold to the manufacturer of butterine. For this purpose, large quantities are shipped abroad, the greater part going to Holland from which place it is distributed to other European countries.

A high grade of fat may also be rendered for edible tallow. This was the type fat used originally in the manufacture of oleomargarine. For the manufacture of artificial butter see Chapter XIII. A second grade of fat is rendered for ordinary tallow which may be further separated into tallow oil and tallow stearin. Several grades of tallow are known. They may be used in soap making, candle manufacture and in the preparation of glycerine, oleic and stearic acids. Tallow may be utilized for lubricating purposes, being generally compounded with other material.

From the sheep, tallow may also be obtained. It is hard and white in appearance and is known as mutton tallow.

One of the most important factors in the packing house is the rendering of the fat from hogs. Several grades, prepared by

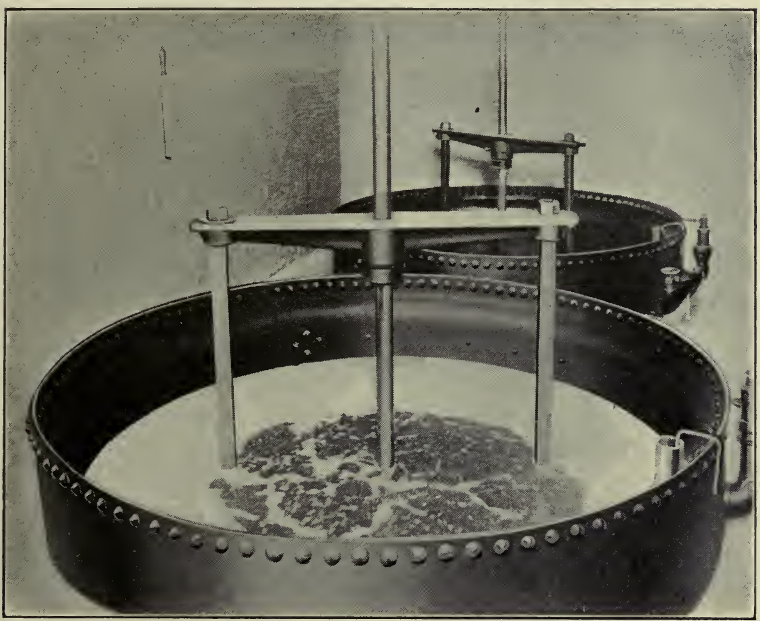


Fig. 52.—Lard Boiling. (Courtesy of Armour & Co., Chicago, Ill.)

different processes, are placed upon the market, known as kettle rendered lard, prime steam lard, refined lard and compound lard. The last named product is a substitute for lard and consists largely of cotton seed oil, oleo stearin and tallow. Kettle rendered lard is the highest grade of household lard. It is generally supposed to be made entirely from leaf lard, but only two-thirds leaf lard is used as a rule, the remaining amount being fat taken from the back. Neutral lard is made principally from leaf lard but by a more complex process (Fig. 52).

The Feet.—From the feet of salughtered animals, a valuable oil known as neats-foot oil may be obtained. The bones are sawed, separated from the hoofs, washed to free them from blood and subjected to live steam. During this process, the bones fall apart and the oil separates out. The bones may be ground into meal and the liquid containing dissolved protein may be utilized for the manufacture of glue. The oil which is drawn off is refined and used largely for leather dressing.

Bone Products.—From the bones of the head and feet many useful products may be obtained. One of the most valuable is bone-black, which is largely used in the industries for decolorizing, as in the bleaching of sugar, glucose and similar products. A black pigment may be secured also, and used as a pigment for paints and shoe blackings. Some bones are ground and used for fertilizing purposes while others are worked up into fancy articles such as knife handles, buttons, combs, fans and many similar products.

Tankage.—Tankage is the name given to the residue which remains in the tanks where meat scraps have been rendered to separate out the fat. In former years, it was always considered waste material and was thrown away. The operation consists in boiling down the meat scraps, under pressure in a closed tank or "digester," for several hours. After all the parts are thoroughly disintegrated from the effect of the high temperature, the fatty matter separates out and can be withdrawn through outlet pipes and by the process of skimming. The material which remains in the vats is passed through filter cloth and pressed, until most of the water and any remaining fat are removed. It is then dried, screened, and used as fertilizer base. The commercial value depends on the amount of ammonia and bone-phosphate which it contains. As the tank water is very rich in material which contains ammonia, it is concentrated to a syrupy consistency in a vacuum pan, mixed with copperas and dried. It is known as "concentrated tankage" and is used for mixing with low grade tankage to increase the percentage of ammonia.

Blood.—The blood which flows from the slaughtered animals is conducted through drains to large vats or receptacles, care being given to keep it free from all foreign matter, such as refuse, manure and water. It is then cooked by live steam until the albumin has coagulated, after which it is pressed and dried. Dried albumin may be ground and screened if desired. Albumin is used extensively as a fertilizer and in the textile industry in setting the color permanently in such material as gingham. The drained blood is sometimes used in beet sugar refining as a clarifying agent; it is then known as "sugar house albumin."

Mixing Fertilizers.—To make a complete fertilizer, phosphoric acid, ammonia and potash must all be present. As only ammonia and phosphorus compounds are obtained from bones, tankage and blood, it is necessary to add a potassium salt, such as potassium chloride or sulphate. According to need, they are mixed in different proportions, and are thoroughly incorporated with a filler as earth or ashes which acts as a diluent, the fertilizer when used alone being too strong for plant life.

Glue and Gelatin.—Glue and gelatin can be made from many by-products of the packing industry. The chief sources are the liquids in which have been boiled cattle and sheep's heads, feet, bones, sinews, hide trimmings, calves' heads and pigs' feet. Many grades may be obtained from fine white gelatin to a low grade dark appearing glue, according to the part of the animal used, the condition of the raw material and the care in manufacture. In order to produce a high grade product, careful attention must be given to the raw material in order that decomposition does not set in. Only that which is in a sound, sweet condition should be utilized. It is also essential that a low temperature be used in concentrating the glue liquor, so that scorching may be prevented and undesirable changes may not take place. This is accomplished by evaporating the liquid, to the desired density, in a vacuum pan from which it is run into molds, chilled and clarified. It is then cut into layers and dried in an oven.

In order to dissolve the mineral matter, bones are frequently leached with an acid. By allowing them to remain in dilute hydrochloric (2° Bé.) or phosphoric (6° Bé.) for three or four weeks, the bones become soft and spongy. They are then freed from the acid by careful washing, after which they are converted into gelatin.

Bleaching the bones before cooking the glue liquid is practiced by many manufacturers. Sulphur dioxide is most frequently used, although other bleaching agents may be employed, such as zinc sulphate or chloride and peroxide of hydrogen. In addition to bleaching these agents act as preservatives, thus preventing decomposition from setting in. Formaldehyde is also used in small quantities as a preservative.

Canning of Meat, Beef Extracts, Sausages, etc.—As a rule the canning of meat is carried on as a separate industry. See Chapter XIX. It is, however, one of the side issues that is frequently found in the packing house, being established with the view of saving a large proportion of meat that would otherwise be wasted, or would be sold at a very low price. In this way many of the cheaper cuts of meat, which are nourishing and healthy, can be utilized. The preservation of meat by hermetically sealing, has led to still another department within the packing house. In the soaking and cooking of meat, part of the water-soluble constituents are dissolved out. By concentration in a vacuum pan, these waste liquors together with the bone liquid, may be converted into beef extracts. Fresh meat is rarely used for this purpose among packers, consequently the cost of preparing beef extracts by them is very small. For manufacturing processes, see Chapter XIV.

In the sausage department, the packer finds another way of disposing of those portions of meat which are nutritious but not palatable in their original condition. Sausages, bologna, frankfurts, scrapple and similar products are prepared after various formulæ and placed upon the market. Besides meat from different parts of the beef and pork, such products may contain corn flour, cracker meal, boiled potatoes, starches and dextrins. These are frequently spoken of as "fillers" and serve to prevent shrinkage in bulk under the influence of heat. A great variety of flavoring agents are added, such as sugar, salt, white or red pepper, cinnamon, mace, allspice, cloves, coriander, carraway seeds, marjoram and onions or garlic. Salt-petre and color water, consisting of dyes of various kinds, assist in giving a better appearance. A common practice still exists in the use of borax and boracic acid for purposes of preservation.

The manufacture of animal casings from the round or small guts, middle or large intestines and bladders, of cattle, sheep and hogs, furnish another example of the utilization of material entirely lost until the establishment of the modern packing house. In order to supply the demand, artificial casings may be prepared from cellulose, to take the place of animal casings. To improve the appearance of casings, to insure against shrinkage and to prevent molding, varnish is sometimes used. It is prepared from shellac, boracic acid, ammonia and water.

There is probably more chance for deception in the manufacture of these products than in any other form of animal food found on the market. When properly prepared, they are highly prized as food products. The frequent use, however, of such material as borax, boracic acid, sulphite of soda, undesirable colorings and excessive quantities of filler, is making the inspection of factories the only safeguard that the consumer has for protection against the adulteration of these products.

Minor Packing House Products.—In connection with the packing industry, many other branches may be found, such as the manufacture of chipped dried beef, the curing and smoking of tongues and hams, and the preparation of pharmaceutical products from the various organs of slaughtered animals. From the mucous membrane of the stomach of hogs, pepsin is made and a similar ferment known as pancreatin may be obtained from the pancreas or sweetbreads of animals.

In a like manner, from the bullock may be extracted cardine from the heart, medulline from the spinal cord, musculine from the muscular tissues and cerebrine from the brain. The thyroid glands of the sheep and the bullock yield thyroidine. It is claimed that these extracts from animals are beneficial in the treatment of diseases of human organs similar to those from which the extracts are prepared.

CHAPTER XVI.

MILK.

Fig. 53.—Burnside Farm, N. Y.

Source.—Milk is a white opaque fluid which is secreted by the lacteal glands of the female of all animals, which belong to the mammalian class. It is intended by nature to supply nourishment to the young, until such a time as it is able to take food similar to that utilized by the parents.

In different parts of the world various animals are bred for the purpose of producing milk for the use of mankind. Probably the goat was one of the first animals to supply milk to the human family, and in the rough, hilly districts of Europe, especially in the Swiss Alps, it is still very common. The milk of the buffalo, the camel, the mare and the reindeer is frequently used, while in parts of Europe the ewe has produced much milk for the manufacture of cheese.

History does not tells us how the cow came to be developed as a producer of milk, but in most civilized countries where the climatic conditions permit, cow's milk is almost entirely used. It is not more desirable for human food than the milk of other animals, but in her development the cow has shown herself to be able to give the best return for a given amount of care and feeding.

Composition.—Chemically milk is composed of all the essentials necessary to sustain life for a long period and is, therefore, frequently spoken of as a perfect food. It can only be regarded in this light, however, when utilized by the type of animal for which it is intended.

The composition varies in different animals, even in animals of the same species, but the difference is rather in the relative proportion of the various constituents, than in the general properties and composition of the ingredients themselves. The following figures will give a general idea of the composition of cow's milk, although a great variation may occur according to the breed, age of cow, period of lactation, amount and character of the food, etc.

	Per cent.
Water	87.2
Total Solids	12.8
Fat	3.6
Carbohydrate	4.9
Protein	3.3
Mineral matter	0.7

Water is the largest constituent of the milk, containing in solution, semi-solution or in suspension, the remaining ingredients which are known as the total solids. Of these total solids, fat is commercially the most important as it is the source of butter and to a great extent cheese. The amount differs more than any other constituent, being low in the Holstein and relatively high in the Jersey and Guernsey. The average should not fall below 3 per cent. and except in very rich milk, it will not exceed 5 per cent.

Fat occurs in milk as an emulsion, suspended in the milk serum in the form of globules. On account of their specific gravity these globules rise more or less readily to the top, when milk is allowed to remain at rest, and are then known as cream or top milk.

Chemically, the fat which is known as butter-fat exists in two forms, non-volatile and volatile. The non-volatile or insoluble fats make up about 90 per cent. of the total amount, and consist of a number of fats of which palmitin, olein and stearin are the most important. The characteristic taste and odor of milk and butter are largely due to the existence of certain volatile fats, butyrin, caprin, caproin and caprilin which constitute the remaining 10 per cent. Of these butyrin is the most important. It occurs in the largest proportion and is the fat which on decomposing yields butyric acid, readily detected in rancid butter.

The carbohydrate in milk is known as lactose or milk sugar. It belongs to the disaccharid group as do sucrose and maltose, and is similar so far as its ultimate composition is concerned. The most marked difference is solubility; sucrose and maltose are very readily soluble in water while lactose dissolves with difficulty. Milk sugar, therefore, does not possess the sweetening power of the other disaccharids and is not apt to pall upon the taste so rapidly.

Lactose does not readily yield to yeast fermentation, but under the influence of certain bacteria found in all normal milk, it undergoes partial decomposition yielding lactic acid according to the following formulae:

$$C_{12}\,H_{22}O_{11},\ H_2O \rightarrow 4CH_3\ CHOH\ COOH.$$

This change begins in the milk as a rule almost immediately after it is drawn from the cow and continues until 0.9 of 1 per cent. is formed, when further decomposition is checked by the lactic acid.

The chief protein of milk is caseinogen which exists in an extremely fine colloidal state in intimate contact with calcium phosphate. Caseinogen will not coagulate on heating, but when subjected to an acid which combines readily with the calcium, it will precipitate out of the solution in the form of a curd. It is very important commercially as it is one of the chief constituents of cheese. Albumin and globulin also occur in solution in milk but in relatively small amounts, approximately 0.5 of 1 per cent. of the total protein. They are essentially the same in chemical composition as the albumin and globulin found in blood and egg.

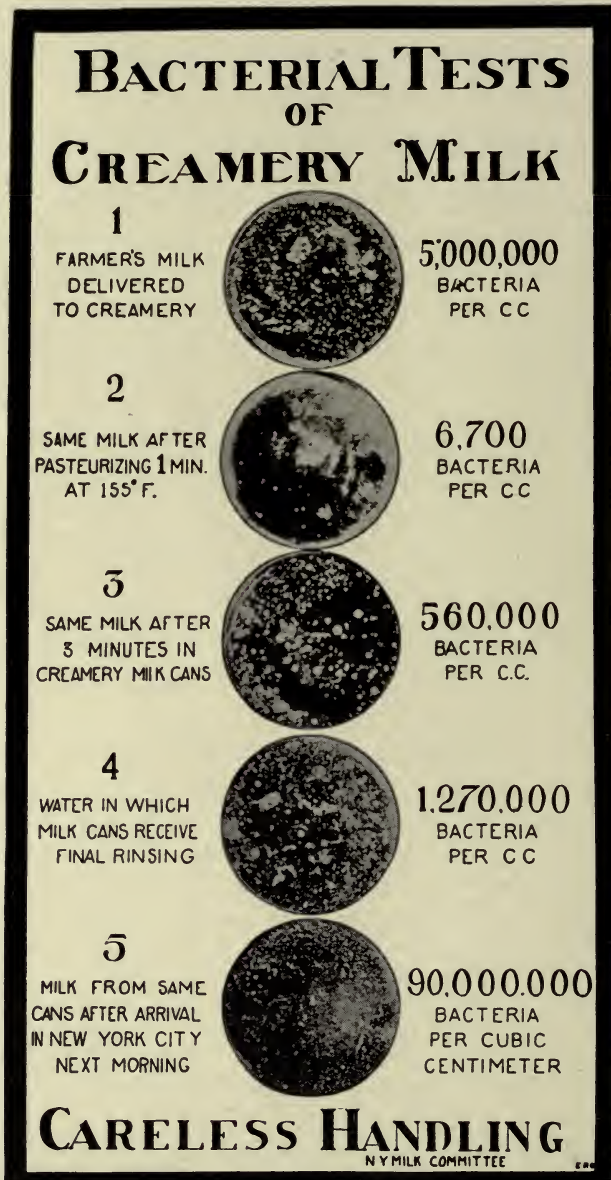
Mineral matter is present in a relatively large amount, 0.7 of 1 per cent. in cow's milk and is utilized mainly for building purposes. Small amounts of a variety of salts occur—phosphate of lime and potash, chlorides and sulphates of sodium and potassium, with very small amounts of iron and magnesium. Human milk contains much less inorganic matter, approximately 0.2 per cent. being present. It is frequently necessary, therefore, in infant feeding to modify milk so it will more closely resemble mother's milk.

Milk contains several other constituents occurring in minute quantities. Lime occurs in combination with citric acid in the form of a salt known as citrate of lime. It is also rich in various enzymes which assist in the digestion of the protein, fat and milk sugar. For a short period after it has been drawn, bactericidal bodies are present. The characteristic color of the fluid is largely due to lactochrome, which occurs in varying amounts, and is generally supposed to be intimately associated with the palmitin.

IMPORTANCE OF THE MILK SUPPLY.

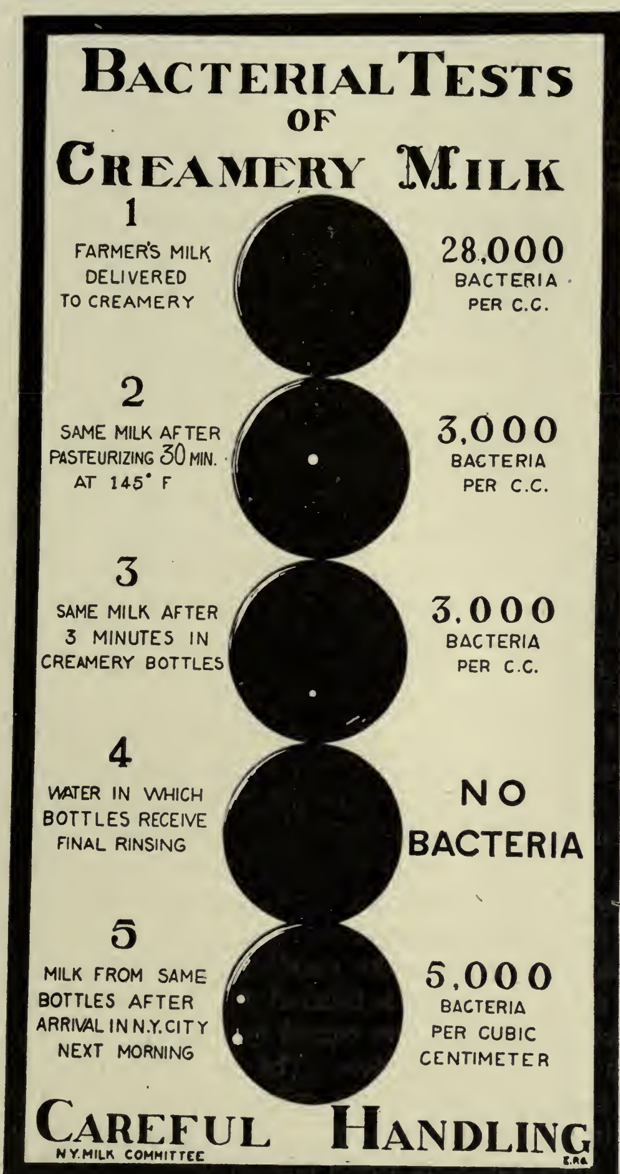
Of all our standard articles of food none have received as much attention as the production and handling of milk. The reason for this may readily be seen, for it has been found that milk is more apt to be dangerous to health than any common food product. It deteriorates very rapidly and as it is usually taken in the raw state, no protection is afforded the consumer through the process of cooking. The fact that it forms the sole diet of the human being at an immature age makes this problem a very serious one. Should there be any contamination, the child would be liable to take it when least able to cope with a disease.

Besides the chemical compounds previously considered, milk contains a large number of bacteria which gain access to it after it is secreted. Unfortunately the warmth of the milk, its fluid condition and its composition make it a most favorable medium



Bacteria Counts Tell the Story of Unsanitary Conditions

Fig. 54.



BACTERIA COUNTS TELL THE STORY OF SANITARY CONDITIONS

Fig. 55.

for the growth of these micro-organisms. They reproduce very rapidly and unless precautions are taken to inhibit their increase, the number becomes enormously large in a comparatively short time (Figs. 54-55). Through their action, changes begin to take place in the milk constituents and in time decomposition advances so far, that the milk is no longer fit for consumption.

Diseases from Milk.—The greater number of the germs in milk are harmless excepting the germs of specific diseases as tuberculosis, typhoid, scarlet fever, diphtheria and septic sore throat. The most dreaded disease is that of tuberculosis. The bacilli may come directly from the cow affected with bovine tuberculosis, in which case there is a possibility of large numbers being present in the milk when it is drawn from the teats. Such milk when mixed with that drawn from other cows, may contaminate the supply from the entire herd. Expert examination has proved that the disease is as prevalent among cows as it is in the human family especially when the animal has been kept under bad hygienic conditions. Rosenau states* "The fact that bovine tuberculosis is frequently fatal, especially in children, may be divined from the fact that fifteen per cent. of the fatal cases of tuberculosis in children under five year of age that have been studied, were due to the bovine type of bacillus" and "from five to seven per cent. of all human tuberculosis is ascribed to infection with the bovine bacillus." This shows the importance of the care which should be given in the milch cow and the necessity of making the tuberculin test from time to time.

Milk may also be contaminated from persons having pulmonary tuberculosis or through the contaminated cloths or insanitary actions of the milker. It is believed that epidemics of diphtheria and scarlet fever have been caused by the milk supply, probably through secondary infection. The great importance of the health and cleanliness of the milker and his family is again shown in typhoid, since the cow does not have that disease. An impure water supply in which milking utensils are washed has frequently been the cause of the spread of typhoid. For this

* Rosenau—The Milk Question, p. 100.

reason no water which is not above suspicion should be used about the dairy, for either drinking or washing purposes. In recent years, pathogenic streptococci causing sore throat have been traced to infected milk.

Cholera infantum is believed by some authorities to be due to the abnormal increase of bacteria of filth, rather than to any one species of micro-organism. That it is due to milk bacteria has been proved by the fact that the trouble occurs in greatest abundance at the season of the year when milk bacteria are most numerous; that it is chiefly confined to infants fed upon cow's milk and that the disease is greatly reduced when care is given to supply pure milk.

Necessity for Cleanliness.—Since milk may so easily become contaminated, since it is a favorite medium for the development of bacteria and must so frequently be carried a long distance, cleanliness is an absolute necessity in the production and handling of our milk supply. Means should also be taken to prevent the growth of micro-organisms, for even when produced under sanitary conditions, bacteria in small numbers are always present. Their development may be inhibited by dropping the temperature immediately after milking to 50° F. and maintaining this temperature until the milk is delivered. The importance of perfect cleanliness and low temperature cannot be over-estimated.

Safeguarding the Milk Supply.—To safeguard the supply, laws have been passed by the city and state governments, which while differing in detail, contain the same general rules. As regards composition milk must not contain more than 87-88 per cent. water and should contain 12-13 per cent. total solids of which 3 per cent. should be fat. It must be guarded from producer to consumer, by surrounding it with sanitary conditions and a temperature sufficiently low to prevent growth of micro-organisms. No preservative, such as borax, boracic acid, salicylic acid or formaldehyde should be used. Some cities also have a law in regard to the bacterial count, but this has been found impracticable in large communities.

Because of its wide usage as a food, milk is more closely supervised than other articles in the diet. It is inspected at the farm, at creameries, during transportation, at receiving stations and in distributing centers. Regulations are now more or less enforced affecting surroundings where milk is produced. The water supply must be above suspicion. The utensils should be heavily tinned and seamless. They should be subjected each day to a thorough washing and if possible to live steam or exposure to sunlight. The stables should be light, well ventilated and frequently whitewashed. No utensils, feed or other animals should be kept in the stables. Bedding and manure must be daily removed. The cow should be healthy and kept as clean as possible. The milker and dairyman's family should be free from contagious disease. The milk should be drawn through a small mouthed sanitary milk pail, strained and cooled immediately.

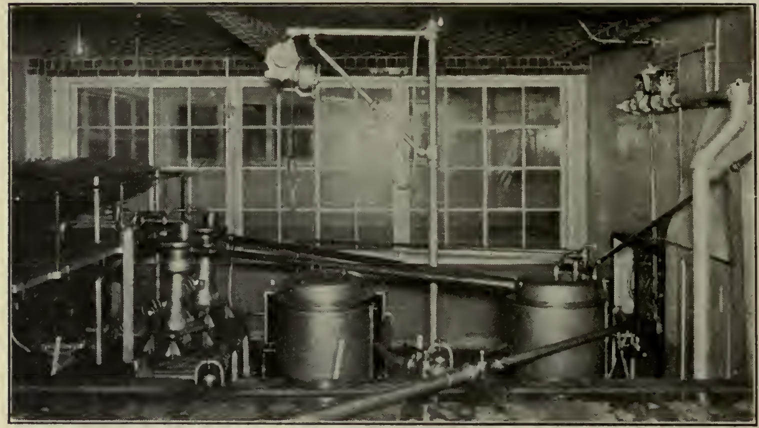
During the journey to the consumer milk should be kept out of contact with air and should be iced. Sanitary conditions should also prevail where it is distributed. Although the state may control more or less the supply of milk from the producer to the consumer, once in the hands of the housekeeper, the law is powerless to control the handling of milk. Too frequently through ignorance or utter carelessness, milk which has been carefully handled by farmer and distributor is ruined by the housewife. It is as much her duty to see that milk is guarded carefully as it is of those who have handled it before her. The following hints to housekeepers have been contributed by some of the students of Teachers College: Buy for daily use; buy bottled milk whenever possible; when milk must be bought from an open can, use a covered receptacle to put it in, as a glass fruit jar; do not transfer bottled milk to another receptacle; on receiving, wash the top and outside of the bottle thoroughly and place at once near the ice in the ice-box; do not mix old and new milk; since milk absorbs odors, do not put strong smelling food near it; keep well covered at all times; when the bottle is empty, rinse with cold water, wash thoroughly with hot water and set to drain away from dust; do not use milk bottles for any other purpose; if there is a contagious disease in the family, until the danger is over, place a clean covered container where the milkman may pour the contents of the milk bottle which he is delivering into the container, or keep all bottles delivered during the period of illness before returning, at which time they should be thoroughly sterilized; general rule—keep milk cold and free from dirt.

Our Duty to the Producer.—As the study of the milk problem advances, more and more has been required of the producer. The law now demands that cows must be in a healthy condition, that old barns and surroundings must be cleaned or new barns built, stables must be whitewashed, the water supply must be examined, new utensils must be bought and more care must be given to cleanliness, which means more labor at an additional cost. These requirements have greatly added to the cost of the production of milk, and the farmer can no longer supply milk at a profit for the same price as when insanitary conditions prevailed. The advance in price should, therefore, be cheerfully borne by the consumer who is receiving a far better product to-day than in years gone by.

Testing of Milk.—Milk is usually tested by the lactometer which registers the specific gravity, and by the Babcock test which gives the percentage of fat and also assists in the detection of formaldehyde. The estimate of the amount of water and total solids is made together with the bacterial count. For further information in regard to these tests see a standard work on milk as *Milk and Its Products* by Wing, *The Production and Handling of Clean Milk* by Winslow, Harrington's *Practical Hygiene,* or Van Slyke's *Methods of Testing Milk and Milk Products.*

Sterilization.—Even with ordinary care milk contains a large number of bacteria which multiply rapidly. As previously seen they may be a harmless type or those of specific diseases. These troubles have led to the treatment of milk by heat, the oldest method being that of sterilization.

As sterilization means the destruction of all micro-organisms, it is necessary either to hold milk at a temperature of 248° F. for 15 minutes or to raise it to the boiling temperature on three successive days. This insures not only the destruction of bacteria



A B C

Fig. 56.—Pasteurization of Milk. The milk passes from the receiving tank (A) through the clarifiers (B) to the pasteurizer (C) where it is heated to 145° F. It is then conducted to the holding tanks (Fig. 57). (Courtesy of the Sheffield-Farms-Slawson-Decker Co.)

Fig. 57.—Holding Tanks. Milk heated to 145° F. is conducted successively to four holding tanks where it is held for fifteen minutes in each tank. At a temperature of about 142° F. it passes back through the pasteurizers and is rapidly cooled. (Courtesy of the Sheffield-Farms-Slawson-Decker Co.)

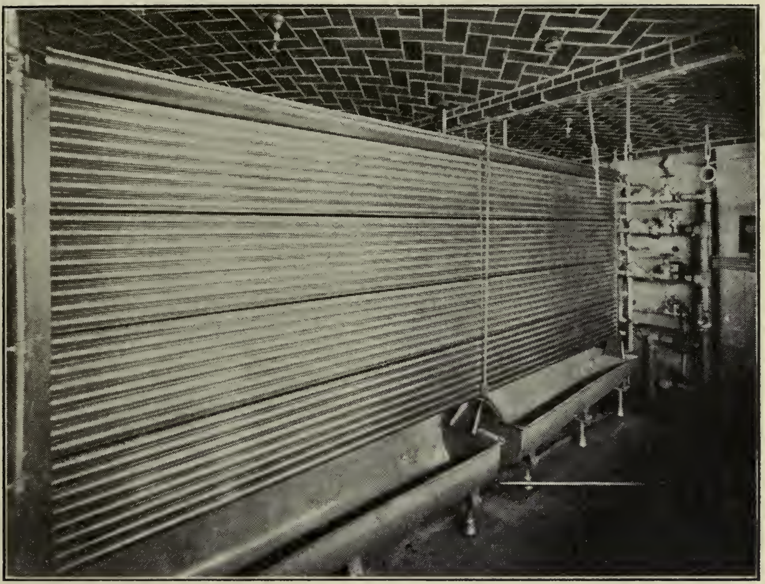


Fig. 58.—Milk Coolers. (Courtesy of the Sheffield-Farms-Slawson-Decker Co.)

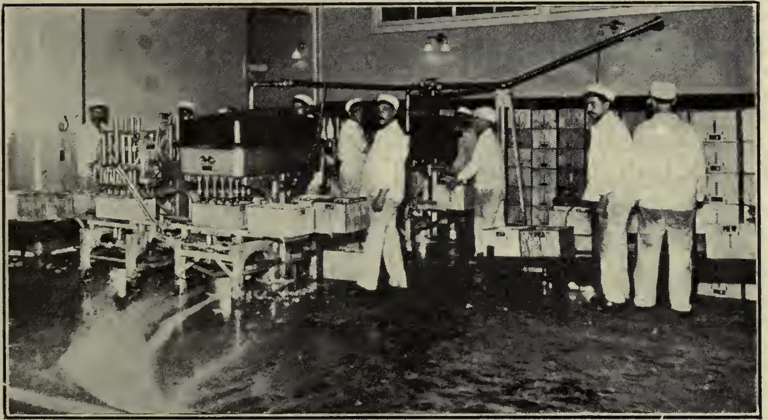


Fig. 59.—Milk Bottling Machine. (Courtesy of the Sheffield-Farms-Slawson-Decker Co.)

but spores of a highly resistant type and renders the milk practically sterile. If air be excluded such milk can be held indefinitely. While undoubtedly this is the most effective method of protecting milk against bacterial decomposition, it unfortunately so alters the composition as to make it more difficult to digest. This has proved so serious an objection that sterilization has been practically abandoned in America, and either pasteurization or the use of clean raw milk has taken its place.

Pasteurization.—The term pasteurization means the heating of milk below the boiling point, from 140° to 160° F., followed by rapid cooling (Figs. 56-59). This method was named from Pasteur who suggested its use in 1864 for the preservation of beer and wine. It was not, however, until 1886 that the process was applied to milk. It differs from sterilization mainly in the degree of heat to which bacteria are subjected. All micro-organisms are not destroyed by this method so pasteurized milk will in time decompose. It has been found, nevertheless, that from 95 to 98 per cent. of bacterial life and practically all of disease bacteria have been rendered harmless, so milk thus treated can be kept from souring from twelve to twenty-four hours longer. If milk has been kept for a period before pasteurization, poisons may have been formed in it which heat will not destroy. It is, therefore, absolutely essential that only clean, fresh milk should be pasteurized. The process can in no way take the place of cleanliness and should never be used to atone for insanitary methods in the production and handling of the milk supply.

If a low temperature has been used pasteurizing does not injure milk so far as its nutritive value is concerned and it affords a certain protection against such diseases as tuberculosis and typhoid which have been previously discussed.

Certified Milk.—The term is intended to signify that the milk is certified as to its quality and wholesomeness by a medical milk commission. While pasteurization properly carried out has greatly assisted in safeguarding the milk supply of large cities, where enormous quantities must frequently be carried long distances, it is by no means ideal. It frequently means a purified rather than a pure milk. This has proved satisfactory for ordinary household purposes and for adults, but in infant feeding nothing can take the place of pure raw milk produced under ideal conditions. A standard of excellence has been fixed by medical commissions and milk which can satisfy these requirements is sold under the name of certified or guaranteed milk. The bacterial count must be low, and it must possess the other characteristics of pure wholesome milk. This can only be secured by perfect cleanliness in regard to the dairy, dairy methods, care of the cow, and health of the milker. To comply with sanitary regulations means an excess cost to the producer, so certified milk may be sold at a higher price. Such milk is frequently sold under the special name of the dairy, as Walker-Gordon milk.

Modified Milk.—As the composition of cow's milk differs from that of human milk, being higher in protein and mineral matter and lower in milk sugar, it is frequently found necessary to change the composition of cow's milk to more nearly make it resemble that of the human being, or to give a milk of known composition especially adopted to the particular needs of the infant or invalid. Water, barley water, lime water or dextrinized gruel may be used as a diluent and cream and milk sugar may or may not be added. Such a product is called modified milk.

All precautions stated above for the production and handling of clean milk as well as the requirements of the certifying Medical Society should be observed in producing modified milk.

CHAPTER XVII.

MILK PRODUCTS.

Condensed Milk.—The importance of milk in the diet and its rapid deterioration even under the most favorable conditions. have led to much experimentation along the line of its preservation for a long period.

In the early part of the 19th century, an attempt was made to hold milk indefinitely by reducing the percentage of water. As a high temperature was used in the condensing process, the result was a boiled milk, the composition of which greatly differed from the raw material. Lactose like any other sugar caramelized in time and gave to the finished product a dark color and a bitter tatse. Lime salts, so necessary in the digestion of milk, were thrown out of solution and the protein matter was much altered in composition. The process proved a failure.

It was not until 1856 that another attempt was made to preserve milk by condensing it. At that time Gail Borden was granted a patent "On a process for concentrating milk by evaporation in vacuo, having no sugar or other foreign matter mixed with it." This early process reduced the temperature to 160° F. and eventually resulted in placing a satisfactory product on the market. Although the early days of the condensed milk business were full of discouragement to the manufacturer, the industry has now grown to enormous proportion, rapid strides having been made during the past ten years. This shows the rapid increase in the consumption of condensed milk not only in countries where the breeding of the cow is impossible, but also for use on ocean liners, in the navy, lumber and mining camps and in home markets.

The successful condensing of milk requires that the raw material be produced under the best hygienic surroundings, and invariably the dairy conditions will be found to be in a high state of development, wherever milk is being produced for the condensing industry.

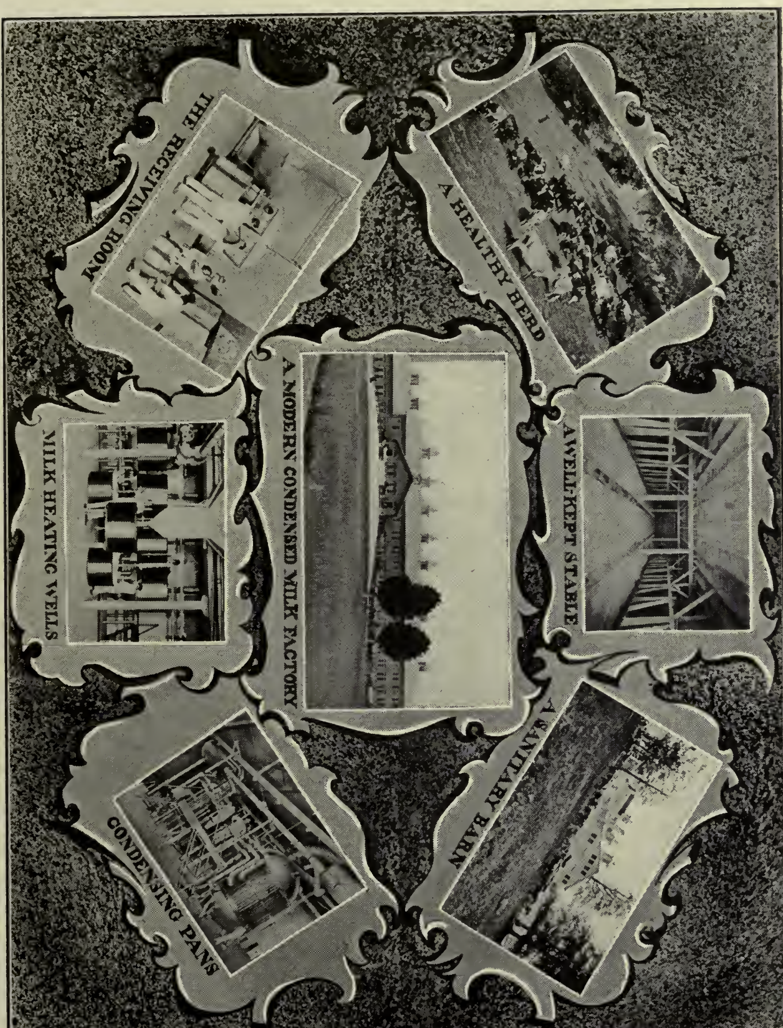


Fig. 60.—Condensed Milk Industry. (Courtesy of Borden's Condensed Milk Co.)

There are two classes of condensed milk, sweetened and unsweetened.

Process.—When milk is received at the factory it is tested, filtered to remove dirt, and immediately sterilized by raising the temperature of the milk to the boiling point. Sugar is added to the extent of about 16 pounds to 100 pounds of milk. The sweetened fluid is run into a vacuum pan and kept at a temperature of approximately 130° F. until it is condensed about two and one-half times. When sufficiently concentrated it is run into 40 quart cans which are surrounded by ice. During this operation which lasts one hour, the milk is constantly stirred with paddles after which it is immediately run into tin cans, capped, labeled and boxed. While not sterile this product will keep for a long period. The long continued heat should destroy most bacteria and the addition of sugar acts as a preservative.

An unsweetened condensed milk meant for immediate use is put on the market by many condensing companies. The process of manufacture is essentially the same, with the exception that no cane sugar is added, and the concentration is a little over three times. It is usually sold in glass jars capped with paper caps, similar to fresh cream, and will remain sweet and fit for consumption as long as fresh cream.

Evaporated Milk.—Evaporated milk is an unsweetened condensed milk sold in hermetically sealed cans. As no cane sugar is added, it depends entirely on sterilization for its keeping quality. The raw material is held in heating wells for ten to twenty minutes, then is run directly into the vacuum pan where it is concentrated two and a quarter times. After cooling, the evaporated milk is immediately put into cans and sealed. The hermetically sealed cans are sterilized at a temperature of 235° F. for one-half hour. While cooling, they are subjected to shakers to mix the jelly. This agitation breaks up any coagulum which may have formed during sterilization. The cans are finally placed in a curing room where they are kept for thirty days, after which they are examined before being placed on the market. As this product is sterile it will keep indefinitely.

Concentrated Milk.—The Campbell process of concentrating milk has placed upon the market in recent years a small amount of milk, relatively free from bacteria, and which can be purchased at the price of ordinary milk. The best fresh milk which can be obtained is used. After being tested the raw product is put through the centrifuge, in order to clarify it from stable dirt and to separate the cream and skim milk. The cream is pasteurized, while the skim milk is heated for two or three hours at a temperature of 140° F. during which a continuous blast of filtered air is driven through it. Evaporation is continued until three parts of the original product is condensed to one part of the concentrated skim milk; after which the pasteurized cream is added. The product is placed upon the market in small bottles to which three parts of water must be added to give the original consistency. On account of the low temperature used, concentrated milk has not materially changed in composition and after the addition of water, it appears to have the properties of ordinary fresh milk. According to Professor Conn, the method of using combined heat and aeration destroys most of the bacteria, especially those of specific diseases, and gives a relatively safe milk even for infant feeding. On account of its concentration such milk when kept below 50° F. will last for a week or ten days.

Milk Powders.—The process of reducing milk to the powdered form has become quite an industry in recent years. To obtain a successful product, the milk must be desiccated at a low temperature in order to prevent as little chemical change as possible from taking place. This is frequently carried out by drying it in a thin film on metal plates in vacuo. The resulting creamy white powder will unite readily with water to give the original consistency of the milk. On account of the fat, powders prepared from whole milk will not keep indefinitely unless placed in cold storage; those from skim milk have been found more satisfactory. They are used to a large extent for cooking, especially where fresh milk cannot be obtained.

BY-PRODUCTS OF THE BUTTER INDUSTRY.

The chief industry using milk is the butter industry which has been described in Chapter XIII. The most important by-products of this industry are mentioned below.

Skim Milk.—From whole milk the fat is separated in butter-making very largely at present by the centrifuge. With this method only a trace of the other constituents is removed with the fat; this leaves the skim milk rich in protein and carbohydrate. As skim milk contains all the normal ingredients of ordinary milk except fat, it can very readily be used for cooking purposes, or as a beverage for people who find cream hard to digest. As the law, however, frequently forbids the selling of skim milk, it has been utilized to a great extent for cattle food or in many cases it is thrown away. This is a waste of valuable material for the protein and lactose can be recovered by comparatively simple methods.

Dried Casein.—The skim milk is run into a vat and a small amount of sulphuric or acetic acid is added. This precipitates out the caseinogen in the form of a curd which can readily be removed from the whey, washed, pressed, dried and sold as dried casein. It is used in the paper, leather and textile industries, as an ingredient of paints, glues, and cement, and for the manufacture of imitation ivory articles.

Milk Sugar.—After the removal of the caseinogen, the water may be evaporated (over hot water) from the whey until the lactose crystallizes out. It is generally reduced to the powdered form and is much used in pharmacy and for infants' and invalids' food.

Buttermilk.—Buttermilk is the fluid which is left after churning in the process of butter-making. It is commonly used as a food for young calves and pigs, and occasionally as a beverage, especially during the summer months. The chief point in which it differs from milk is its poverty in fat and its increase in acidity, due to the formation of lactic acid which rarely exceeds 0.5 per cent. It is comparatively easy to digest on account of the absence of fat and the changed condition of the caseinogen, which exists in a finely flocculent form.

Artificially Soured Milk.—A milk which has been artificially soured by the addition of lactic acid ferments can now be found on the market, or can be prepared at home. It has been highly recommended by Metchnikoff. The product is prepared by pasteurizing pure fresh milk. The temperature is then lowered, cultures of lactic acid bacteria are added and the mass is held at 100° F. for several hours. It is then bottled and sold under a trade name.

CHEESE.

Historical.—Cheese has been known as a valuable food for at least one thousand years before the Christian era. It is believed to be one of the oldest products manufactured from milk and probably owes its origin to the accidental storing of milk curd.

In the early historic days of the Roman Empire, it formed an important article of diet and is still used as a chief source of protein by the Italians as well as many other European nations. It is largely manufactured at the present time in France, Italy, Germany, England, Switzerland and Holland. The Americans produce large quantities of cheese especially in New York and Wisconsin, but do not as a nation consume as much as the Europeans.

The industry in America was started in a small way, principally by immigrants who sought to earn a livelihood in the New World by the same occupation that they had carried on in their native land. This is particularly true of the cheese industry in Wisconsin, which owes its origin to the settlement of twenty-seven Swiss families during 1845, in the rough hilly country of Greene County. For a long period the wives and daughters of the home were the cheese makers, but like many other industries, it was gradually transferred to the manufacturer.

The product is prepared from milk by processes which eliminate water, and gather a large part of the solids together, in such a form that the nourishment is retained and capable of being preserved for varying periods of time. Many varieties are made at the present time. Cow's milk supplies most of the raw material, although the milk of the ewe and goat are used largely abroad for the manufacture of certain well known cheeses. As a rule, milk is used in its natural condition and the product is then known as whole-milk or full cream cheese. Cream cheese is made from milk and cream, while skim-milk cheeses are manufactured from milk from which part of the fat has been removed.

Whatever the kind of milk used, the general process of manufacture is the same. The raw material must be treated in such a way as to precipitate the caseinogen in the form of a curd. This may be accomplished in two ways; by the natural development of lactic acid and by the addition of rennet. The first variety known by some such name as pot cheese or cottage cheese is not a true cheese, as it has been prepared without the use of rennet, which is essential in cheese-making. This type cheese is prepared more frequently in the home, is soft in texture and has poor keeping quality. The second variety represents the many kinds of domestic and foreign cheese found in the market.

Composition of Cheese.—Generally speaking, the composition of cheese is about from one-third to one-quarter each of water, fat and protein, with a small amount of mineral matter. The protein is largely predigested having been changed to casein by the action of rennet. Only a small amount of unchanged caseinogen can be found while in many well cured varieties, through the action of micro-organisms, part of the casein has been further changed to meta-protein, peptone and amino-acids. The mineral matter consists of the salts of milk with a small addition of common salt to improve the flavor.

Cheese-making.—The large cheeses found in the American market are prepared by processes more or less copied from the English Cheddar Process. Cheddar cheese was first made in the village of Cheddar, England, about 250 years ago. It has gradually grown in popularity until the manufacture has now spread over the civilized world.

Process Used in Cheddar Cheese.

I.	Straining milk.	Lactic acid fermentation.
II.	Ripening—(82°-86° F.).	
III.	Mixing rennet.	
IV.	Clotting.	
V.	Cutting.	
VI.	Stirring.	
VII.	Cooking 98° F.	
VIII.	Removing part of whey.	
IX.	Cheddaring or matting.	
X.	Grinding.	
XI.	Salting.	
XII.	Pressing.	
XIII.	Curing.	

The preliminary treatment of milk is of the greatest importance. Successful cheese-making depends to a great extent on the purity of the raw material. Great losses are frequently caused by carelessness in the production and handling of the milk supply, for the quality of the milk in respect to its cleanliness, determines largely the quality of the product that can be manufactured from it. The same cleanliness should be observed as in the production of market milk, clean and healthy cows and milkers, sanitary conditions of stable, utensils and other apparatus. Special attention should be given that no odors can be absorbed from manure, pig pens or silos and that the cow has not eaten strong smelling food, such as onions, garlic and the like.

As quickly as possible after being drawn from the cow, milk should be strained and cooled. To assist the escape of volatile matter, it is sometimes aerated by being poured through the air from one container to another. Stirring also helps the escape of animal odors as well as prevents the cream from rising to the top. As lactic acid is desired, milk is allowed to ripen naturally or by the addition of a starter, at a temperature of 82°-86° F. Tests are made from time to time until the desired acidity has been developed. The milk is then run into shallow rectangular tanks, so arranged that they can be readily tilted, and containing pipes through which hot water can be circulated. A temperature of about 85° F. is maintained. While heating the milk is constantly stirred with paddles to prevent the cream from rising to the top. If any coloring matter is to be added it is put in at this time. When thoroughly mixed and of the desired temperature, the coagulative agent rennet, is added and the mass is again stirred for a few minutes and is then allowed to rest.

The active principle of rennet is found in the lining of the stomach of milk fed animals. As a rule it is obtained from calves although it has been taken from pigs and puppies. Through the action of rennet, the conjugated protein caseinogen is split into simple proteins, casein and pseudo nuclein, thus making cheese a predigested food. The activity of rennet is greatly assisted by keeping the mass at body temperature, and by the successful ripening of the milk in an earlier stage. The clot or curd as it is known to the manufacturer, forms in about ten to fifteen minutes, but is usually allowed to stand one-half hour before it is put through the process of cutting. It is then firm enough to break with a clean fracture, when gently pressed with the finger.

Until recent years, the curd was simply broken into irregular pieces with the hand or some instrument, in order to allow the escape of the whey. Experimentation has proved that there is less loss in the fat content, if the curd is cut into uniform pieces. The process is now carried on by curd knives which cuts the mass into small cubes. As the whey makes its escape, the cubes sink to the bottom of the vat and are kept from uniting by a gentle agitation of the entire mass.

In order to facilitate the further separation of the whey, the temperature is raised to 98°-100° F. This shrinks the curd until it is about one-half of its former size and causes the development of more lactic acid. When sufficient acid has developed, the whey is again removed and the curd is allowed to mat together, various changes taking place during the process. The curd is then ground, in order to reduce it to particles of convenient size for receiving the salt and pressing it into shape.

The salt is added principally to give flavor. It has, however, another influence, for salt having a great attraction for water, the curd is hardened. The mass is next put into a press for twenty-four hours to give it shape. After being taken from the press it is put into the curing room, where it undergoes fermentation for four or six weeks or longer. During this time the cheeses are turned at frequent intervals and are rubbed on the outside with whey butter, a fatty liquid which rises to the top of the quietly standing whey.

Curing.—As cheese is not eaten for its nutritive value alone, but more frequently for the strong appetizing taste, this part of the process is most important. It consists in subjecting the cheese to the action of micro-organisms, which in their desire for food, decompose material giving rise to characteristic flavors. During this series of fermentations which are not altogether understood, gases develop which cause holes to be formed in the cheese. The ripening process is carefully guarded as to temperature so it will not proceed too rapidly or too far, in which case putrefactive fermentation is apt to set in.

As much of the success of cheese-making depends on the curing, bacteria and molds are now being carefully studied in connection with this industry. Methods once established by which ripening can be controlled, will insure a uniform product, an extension of the manufacture of certain varieties of cheese, and a saving of much money to the industry.

For information in regard to the manufacture of well known cheeses, such as Roquefort, Edam, Camembert and Brei, see a standard book on dairy products as *Milk and Its Products* by Wing or *The Practice and Art of Cheese-making* by Van Slyke and Publow.

Uncured Cheeses.—Several varieties of soft uncured cheeses may be found on the market, of which Neufchatel and Philadelphia cream cheese are the best known. They are prepared by coagulating ripened milk with rennet, allowing the curd to develop a mild acidity, after which the surplus moisture is removed by drainage and pressure. The curd is then ground, salted, molded into shape and wrapped in thin paper and tinfoil.

Adulteration.—The only extensive form of adulteration practiced is the substitution of lard for the usual amount of fat. Lard and skim milk can be mixed together with coloring matter, put through a process first to emulsify the lard, after which regular processes of cheese-making can be carried out.

Although adulteration has not been practiced to any large extent, much misbranding of cheese has been discovered in the United States. Cheese manufactured in this country has been frequently found to bear a label conveying the impression that the article is of foreign make, also, that the cheese has been made of cream and milk, when only whole milk has been used.

CHAPTER XVIII.

PRESERVATION OF FOODS.

Methods used in preserving food material may be classified as follows:

Physical	Drying. Cooling. Sterilization and exclusion of air.
Chemical	Sugaring. Salting. Smoking. Use of fats and oils. " " spices.
Use of Preservatives	Borax and boracic acid. Sulphurous acid and salt. Benzoic " " " Salicylic " " " Formaldehyde.

The attempt to preserve food material has been practiced from the earliest ages, many centuries before the cause of decay was understood. This custom undoubtedly arose from the desire to hold provisions obtained in a successful chase or during an abundant harvest, for periods of famine, pestilence and inclement weather. Modern life is making this subject of vast importance, for the crowding of people into large cities necessarily means the carrying of food for long distances, and present habits of living demand the open market for twelve months in the year. To meet this problem, bacteriology has been called upon to make plain the habits of the micro-organisms, which live on food and are the cause of the decay.

DRYING.

Drying is the oldest and simplest method, the principle being exclusively the withdrawal of water. Mold can live on a very small amount of moisture for it is frequently seen growing on damp floors, walls, cloths, food and the like. Bacteria demand considerable water and will not grow unless well supplied. They need a medium that is practically liquid, for they are only able to absorb food in a fluid condition. Many types of bacteria will cease to grow when the amount of water falls to 30 per cent. and all stop developing when it is below 25 per cent.

Nature uses this method of preservation, for when the grain is ripening much of the moisture which was present in the green stage gradually disappears, leaving the mature grain shriveled and dry. If this were not so, putrefaction would soon take place. Much of our food material classed as non-perishable, such as cereals, starch, sugar, flour and meal is preserved in this way. That they are good food for micro-organisms can readily be seen by their rapid decomposition when water is added.

Drying seems to be very much better adapted to fruit and vegetables than it does to protein matter, although meat is frequently shredded and dried by exposure to sunlight, in many parts of the world and to some extent in the arid regions of this country. It should only be practiced in climates where there is little moisture in the atmosphere, or the meat will spoil before it becomes sufficiently dry, and in districts far removed from crowded habitation where bacterial life is not abundant. While dried meat has a fair amount of palatability and has maintained all of the nutritive properties, it is not as digestible and looks less attractive so will never be popular. Dried, smoked or chipped beef are common articles of commerce, but either smoking or the use of condiments has been added to the drying method. This method is also used with the addition of salt to produce a form of protein known as pemmican used extensively by Arctic explorers.

With fruit and vegetables drying is very effective. The simple method of exposing fruit to the sunlight was practiced universally until modern times. In California and such sections as are free from rain and excessive moisture, open-air drying is still extensively employed. The fruit is cleaned, cut, placed on wooden trays, sterilized with sulphur and placed in the sunlight for five or six days or until sufficiently dried. In other parts of the United States, indoor drying is now used, principally on account of the moisture present in the atmosphere.

Several methods are used at the present time:

I. Fruit is put in large drying chambers and currents of warm air are passed over it. The water is withdrawn until 25 to 30 per cent. only is left.

II. Evaporation by vacuum dryers is more rapid but the color is changed. This may be overcome by the use of chemical means such as the use of H_2SO_3, called sulphuring.

III. Hydraulic pressure has been found to be very effective, but is little used.

Many methods of drying are trade secrets.

These modern methods have greatly increased the number of dried products on the market. One can now find in commerce peas, beans, apricots, apples, plums, raisins, figs, berries of all kinds, compressed vegetables, soups with or without meat, and a vast number of similar products. Present methods are also far more sanitary. The old-fashioned habit of sun-drying often meant an exposure to flies and dirt of all kind. The flavor of dried fruit is to some extent altered, due to oxidation, but the nutritive value is the same as in fresh fruit.

COOLING.

The principle with this method of preservation is surrounding food with conditions unfavorable for bacterial development. The thermal death point of micro-organisms ranges between wider limits than any other form of life. Boiling does not kill all, neither does freezing. The best temperatures at which to hold food in cold storage, or to which it should be raised with sterilization, are now being carefully studied.

Advantages of Cold Storage.—I. No nourishment is taken from food.

II. No foreign matter is added.

III. No new taste is imparted so the flavor is not greatly changed.

IV. The digestibility is not diminished.

V. A large quantity of perishable goods can now be kept that were formally thrown away.

Disadvantages of Cold Storage.—I. The keeping quality is impaired especially when too low a temperature has been used. The physical condition is frequently altered so bacteria can more readily act upon it as with meat or fish. Such food should be consumed as quickly as possible when taken from refrigeration.

II. Fruit deteriorates rapidly after having been in cold storage. This is frequently caused by a large amount of moisture condensing on the surface of cold fruit when taken into a warm place, thus making the conditions most favorable for mold growth.

III. It has led unscrupulous dealers to hold back products for high prices.

In spite of these disadvantages, cold storage has been one of the best methods so far used for preserving foods. Beginning in 1860, its use has spread enormously and has made possible the uniform distribution of fresh foods, such as meat, poultry, eggs, milk, fruit, vegetables and the like throughout every part of the country. By an interchange of the surplus with foreign nations, it has vastly improved the world's food supply and has greatly remedied the enormous waste, in many sections of both hemispheres.

Manufacturers' methods of coolings are either employment of ice or the expansion of compressed gas, as used in the ammonia process. The housewife must as a rule depend upon an ice chest which is generally kept too warm. The temperature of an ordinary refrigerator registers from 50° to 60° F., whereas it should be kept below 50° F.

Precautions in Care of Chest.—I. Do not wrap ice in newspaper. It is only in melting that low temperature is maintained.

II. Keep ice chest well filled with ice.

III. Keep the chest as dry as possible as cold damp air harbors many low forms of plant and animal life.

IV. Charcoal should not be utilized for lining as it soon becomes clogged and makes a fine incubator for bacteria.

V. Wash frequently with warm water and a neutral soap.

STERILIZATION AND EXCLUSION OF AIR.

See Chapter XIX. The Canning Industry.

SUGARING.

Preserving by means of sugar is not used to as large an extent to-day as it was in former years. The great improvements achieved by canning manufacturers have made their products so popular that they have largely taken the place of the old-fashioned preserves.

The principle of the sugaring method is surrounding food with conditions unfavorable for growth of micro-organisms. Bacteria do not grow well in a pure sugar solution unless it is very weak. If the solution be strong, development is entirely prohibited. Yeasts will sometimes grow and cause fermentation to set in, but this cannot take place if the sugar is as high as 40-50 per cent. The old-fashioned housekeeper's recipe usually read—"A pound of sugar to a pound of fruit," thus the product was as a rule protected against fermentation. It was quite possible, however, for mold to grow, but the formation always occurred on the surface and could readily be removed.

The great disadvantage with this method is the altered taste. Sugar is added in such large quantities that the strength of its flavor conceals or destroys other flavors that are desired, as the pleasant acidity of many fruits. A second inconvenience is the large quantity of sugar that is required in order to preserve a small quantity of fruit, hence the use of it is very expensive. Preserved fruits are used to-day, only as a sweetmeat.

It has been found possible to preserve meat and fish by the use of sugar alone. Although this method has never been used with protein material in America, it is still customary in Portugal to preserve fish, as the salmon, by splitting, cleaning and sprinkling the interior with sugar. It is said that fish prepared in this way can be kept for a long time with a perfectly fresh flavor.

SALTING.

The keeping of food material with salt has been used from very early times. The discovery of its preservative action was probably accidental, due to the finding of animal carcasses embedded in the saline deserts of Asia. Ancient wine makers frequently used salt water with the object of keeping their product for a longer period, and Pliny speaks of flesh food being treated with salt and meat being preserved with brine. The custom of salting fish was also known to the Greeks and Romans, but it seemed to have been used more as an incentive to the consumption of wine than because of any wish to add to the keeping quality of the product.

The principle of its protective power lies largely in the withdrawal of moisture, for salt has a great attraction for water. Bacteria cannot develop in food impregnated with salt so it can be preserved indefinitely by this method.

A variety of foods can be salted as olives, nuts and pickles, but this process has been used to the greatest extent with meats and fish.

Different methods may be used:

I. Rubbing dry salt into meat.

II. Pickling or the use of a saturated salt solution.

III. Salting and the addition of smoking or drying.

Advantage.—I. Salt is harmless and is needed in the diet.

Disadvantages.—I. The flavor is greatly changed.

II. The physical nature of meat or fish is changed, fiber is toughened so the product is not as digestive.

III. Nourishment is lost as certain constituents of protein matter are soluble in a salt solution and are lost in the brine. A saturated salt solution also renders protein more or less insoluble, hence it is not all available as food.

On the whole, salting has not been found satisfactory. The destruction of taste and the reduced nutritive value are serious, and other methods of preservation have to a great extent taken its place.

SMOKING.

The art of smoking meat and fish to assist in its preservation has been practiced from remote ages. The custom probably originated from the habit of suspending such food material within the tent or primitive dwelling. Being close to an open wood fire, smoke arose saturating the hanging material and not only gave it an agreeable taste, but greatly assisted in the keeping quality. This simple practice is still largely followed in isolated sections. Small smoke-houses are frequently found in many parts of the country, where meat or fish can be laid across slats near the roof and smoke from a wood fire allowed to pass over it.

Fig. 61.—The Sausage Smoke House. (Courtesy of Armour & Co., Chicago, Ill.)

The preservative action is now known to be due to certain products present in the smoke, such as creosote, which contains a bactericidal substance known as guaiacol. Formaldehyde and acetic acid are also present in smoke, but as they are extremely volatile, they are of little use. Creosote being less volatile remains on the exterior of the meat and acts as a violent germicide, while being perfectly harmless to the human consumer of the product. Since many woods also yield turpentine on burning, it is necessary to select beech, hickory, oak or such woods as yield creosote and not organic compounds which would affect the flavor. Water plays an important part in the production of creosote so generally the wood is used in the green state (Fig. 61).

Smoking does not protect against all forms of micro-organisms. Mold can attack food preserved in this way, but it is usually only on the surface and can readily be removed with a cloth dampened with lard or sweet oil. Canvas-covered meats are less likely to be attacked by mold. As smoking does not reach the interior, only material free from contamination should be used.

It is quite customary to combine salting and sugaring with smoking as in sugar cured hams. If such products are of a high grade, they are immersed in a pickle compound of salt, salt-petre, sugar and spices for forty to sixty days, after which they are placed in a smoke-house for three days. This process is excellent but it is long and increases the cost, so a quicker, cheaper method is occasionally substituted. Brine is pumped into the ham and the product is then treated with smokine. This preservative contains minute particles of creosote in solution and may be applied by a brush or by dipping meat quickly into the solution and afterwards drying it. This method is not as effective as the use of the old-fashioned smoke-house and the cresote is more likely to penetrate.

USE OF FATS AND OILS.

Foods which do not contain a large amount of fat are very good put up in oil, sterilized and sealed to prevent the oil from becoming rancid. A coating of oil is also frequently used to preserve foods by the exclusion of air. This method has been used largely abroad where birds are dried and saturated with oil; goose-livers similarly treated are sold as "paté-de-foie-gras." These products are considered great delicacies. In Italy wine is often covered with oil to prevent bacterial action, and in Arctic regions many kinds of meat are frequently preserved in this way. Possibly the most common food on our market put up in oil is the sardine although tuna fish, salmon, mushrooms, truffles and artichokes are also important products.

The name sardine was originally given to a variety of fish found in the Mediterranean near the Island of Sardinia but the commercial usage now includes several varieties, the French sardine being the young of the pilchard, and the American, young herring.

During the process of manufacture the fish are carefully sorted into sizes, cleaned, placed in brine, washed in fresh water, dried in the open on trays, immersed in oil, boxed and sterilized. Olive and peanut oils are largely used abroad while cottonseed is frequently substituted, especially in America. As a rule the French sardine receives greater care in the manufacture and is supposed to improve with age caused by the blending of fish, oil and flavoring.

This method of preservation is also used in Germany in the manufacture of sausages. In the German market, two types of sausage can be found: those so rich in fat that they can be kept for some time; and those which are lean and must depend upon the preservative influence of the high content of spices. The casing in both types is more or less impervious to any material.

USE OF SPICES

Spices were originally added to food to change or modify the flavor, but it has been found that they exercise a powerful preservative effect. See Chapter XXII. Spices.

ALCOHOL.

Alcohol makes all protein matter insoluble thus killing all bacterial life. For this reason, it is used largely in preserving biological specimens. To a slight extent it is also used for foods. Fruit of all seasons can be put down in an alcohol solution and preserved indefinitely.

USE OF PRESERVATIVES.

It is well known that certain chemicals when added to food have a restraining influence upon bacteria, yeast and molds which are associated with its decomposition. Some simply prevent the further development, others act as strong bactericidal agents. In the early days of the canning industry, they were largely used but modern methods of sanitation and sterilization by heat have proved so much more reliable and less expensive, that manufacturers of legitimate products have now almost entirely abandoned their use, regardless of the Pure Food Law.

The harmful nature of these chemical compounds has been argued for and against for a long period. At the present time probably all agree that their use is absolutely unnecessary for goods that are to be consumed within a short period. There is still, however, much discussion as to their use in such products as chili-sauce, ketchup, apple butter and other foods classed as relishes. These products have been cooked thus making them more susceptible to bacterial action after being opened. As they are usually held for a length of time, too frequently under careless conditions, they are apt to become undesirable articles of food. For this reason, benzoate of soda or other preservative is frequently added in small amounts.

Arguments advanced in favor of their use are:

I. These antiseptics are harmless when used in small amounts. One part salicylic acid in 1,000 is not injurious and may be beneficial in warding off intestinal diseases.

II. They are found occurring naturally in many of our fruits such as currants, cranberries, raspberries and crab-apples.

III. These antiseptics are frequently developed during manufacturing processes especially where sterilization by high temperatures is necessary.

Arguments against their use:

I. They are not violent poisons, but are believed to be undesirable as they are antifermentatives so interfere with the digestive ferments.

II. They are irritants so are apt to injure the mucous membrane of the stomach and intestinal canal.

III. The blood has for its chief function oxidation. These chemical compounds interfere with the blood doing its work of oxidation.

IV. The amount is not always small.

Possibly the strongest reasons for prohibiting their use are that it may lead to carelessness in manufacturing processes and to the use of inferior material. Neither can they be regarded as "cure-alls" for they do not affect ptomaines which cause disease.

Artificial Sweetening.—Saccharine has been largely used for sweetening syrups, preserves, jams, jellies, canned goods and similar products. It is a glistening white powder resembling sugar, but with a much greater sweetening power, thus making it a cheaper agent to use. Saccharine is obtained by the oxidation of one of the coal tar products and has no food value. It is believed to be an irritant so its use has been forbidden.

Artificial Coloring.—The employment of artificial coloring in connection with food has been practiced for the past fifty years. The colors have included animal, vegetable and mineral dyes for a long period and recent years have added an innumerable number of coal tar dyes to the list. The animal and vegetable dyes have included cochineal, annatto, turmeric, logwood, saffron and carrot juice, which are generally supposed to be harmless. At present the only mineral dyes being used to any extent are copper sulphate in green vegetables and fruit, oxide of iron in coco, confectionery, condiments, sausages and the like and Prussian blue in sugar refining.

Copper sulphate is generally considered to have a deleterious effect on the consumer but it is not known to be cumulative as in the case of lead. Its use is prohibited in Germany, Austria and Hungary and is limited in many other European nations. The United States does not forbid its being added to food material but the amount must be stated.

The coal tar dyes are unlimited in variety and are used extensively in confectionery, jellies, jams, meat, dairy products, wines and non-alcoholic beverages. Usually the amount is very small rarely exceeding one part in one hundred thousand and for this reason, it is almost impossible to form an opinion in regard to whether or not it is injurious to health. While such coloring matter may not be detrimental to the consumer, the use is unfortunate for it enables the manufacturer to place inferior goods upon the market for high grade material. Articles of food are much preferable in their natural color, and it is unfortunate that the housewife so frequently prefers highly colored goods thus encouraging the use of artificial coloring matter.

CHAPTER XIX.

THE CANNING INDUSTRY.

Historical.—The process of food preservation by canning was invented in 1810 by Nicholas Appert of Paris. The underlying principle of this method, the destruction of all life by means of heat followed by the exclusion of air by hermetically sealing, was established by the experimental work of Spallanzani, in 1765. By placing various nutritive liquids in tubes, sealing, and boiling them for an hour, he discovered that the liquid remained unchanged, as long as the seal was unbroken.

During the warfares of Napoleon, much dissatisfaction occurred in regard to the food that his army was obliged to eat while on the march. An investigation followed which led to the offering of a prize of 12,000 francs to any man who could keep food indefinitely in its natural condition without adding the preservatives then in use, which included salt, sugar, vinegar and smoke. It was won by Appert, who, after long practical experience in confectioneries, kitchens, breweries and distilleries, had been working for many years along the line of food preservation, using the theory advanced by Spallanzani. Food material was placed in air tight containers after it had been subjected to such a degree of heat that the contents had been thoroughly sterilized. The apparatus used by Appert was necessarily very crude but his discoveries laid the foundation for one of the greatest industries of modern times.

About the same time, Peter Durand obtained a patent in England for preserving meat, fruit and vegetables in tin cans, and shortly after several other manufacturers introduced similar methods. The theory upon which these men worked was, that the oxygen contained in air was the destructive agency and its exclusion alone would preserve food which had been cooked. It was not until the time of Tyndall and Pasteur that the real cause of putrefaction was understood. The industry was established in the United States by Ezra Daggett, who after learning the trade abroad canned salmon, lobsters and oysters in New

York in 1819. Shortly afterward William Underwood started to pack tomatoes, and in 1837 Isaac Winslow began experimenting with the canning of corn in Portland, Maine. Spreading gradually throughout the east, this industry was finally introduced into the middle west about the time of the breaking out of the Civil War and within a year or two, we find its establishment in California. An enormous impetus was given to canning when it was discovered that canned goods were vastly superior to dried food in palatability, for army use. The growth of the industry since that time has been very rapid and at the present time, canneries are scattered throughout the United States. Along the Atlantic Coast, large quantities of vegetables, meat and fish are preserved. Oregon and Washington supply much of the salmon, Chicago packs largely meat, while California furnishes fruit and vegetables of the highest grade.

The rapid growth soon led to new and better methods of making cans, great improvements in machinery, skilled workers and much experimentation in regard to the best methods of sterilization. In the latter work manufacturers have been greatly assisted by scientific investigation.

While the United States puts out enormous quantities of certain products, such as corn, tomatoes and salmon, European countries have a considerably larger variety of articles. Numerous combinations of mixed vegetables, meat and vegetables and meat delicacies are placed on the market, one country alone having canneries whose output includes several hundred different items. The future possibilities of this industry, both at home and abroad, are very great if by rigid inspection, only canned foods consisting of good wholesome material, packed with proper care under sanitary conditions are placed upon the market.

Process.—As before stated, the two principal points to be borne in mind in the preservation of foods by canning are:—1st, the destruction of all micro-organisms and their spores by means of heat; 2nd, the exclusion of air by hermetically sealing. As a rule, the can and food are sterilized at the same time but the details of the process necessarily vary with different products and in various canneries. Fruit and vegetables should be selected when at their best, transported as quickly as possible to the factory and immediately sorted for quality. They are then washed, treated according to the product and placed at once in cans. Care is given that the cans are filled full, then closely covered with the exception of a small hole for exit of steam. They are then subjected to the temperature of boiling water or higher according to the material. The hole is immediately closed with solder, the

Fig. 62.—Stock Boilers. (Courtesy of the Franco-American Food Co.)

cans reheated and allowed to cool. Some factories accomplish the same result by means of a steam heated "exhaust box," which withdraws part of the air in the filled cans, before they are sent to the capping department. With either method a partial vacuum is formed within the can which causes the end to be depressed. Should the process of sterilization be imperfect and bacteria or their spores be left within the can, fermentation soon starts in and the formation of gas causes the top to bulge. Canned goods are usually kept for one month and are then tested by striking with the finger. Expert examiners are able to tell by the sound if a partial vacuum still remains.

With the best manufacturers all cans which show the presence of gas are thrown away. In some factories, however, they are resterilized. This practice is dangerous, as injurious products may have developed which are not affected by reheating (Figs. 62 and 63).

Success of Canning.—There has been a great difference with various foods in regard to successful canning. Fruits are more

Fig. 63.—Sterilizing Process. (Courtesy of the Franco-American Food Co.)

subject to yeast and molds which are killed at a comparatively low temperature, so have given little trouble. Tomatoes, corn and peas, however, have been successfully canned only after much experimentation. Even after careful treatment and sealing, these products have frequently undergone the putrefactive changes that it was the purpose of canning to prevent. Through scientific investigation, the discovery was made that these vegetables are invaded with bacteria, the spores of which will resist heat for a length of time. If when the can is sealed a single spore remains alive, it is capable of completely ruining the product in the course of time. For a long period it was thought impossible to can green corn, for that vegetable had given the manufacturer more trouble than any other product. With the aid of the bacteriologist, the problem has been completely solved. Corn is not only invaded by extremely resistant spore bearing bacteria, but the kernels are not easily penetrated by heat. Those which lie next to the can are easily sterilized but the interior layers do not heat readily. For this reason a thermometer is usually put in the center of a test-can and the temperature is carefully registered. It has been found necessary to use 250° F. for 65 minutes in order to kill all spores present.

Regardless of the product, the success of canning depends on the sanitary conditions which prevail throughout the factory, the quality of the material and the rapidity with which it is handled.

Meat Products.—In the canning of meat, the fore-quarter as a rule is used, the hind-quarter selling better as fresh meat. Although this may mean a poorer grade meat, it does not necessarily indicate that it is any less healthy. Before sterilization, meat is usually cut into uniform pieces, as different sizes would mean disintegration of the smaller pieces, before the larger ones are cooked, thus giving a bad appearance to the finished product. The meat is then par-boiled for 8-20 minutes to secure shrinkage before being put in cans. The further processes of sterilization and exclusion of air are quite similar to those used in other canning industries.

A large variety of potted and deviled meat can also be found on the market. As the process of manufacture is usually a trade secret their exact composition is difficult to determine, but they are largely composed of beef or pork, mixed with spices and flavoring, the larger amount of condiments being used with the deviled varieties.

Containers.—Manufacturers use either glass or tin in preserving. The preference usually is in favor of glass but it is a question whether this is warranted, except in certain products which cannot be preserved to the best advantage in tin.

Advantages of Glass.—I. Food material such as fruit or vegetables look very attractive.

II. It contains no lead or other dangerous material.

III. In the household it is much easier to handle.

Disadvantages of Glass.—I. The jars to be strong must be made of thick glass which is likely to break with a sudden change of temperature. They also break easily if struck with a blow.

II. They cannot be handled with automatic machinery.

III. Transportation is difficult on account of the weight and liability to break. They occupy too much space.

IV. It is frequently necessary to cover the glass with paper as light has a bleaching effect on some products.

Caution.—When glass jars are used in the home they must be made air tight. This is a difficult thing to do especially where rubber bands are used. Old rubber bands have lost their elasticity so are not safe to use. It pays to buy new ones. As sulphur has been used to impart elasticity and to keep the rubber from sticking, the new bands should be moistened before using.

Advantages of Tin Containers.—I. They are light to handle and occupy less space in storing and during transportation.

II. They are less likely to break.

III. Products are protected from light.

IV. They are much easier to make air-tight.

V. Tin cans cannot be refilled.

VI. If a good quality of tin has been used and the can carefully made, there is no danger of poisoning.

Disadvantages of Tin Containers.—I. Tin cans are not practical for use in the household.

II. They are dangerous if a poor grade of tin has been used or the process of manufacture has not been thoroughly carried out.

III. With such products as raspberries, cherries, plums and beets, they are not desirable as the tin coating is attacked resulting in a loss of color, flavor and quality. Salts of tin are also formed which are objectionable. For the protection of such products a recent improvement has been made by coating or lacquering the inside of the can. While such coatings are not perfect, they are a step in advance and further improvement will undoubtedly be made in the near future.

According to work done by the United States Department of Agriculture,* such products as corn, peas, beans and tomatoes have little action on tin so a coating is unnecessary.

Fig. 64.—Can Closing Machines. (Courtesy of the Franco-American Food Co.)

On the whole there is practically little risk now in the use of tin, as the manufacture of cans has greatly improved. They are made of sheet iron which has been cleaned and rolled out to the proper thickness, dipped into acid to remove oxide, put quickly into water then dried, after which the sheet is dipped quickly into melted tin. Before being made into cans by machinery they are carefully examined. If the oxide has not been removed the

* The Canning of Foods. Bulletin No. 151. Bureau of Chemistry.

tin will not stick, thus leaving the iron exposed to the action of organic acids occurring in fruits and vegetables. All imperfectly made sheets are rejected. The modern can is made with lock seams and outside soldering (Fig. 64). As the sealing in many cases is done by double seaming on the top, no solder is used except on the side seam. This overcomes possible contamination by solder in contact with food material.

To insure the safe usage of products packed in tin, it is absolutely necessary that the contents be removed after the can has been opened, to prevent oxidation.

Adulteration.—Since modern methods of sterilization have been employed, the use of preservatives has been practically abandoned in the canning industry, as they simply add to the cost. Saccharine, bleaches and coloring matter now constitute the chief adulterants. Saccharine is frequently added to corn, tomatoes and peas to disguise the fact that sweet varieties of the garden vegetable have not been used. A bleaching agent is frequently employed to whiten corn, and peas are given a bright green shade by the addition of copper salts. During canning and on standing peas are apt to lose part of the chlorophyl through oxidation processes, which give them a yellowish appearance. Copper salts will unite with the nitrogenous constituents of the peas to form a compound with a brilliant green, thus restoring the original color, although the shade lacks the delicacy of the natural green. The coloring of peas is largely practiced in France, but as a rule is not used by American canners. Very little adulteration has been found in tomatoes except the addition of coloring matter such as cochineal or coal tar dye. The artificial coloring has been used to make inferior material appear as mature and high grade tomatoes.

The adulteration of canned meat is probably more often practised than with vegetables, but it has been found by no means common, by the Bureau of Chemistry. It consists largely in the substitution of cheaper meats and fat and the addition of starch to increase bulk and weight. Coloring matter and preservatives as borax, boracic acid are still occasionally found.

CHAPTER XX.

TEA, COFFEE AND COCO.

TEA.

Historical.—According to the writings of an ancient Chinese author, the virtues of tea were known in the Orient some 2,700 years before the Christian era. Many legends exist as to its original home, some claiming that it was first grown in China, while others speak of its introduction into that kingdom from one of the neighboring provinces of India.

For a long period it seems to have been used as a medicine rather than as a beverage. Gradually growing in popularity, however, it eventually became a national drink and the cultivation of the tea plant for this purpose grew to be an important industry in China, Japan, India and Ceylon.

It was not until the later part of the 16th century that the Dutch East India Co., in their journeys to the Orient, carried back to Holland some of the curiosities of the Eastern World, one of them being Chinese tea. Knowledge of it finally went to England and in 1657, we hear of the first tea-house being opened in Exchange Alley, London. For many years the price per pound was so high that tea was looked upon as a rare luxury, but by the latter part of the 17th century it was being imported from China in such large amounts, that it ceased to be a rarity. As the price lowered the annual consumption grew until at the present time Great Britain uses considerably more than one-half of the world's total production. Tea was introduced into the colonies as early as 1680, the price at that time being five or six dollars per pound, for the cheapest varieties.

Cultivation of the Tea Plant.—The tea plant is a hardy evergreen shrub, which grows to a height of from twelve to fifteen feet in the wild state, but under cultivation it is usually dwarfed in order to stimulate the greatest possible growth of the young shoots. These yield the tender new leaves so desirable in teamaking. It will grow in a variety of climates, but the sub-tropical appears to be the best, especially in sections where the rainfall approximates fifty inches annually. The plant is usually

Fig. 65.—The Tea Plant. (Courtesy of McCormick & Co., Baltimore, Md.)

placed on a southern exposure, so the sunshine will protect it from cold, and in soil which has a certain water-retaining property. In China most of the tea gardens are small, each farmer producing enough for the consumption of his own family, while the surplus is sent to the market. Following this idea, the United States Department of Agriculture has strongly recommended the growing of tea on the farms of the South Atlantic and Gulf States. With very little trouble and expense, the southern farmer could at least raise enough tea for his own use, while the plant itself makes a hedge well worth cultivating for purely ornamental purposes. Farmers Bulletin, No. 301, "Home Grown Tea" gives many ideas as to the successful cultivation and manufacture of tea in the United States.

In modern methods of cultivation, the plants are raised from seeds in nurseries and are set out in their permanent home in the open when about twelve inches high. According to climate, soil, etc., the first crop is borne in three or four years, and from that time, the shrub may be picked at regular intervals. It is customary to occasionally allow the plant to rest, thus insuring a longer life.

General Classification.—The differences in the tea appearing on the market do not depend upon the variety of shrub, but rather on the size of the leaf and the way in which it is treated during manufacturing processes. According to the method of curing it is designated as:—

I. Black tea, which has a dark. dull appearance.

II. Green tea, which has a rather brilliant tinge due to the retention of part of the chlorophyl.

For a long period, China so jealously guarded her tea gardens, that her green and black teas were supposed by foreign nations, to be produced from different species of shrub. That this idea was false was finally proved by Robert Fortune, who travelled in China on behalf of the Horticultural Society.

Tea is also classified according to the size of the leaf (Fig. 66).

I. Pekoe, which consists of the three young shoots at the tip and are known as flowery pekoe, orange pekoe and pekoe according to their size. As these leaves contain the least fiber and the most juice, they produce the finest grade of tea.

II. Souchong is prepared from the leaves immediately below the pekoe variety and makes a tea of popular price. Classes I and II are sometimes mixed when the product is known as pekoe-souchong.

III. Congou is a cheaper variety prepared from the more fully developed leaves below the souchong size. In the American market this term is sometimes used as a general name for China Black Teas.

Young Shoot of Tea Plant
(after Money)

a, Flowery PeKoe b, Orange PeKoe
c, PeKoe d, Suchong (first)
e, Suchong (second) f, Congou
H, Bohea

a and b (mixed) PeKoe; a, b, c, d, e
PeKoe - Souchong.

Fig 66.

IV. Bohea is a name frequently applied to any larger leaf used for tea-making than the congou variety. This tea is no longer found in our market.

Processes of Manufacture.—

Black Tea	Green Tea
Leaves picked.	Leaves picked.
Withered in the sun.	Withered in pans.
Rolled until soft.	Rolled until soft.
Fermented.	Withered again.
Fired.	Sweated in bags.
Sorted.	Slowly roasted.

Picking.—The tea leaves are plucked entirely by hand, the operation generally being carried on by women and children. In

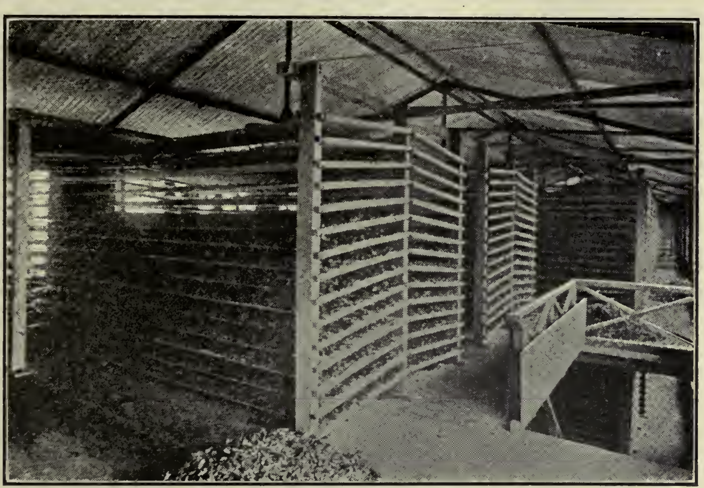


Fig. 67.—Withering Tea Leaves. (Courtesy of The Spice Mill Publishing Co.)

China and Japan there are several harvests. The first picking commences about the middle of April and gives delicate pale green leaves, which usually command a high price. About two weeks later, the bush is again ready to be plucked and again a third and fourth picking follow, each harvest yielding leaves a little lower in quality. In Ceylon where there is practically no winter, picking takes place about every ten or twelve days the year round.

Withering.—Whether small or large, the leaves are of the same general structure. All consist of a certain amount of fibrous material which must be softened by rolling. In order to make this operation easier, the leaves are first withered, either indoors or by exposure to the sun, until part of the moisture has evaporated (Fig. 67). In good weather this operation takes about eighteen to twenty-four hours but when cloudy or rainy, artificial heat must be used. Withering not only softens the leaves, but assists in the production of the greatest amount of enzyme which is needed in the later operation of fermentation.

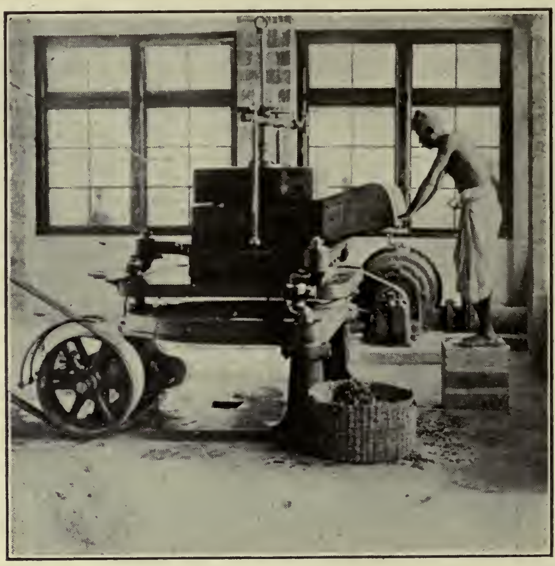


Fig. 68.—Rolling Tea Leaves. (Courtesy of *The Tea and Coffee Trade Journal.*)

Rolling.—In China, rolling is still done very largely by hand (Fig. 68). The worker gathers a quantity of leaves in his hands and rolls and kneads the mass with a very similar motion to that used in the kneading of dough. In India the withered leaves are rolled almost entirely by machinery. This operation bruises the leaves, takes out excess moisture, and gives the characteristic twist to the leaf.

Fermentation.—Fermentation is the most important part of the preparation of black tea, for its influence on the quality and character of the tea is very great. The rolled leaves are piled in heaps on mats or frames and allowed to ferment until it turns a bright copper tint. During this period, the tea leaves are subjected to the influence of enzyme action and important chemical changes take place. The green color of the leaves and the disagreeable odor disappear, and a fine flavor due to the development of essential oils is acquired in proportion to the amount of enzyme in the leaf. According to the investigations of Dr. H. H. Mann "The tannin is oxidized during fermentation and combines with other substances in the leaf-forming compounds, some of which are insoluble in water; there is, therefore, a decrease in soluble tannin." Experienced judgment is necessary to determine how far fermentation should proceed; too little means rawness and if carried too far, much of the delicate flavor is lost.

Firing.—Fermentation is checked by the application of heat. The leaves are sometimes exposed to the sun then fired or they may be immediately fired, care being taken that the temperature is sufficiently high to remove moisture, but not high enough to drive off the volatile oils which have been developed during curing.

Sorting.—After cooling, tea is sorted into grades by sifting, is packed into lead-lined chests and is ready for transportation.

Green Tea.—The preparation of green tea differs from that of black tea in several important operations.

I. The method of drying is different. While black tea is withered in the sun, the leaves for green tea in Japan are steamed until they lose their elasticity and in China are heated in pans over charcoal fires. In a few minutes the leaves become soft and pliable and are ready to be rolled.

II. After rolling, the leaves are again subjected to the action of a slow, steady fire, the process of fermentation being omitted. The chlorophyl is, therefore, more or less retained and tannins are not oxidized to insoluble forms. This means that a larger amount of tannic acid is found in green tea when used as a beverage. The difference in flavor is entirely due to fermentation.

Adulteration.—In former years when tea was expensive and investigation slack, there was much fraud practiced, especially in the Chinese varieties. The adulteration consisted chiefly in the addition of foreign leaves and in facing. The leaves of the ash, beech, willow, rose and buckthorn were frequently mixed with those of the tea plant. Such substitution can readily be detected with the microscope as tea leaves have a characteristic appearance. Facing consisted in treating the leaves with various coloring matter, such as Prussian blue, indigo or plumbago. By such means leaves which were inferior or had been damaged in manufacturing processes or during a sea voyage, could be improved in color and general appearance. As black tea does not need as much care in preparation for the market, attempts were also made to face such tea and sell it for green tea.

Since laws have been passed prohibiting the importation of faced tea, there is practically no adulteration to be found in the tea sold in the United States. Tea growers are more carefully watched, government inspection is more rigid and competition is much greater than in the past. For a long period the Chinese were the chief exporters to this country, but the rapid growth in the popularity of the India and Ceylon teas has forced China to send better grades to hold her place in the American market.

Tea as a Beverage.—The main constituents of tea to be considered in the preparation of the beverage are caffein and tannic acid. Caffein is the ingredient which gives the stimulating property. It belongs to a class of substances known as alkaloids.

Caffein is not present in the leaf but is probably developed during fermentation. Just below the boiling point of water, it is remarkably soluble. Tannic acid is not particularly soluble at the boiling point, but will become so on prolonged boiling. These two facts must be taken into account when preparing the beverage. Caffein is a mild stimulant and is desired while tannic acid so far as possible should be avoided.

General Rules for Tea-Making.—Heat freshly drawn water to the boiling point. Pour it on the requisite amount of tea, which has been placed in a previously scalded pot, made of a non-conducting material. Allow to stand in contact with the leaves from three to five minutes. The spent leaves should not be used again. Practically all the stimulating ingredient has been removed and that which is left is deleterious to health.

Tea should never be boiled; the delicate aroma is lost as the essential oils volatilize. Boiling also makes soluble the tannin, too much of which is undesirable.

Composition of the Beverage.—Beside caffein, tannic acid and volatile oil, tea contains minute amounts of nitrogenous matter, fat, dextrin, fiber and mineral matter.

COFFEE.

Historical.—The early history of the cultivation of the coffee bean is lost in antiquity, but it is to Arabia that the civilized world is indebted for the knowledge of its use as a beverage. Tradition gives various tales of its introduction into Arabia, one of which places its original home in Abyssinia, province of Caffa, from which it is supposed to have received its name. The Ethiopians were known to have used coffee in very early ages, but with that nation it appears to have served as a food rather than a beverage. Wherever its origin may have been, Europeans discovered its use in Arabia during the 15th century. Undoubtedly the knowledge of it spread very largely through the Arabian merchantmen, who added the coffee bean to other oriental luxuries, and to the Mohammedan pilgrims who flocked annually to Mecca. Learning to drink coffee while in the "Sacred City," these pilgrims carried back with them, saddle-bags of the coffee bean to all parts of the globe professing the faith of Islam.

It reached Constantinople in the 16th century and spread from there to the countries bordering on the Mediterranean, finally being introduced into London, Paris and other European cities during the 17th century.

Originally all of the coffee used in Europe was grown in Arabia. As much of it passed through the port of Mocha, it was known under the name of Mocha coffee. Later coffee was grown

18

in the European colonies, in the French West Indies and on the island of Java. Its cultivation soon spread to Sumatra, the Malay Archipelago, Ceylon, the Philippine and Hawaiian Islands and in the Western World to Cuba, Porto Rico, Mexico, and parts of Central and South America. About 1740 it was planted in Brazil where it gradually grew to be so important an industry, that at the present time Brazilian plantations produce three-quarters of the total supply and that government controls the coffee market of the world.

The Coffee Plant.—The coffee plant is a very beautiful shrub attaining a native growth of some 18-20 feet, but under cultivation, it is rarely allowed to exceed 4-6 feet in height. This dwarfing the plant, increases the crop and facilitates picking. The leaves are a fresh green color expanding outward and downward, giving a very pleasing appearance. The flowers occurring in clusters are white in color and have an odor strongly resembling jasmine. The flowers and fruit which are frequently called "the cherries" are found on the tree at the same time and in all seasons, in various stages of development. It is from these cherries which turn a dark crimson color on ripening, that the coffee bean is obtained. The outer part of the cherry is fleshy similar to other fruit, while within are two seeds, laid face to face, covered by a very delicate membrane known as the "silver skin" and an outer straw colored husk called "the parchment" (Fig. 69). The main processes of manufacture consist in freeing the fruit from the pulpy matter and removing the two inner skins which surround the seeds These seeds are in reality the unroasted coffee bean of commerce.

Fig. 69.—Coffee Bean.

Cultivation.—The coffee shrubs thrive best in rich, well-irrigated soil and in tropical climate where the rainfall exceeds 75 inches per annum. They are propagated from seeds, which are planted directly in the fields or grown in wicker baskets in nurseries until 18 inches high, when they are transferred to their permanent homes in the open. An absence of frost is essential to the growth of the plant and protection from wind and sun is commonly given by planting shade trees between the young coffee shrubs. The first crop of any importance is born when the plant is from 4 to 5 years old, and with care, harvesting may be continued at regular seasons for 20 years or more. The fruit is ready to be picked when it is dark red in color strongly resembling a ripe, red cherry.

Processes of Manufacture.—*Harvesting.*—In Arabia, the fruit is allowed to remain on the tree until it falls off of its own accord, but on Brazilian plantations, which are by far the largest in the world, the cherries are usually picked by hand. They are allowed to fall directly on the ground or on sheets from which they are later raked together, and a first rough sorting is given before they are packed in bags to be removed to where further treatment is given. There a more careful sorting, sifting and winnowing take place, and the berries are at once treated with the dry or wet method for removal of the pulp.

Dry Method.—The berries are spread out on drying grounds where they are left exposed to the sun for two or three weeks, during which time fermentation takes place and the pulpy mass gradually dries. It can then be removed by pounding in a mortar or by passing through a hulling machine. This method is still used in Arabia and to some extent on modern plantations of Brazil, many planters claiming that it has advantages over the modern wet process.

Wet Method.—Where the wet process is used inclined canals are frequently built, where the cherries can be dumped and carried by gravity to the pulping machine. While floating down, imperfect and unripe berries rise to the top and can readily be removed, after which the well developed berries are washed with fresh water (Fig. 70).

Pulping.—The pulping machines are of various types, but as a rule they consist of a revolving cylinder with a rough surface which faces a curved metal plate. The berry is crushed between the two surfaces in such a manner that the pulp only is separated. The interior consisting of the coffee beans with the two coverings must not be injured. A separation is made by sifting and all imperfectly pulped must be reprocessed.

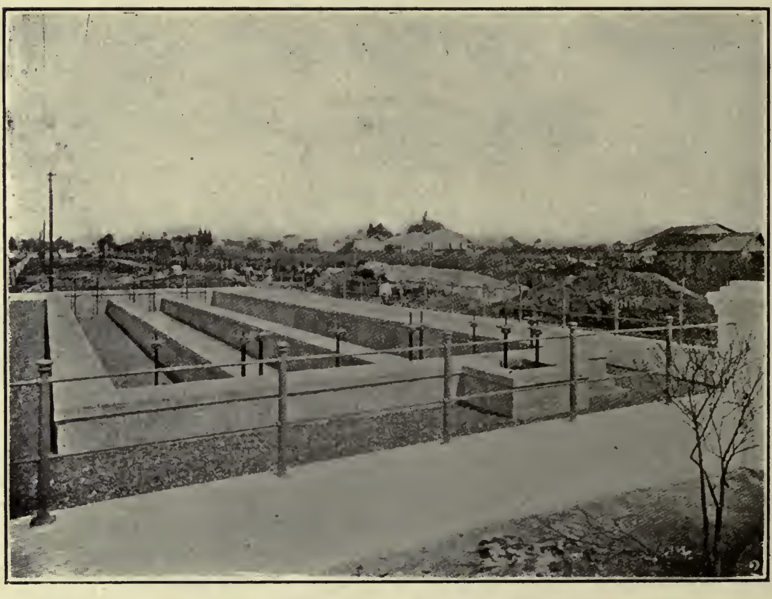


Fig. 70.—Views of Coffee Cultivation and Industry of Brazil. Washing Tanks. (Courtesy of The Spice Mill Publishing Co.)

Fermentation.—The beans are next allowed to ferment for twenty-four to seventy-two hours in order to soften and loosen any adherent pulp. The essential part of this process is enzyme action on the adhesive substance, but as to its effect on the flavor of the coffee, no full investigation has as yet been made.

Washing and Drying.—Successive rinsings with water finally leave the parchment covering quite free from adherent pulp. It is now known as "parchment coffee" and must be subjected to a drying process in order to remove the two inner coats by friction. Coffee is dried in most places out-of-doors, on the ground, during which time it is carefully watched. Too slow or too rapid drying greatly injures the flavor of the coffee.

Peeling.—The two coverings can now be readily loosened by an ingenious machine which cracks the parchment and inner skin without injuring the beans. The hulls and dust are separated out by winnowing, leaving the coffee beans clean and ready for sorting.

Sorting and Packing.—In order to secure uniformity, the beans are separated into six to eight grades. They are sorted first, according to size, by sifting through various mesh sieves; second, according to weight by being subjected to strong currents of air blowing upward. The coffee is then bagged ready for removal to the shipping port, at which place it is frequently blended and repacked before shipment.

As coffee deteriorates after roasting, that process is usually carried on in the country where it is to be consumed. On arrival at the coffee-house, the raw bean is subjected to a thorough cleansing process to remove all foreign matter.

Roasting.—The cleaned beans are run into a revolving oven and are subjected to a temperature of 200° C. In the production of a good coffee this is one of the most important steps. Count Rumford in an essay published in 1812 says—"Great care must be taken in roasting coffee, not to roast it too much; as soon as it has acquired a deep cinnamon color, it should be taken from the fire and cooled; otherwise much of its aromatic flavor will be dissipated and its taste will become disagreeably bitter. The progress of the operation and the moment most proper to put an end to it, may be judged and determined with great certainty; not only by the changes which take place in the color of the grain, but also by the peculiar fragrance which will first begin to be diffused by it when it is nearly roasted enough. This fragrance is certainly owing to the escape of a volatile, aromatic substance which did not originally exist as such in the grain, but which is formed in the process of roasting it."

When a light cinnamon brown is desired, coffee is allowed to remain in the oven for thirty minutes and from thirty-five to forty minutes, if a heavy chocolate color is wanted. It is then quickly cooled by blasts of cold air and is ready to be bagged or boxed for the market (Fig. 71).

The effect of roasting is both physical and chemical. The physical state of the bean is changed to a brittle form, in which

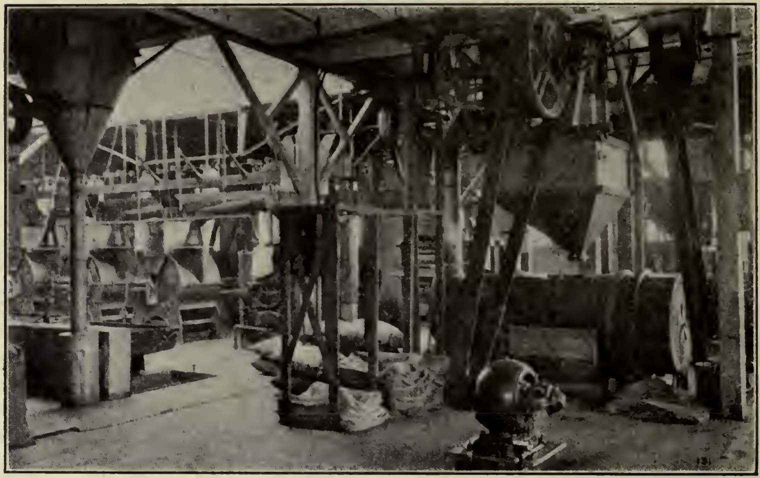


Fig. 71.—General View of Coffee Roasting Room. (Courtesy of The Spice Mill Publishing Co.)

it can more easily be ground or pulverized. Two very important chemical changes also take place; first, the formation of caramel which greatly improves the taste—this flavor can readily be imitated in the production of coffee substitutes; second, the production of an oil known as caffeol to which the aroma of roasted coffee is due. As this oil is volatile, coffee should be consumed as quickly as posible after roasting and should never be pulverized until at the time of the preparation of the beverage.

Adulteraton.—Adulteration of coffee has consisted in the addition of foreign matter, the substitution of cheaper substances, and in facing. As with tea facing, the addition of coloring matter has been used largely to conceal poor or damaged coffee or to make inferior varieties appear as high grade material. In former years an imitation bean was manufactured and occasionally mixed with coffee, but the price of coffee is too low at present to make such substitution profitable. The addition of foreign substances was much more practiced with ground coffee than that sold in the bean form, since they could be less readily detected. Cereals of various kinds, peas, beans, acorns and the like have from time to time been added, but the chief adulterant has been found to be chicory which is the kiln dried root of the wild endive.

In recent years misbranding has been found more frequently than adulteration. The early coffee market drew its supply almost entirely from Arabia and from the islands of Java and Sumatra. These coffees were known on the market as Mocha and Java. As the coffee industry spread, there was a strong tendency to label the product from new coffee fields as Mocha and Java, since those two names had taken a firm hold in the minds of the housewife. The passing of the Food and Drug Act of June 30, 1906, has made this, also, a misdemeanor. Although undoubtedly much coffee is still on the market not properly labeled, there is a strong tendency now on the part of the manufacturers, as well as the government, to have coffee imported under its own name.

Coffee as a Beverage.—One of the most important constituents of coffee and the ingredient to which it owes its stimulating effect, is the alkaloid caffein. It is the same substance as is found in tea but occurs in a rather smaller proportion, approximately 1 to 2 per cent. being found in the unroasted bean. Tannic acid is also found with a larger amount of other substances as fat, gum, fiber, sucrose, dextrin, reducing sugar and mineral matter. As coffee contains volatile oils, every effort should be made to retain them, in the preparation of the beverage, or much of the aroma and flavor will be lost.

Coffee Extracts.—In recent years, products have been found on the market called coffee extracts. They consist essentially of a coffee solution from which the water has been evaporated in vacuo and the resulting mass, dried and ground. When added to boiling water, they are supposed to have the original consistency of coffee solution.

COCO.

Historical.—Coco was not known to the European nations until after the discovery of the Western World. On his return from the third voyage to America, Columbus was supposed to have carried back with him to Spain, the coco bean, as a curiosity from the newly discovered land. It was introduced into Europe in 1528 by Cortez after his conquest of. Mexico. The explorer found the natives of the new land using the roasted bean, ground and mixed with maize meal, moistened with the sweet juice of the maize stalk and flavored with vanilla and various spices. It was known to them as chocolatl and was considered to be highly nutritious as well as a beverage of great delicacy. Evidently it was also held in high esteem by the Europeans for the tree from which the fruit is obtained, was known to them as "Theobroma,—food for the Gods." Although so highly prized, its use spread very gradually in Europe and it is not until recent years, that it has grown considerably in popularity. Possibly this is due to the fact that tea is used so extensively in the British Isles and coffee in the continental countries. Coco was first introduced into the States by the fishermen of Gloucester, and its use has increased to so great an extent that one-fifth of the world's crop is now consumed in the United States.

Cultivation.—Coco is the fruit of a tropical tree commonly known as the coco tree although it belongs botanically to the species cacao, the most commonly used being the variety theobroma cacao. Thriving only in tropical climate, 20° both north and south of the equator, its cultivation is very limited. Only those localities of America and Africa with their neighboring islands, that have well-watered, well-drained soils and plenty of rainfall, can be utilized for the growing of the tree. The Western World produces by far the largest part of the world's crop, Ecuador and Brazil being the largest exporting countries. Mexico still produces the greatest amount of coco, but uses most of it for her own consumption.

The coco tree is grown from seeds either planted directly in the fields or in nurseries. It attains an average height of about 20-30 feet and bears small, red, wax-like flowers which appear either singly or in clusters, along the trunk and main branches of

Fig. 72.—Pods and Leaves.
(Copyrighted by Walter Baker & Co, and used with their permission.)

the tree. The fruit is a pod some 8-10 inches long, 3-4 inches thick (Fig. 72). It is when ripe, either lemon color or chocolate brown, according to the variety, and has a thick tough rind enclosing a mass of cellular tissue. Embedded in the pulpy matrix are some forty or more coco beans which are covered with a thin shell greatly resembling an almond (Fig. 73). The beans are arranged in five longitudinal rows. The tree begins to bear fruit when four or five years old and continues to the age of forty. While blossoms and fruit are to be found on the tree, at the same time and in all seasons, there are two main crops gathered yearly, generally in June and December, although this varies in different localities.

Processes of Manufacture.—*Picking.*—The pods are picked, when fully ripe, either by hand or with a knife fastened to a long, bamboo pole. Great care is necessary, that the buds and blossoms which lie next the fruit are not injured.

Decomposition of Pod.—As the rind of the pods when picked, is exceedingly woody and tough and would be difficult to cut, they are laid on the ground in heaps and allowed to decompose for twenty-four hours, or until the rind has become leathery. They are then sorted according to the degree of ripeness and

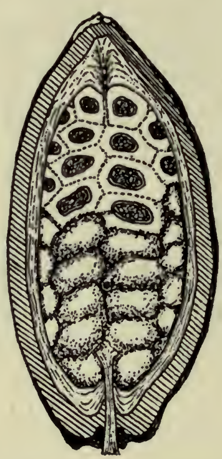


Fig. 73.—Section Coco Fruit

are cut open with a sharp cutlass. The pulp and coco beans, still within their shell, can readily be removed.

Fermentation.—As a considerable amount of the soft pulp still clings to the beans, it is necessary in order to free them, to allow fermentation to take place. This process is carried out by heaping the beans on the floor where they are allowed to sweat, by burying them, or by the use of enclosed sweating boxes where they remain for several days. The seeds are frequently turned to insure regular sweating, great care being also given to keep the temperature from rising too high. Both alcoholic and acetic fermentation take place and several important changes occur. The germinating power of the seed is arrested; the adherent pulp is loosened; color develops and an exceedingly bitter taste is modified so the flavor is greatly improved; the beans are less liable to be attacked by mold and are in the best form for drying.

Washing and Drying.—When fermentation is complete the beans are sometimes washed before drying. Washing is carried out by placing them in sieves or troughs, where they are thoroughly scrubbed and rinsed, to remove all organic matter that may be clinging to them. Whether they are washed or not, the coco bean must pass through a drying process. This is accomplished by the heat of the sun, whenever possible, or in drying houses which are heated by artificial means. In out-of-door drying some ten days or more are required, indoor drying is complete in less time. In some countries coloring matter is used and the practice of polishing the bean after drying is frequently performed. The coco is now ready to be bagged and shipped to the markets of the world.

When received by the manufacturer coco is cleaned, sorted and roasted.

Roasting.—As in the case of coffee, this process must be carefully guarded to insure the development of the desired flavor; too much heat means bitterness and too little leaves the coco with a crude undeveloped taste. The process is usually carried out in large iron drums, heated to from 125°-145° C. and constantly kept in motion. During the roasting the thin husks of the seeds become brittle and are so loosened, that afterwards they can easily be removed; the aroma is increased; the bitter taste is still further modified and the starch is partially dextrinized. When sufficiently roasted, coco is quickly cooled in order to prevent the loss of the aroma.

Crushing.—The roasted seeds are next run through a machine called the cracker. This frees the outer shell from the inner parts which are known as coco nibs. A separation of shells, nibs and germs is effected by sieves and a machine of special device. As the shells retain the flavor, they are sold and used for the preparation of a cheap beverage. The nutritive value is not great, but they make a satisfactory drink for people of weak digestion. The coco nibs are used for the preparation of the commercial chocolate and coco.

Fig. 74.—Grinding Room.
(Copyrighted by Walter Baker & Co., and used with their permission.)

Preparation of Chocolate.—The coco nibs are ground into a paste by a series of revolving stones, arranged in pairs and slightly heated to assist in liquefying the coco. While in a semi-fluid condition, the paste is moulded into cakes and allowed to harden. It may be sold in this form as plain chocolate or the ground nibs may be passed into a mixer and finely ground sugar, spices, vanilla and other flavors may be incorporated. After moulding, it is placed on the market as sweet chocolate or as milk chocolate, if condensed or powdered milk has also been added.

Preparation of Coco.—As the coco nib is too rich in fat for ordinary purposes, sometimes approximately one-half of the total weight, it is customary to remove a portion of it. The product is then known as coco. In the United States this is chiefly carried on by running the ground nibs, while in the semi-liquid form, directly from the grinder into an hydraulic press, which removes some 60-70 per cent. of the fat. It is then allowed to cool after which it is reduced to a powder and boxed. The extracted fat is clarified and made into coco-butter. As coco-butter does not readily turn rancid if carefully stored, it is used largely in pharmacy, for candy-making and in the preparation of cosmetics, perfumes, pomades and soft toilet soaps.

Adulteration.—Coco preparations have been much subject to adulteration. In order to increase the bulk and weight, sugar and various starches have been frequently added, while sand, clay, the ground shells of the coco-bean, powdered roasted acorns, chestnuts and other substances of organic and inorganic origin have, from time to time, been found. Fats of cheaper variety, as lard or coconut oil, are used to restore the normal percentage of fat after coco-butter has been removed. In cheaper grades of chocolate, glucose is sometimes used in place of sugar, while inferior flavorings and coloring matter are frequently added.

As a Beverage.—Coco not only furnishes the material for a refreshing and exhilarating beverage, but is a food of great nutritive value. This may readily be seen by the average composition of the coco bean as given by Payen.

Fat	50
Starch	10
Albuminoids	20
Water	12
Cellulose	2
Mineral matter	4
Theobromine	2

Theobromine which is responsible for the stimulating effect of coco, is closely related chemically to the alkaloid caffein, which occurs in tea and coffee and has a similar physiological effect. The presence of so high a percentage of fat, protein and carbohydrate not only makes coco of greater nutritive value than tea or coffee, but both soluble and insoluble portions become a part of the beverage. This is not true of tea or coffee where only the constituents soluble in hot water are obtained.

As chocolate is a concentrated food, it frequently causes biliousness when indulged in too freely.

CHAPTER XXI.

SPICES AND CONDIMENTS.

The word condiment is applied to products which possess no nutritive value, but are added to food to make it more palatable and to stimulate digestion. They may be either organic or inorganic.

Sodium chloride or common salt, the most necessary to man and used to the largest extent, is inorganic. It appears to be the one item of food found in the diet of all nations and every race from the earliest times, the chlorine being utilized by the system in the formation of hydrochloric acid of the gastric juice, while the sodium is needed in the production of the bile. Its use is particularly important among people whose diet consists largely of vegetables and vegetable products.

Salt is procured from natural deposits of sodium chloride in the form of solid crystals, from natural or artificial brine wells and from the sea by the process of evaporation. Formerly much of our salt came from the Bahama Islands. These islands are of coral origin and possess comparatively little vegetation. Small pools can be found in many places where the sun in time evaporates the water, leaving a deposit of salt which could be sent to the market The product was known as Turks Island Brand. Natural brine wells are underground streams which may be the result of sweet water percolating through salt soil, or they may have come from a body of salt water. Artificial brine wells have been made by man by running water into a salt deposit. The brine may then be pumped to the surface which is an easier method of obtaining the salt than by digging.

A large part of the salt on the American market to-day comes from natural brine wells in the vicinity of Syracuse, New York, and along the borders of Lake Erie. They were discovered as early as 1654 by the French Jesuits, who found the Iroquois and other Indian tribes making use of the salt. Michigan in the southern part, Ohio and Kansas are also rich in saline deposits, and much is procured from Utah on the shores of Great Salt Lake.

In the process of preparing salt for the market, the brine is passed through a succession of heaters with an increasing range of temperature. By this means many of the impurities are precipitated and can be filtered off. The brine is then run into evaporators where the water volatilizes and the salt deposits. Since the salt still contains impurities it is purified by recrystallization from water. It is then dried, sifted into grades and packed in bags, barrels or other packages.

SPICES.

Spices comprise all aromatic vegetable substances which may be added to food, principally to make it more palatable. They have been used from the earliest known eras of civilization and have played an important part in the discovery of a water passage to the far east, in the colonizaton of the East Indies, and in the opening up of these countries to western civilization and to western trade.

The tropical parts of Asia have given to the world by far the greatest variety and quantity of spices, such as pepper, cinnamon, nutmeg, mace, cloves, turmeric, ginger and cassia. The tropical countries of America have added several new varieties to the list, as cayenne pepper and vanilla. The West Indies is celebrated for ginger and is also the home of the pimento. From Africa, grains of Paradise, are obtained.

All spice plants are grown in tropical climates, latitude 25° N. and 25° S. of the equator, where there is considerable rainfall and soil with water absorbing properties. Most of these flavoring plants are found on islands in close proximity to the sea. Spices are obtained from different parts of the plant; dried fruit as pepper, pimento, nutmeg, mace; dried bark as cinnamon and cassia; flower buds as cloves; the root as ginger; seeds as caraway; leaves as sage, thyme, etc. Many of these owe their power to essential oils which in some cases are extracted and used as flavoring extracts. The flavor of others is due to esters and to alkaloids.

Uses.—While the principal use of spices is to add flavor to food and beverages, this is by no means their only service to man. Many are used in perfumery, in soap making and in the manufacture of incense. Several varieties are utilized in medicine chiefly to disguise a disagreeable flavor; turmeric is used in dyeing and others in the various arts. In Egyptian days, they were utilized for embalming all the distinguished dead.

While spices have been used from early ages in connection with food for the sake of the various flavors that they yield, it has been left to modern times to discover, that they also assist in the preservation of the material to which they have been added. This is due to the fact that they contain antiseptic principles.

Spices as Preservatives.—That spices are useful as preservatives may readily be detected with such food products as sausages and mince meat. Mince meat as a rule, has for its chief constituents chopped meat and apples. Meat is subject to decay by bacterial action and apples furnish an excellent food for mold and yeast, yet it is a well known fact that mince meat will keep for many months. Sausage meat is subject to rapid putrefaction but in winter weather, it can also be kept for a length of time on account of the high content of spices. Fruit cake furnishes another example. It can be held for an indefinite period and even improves with age. Spices do not furnish a complete protection, however, and food material to which they have been added should not be allowed to stand in a warm place, or fermentation and decay will set in.

Although these facts have been common knowledge for many years, very little experimental work has been done, as to the varieties which contain the best antiseptic properties and the amount which should be used. Unfortunately many of them are irritating to the mucous membrane and when used in excess are harmful. It is very important, therefore, that the manufacturer and housewife should know which spices may be used for their antiseptic properties and what the physiological effect is, of such condiments. To the experimental work of Conrad

Hoffman and Alice Evans, the authors are indebted for the following information.*

That ginger, black pepper and cayenne pepper do not prevent the growth of micro-organisms but that cinnamon, cloves and mustard are valuable preservatives. Nutmeg and allspice delay growth but cannot be considered of any practical importance, since the amount used in cooking is too small to preserve food for any length of time. Cinnamon, cloves and mustard are almost equal in their efficiency. Cloves when used in large enough amounts to prevent growth have a burning taste to the palate, but cinnamon and mustard are particularly valuable as they are palatable even when used in proportions that prevent all growth. The active antiseptic constituents of mustard, cinnamon and cloves are their aromatic or essential oils. Cinnamon contains cinnamic aldehyde which is more effective, if pure, than benzoate of soda.

Commonly Used Spices.—*Vanilla.*—Vanilla is obtained from the fruit of a climbing orchid, native of tropical America, but now grown in Java, Ceylon and other parts of the Orient. It was used by the Aztecs as a flavoring agent for their favorite beverage chocolate, before the discovery of America, and was taken to Europe by the explorers as early as 1510. The fruit is a pod which must be dried and cured with great care in order to obtain the desired flavor. The characteristic odor is developed during the process of fermentation which takes place while drying. The aroma and flavor are due to a substance known as vanillin which gradually crystallizes out from the fluid of the pod. The well cured pods, either whole or powdered, may be found on the market as the vanilla bean or powder, but a more common form is the extract of vanilla. This is obtained by dissolving out the flavoring material by the use of alcohol.

Modern science has furnished a commercial rival to vanilla extract in the production of synthetic product. Vanillin has been largely prepared from engenol, a substance to which oil of cloves owes it characteristic odor, and in recent years much has also been obtained electrolytically from sugar.

* The Use of Spices as Preservatives by Conrad Hoffman & Alice Evans. Published in Journal of Industrial & Engineering Chemistry.

Pepper.—Various spices can be found on the market under the general head of pepper, but the most common forms are black and white pepper. Pepper is one of the oldest spices known to mankind and is still used in enormous quantities. Although it now sells at so low a price that it may be utilized by comparatively poor people, it was worth its weight in gold during the days of the Roman Empire. The high price in the Middle Ages led the Portuguese to seek a water route to the far east, and the first vessel that sailed around the Cape of Good Hope had for its object the finding of a cheaper way to procure pepper.

Fig. 75.—Pepper Plantation near Singapore. (Courtesy of The Spice Mill Publishing Co.)

The black variety is prepared from the dried, unripe berry of a vine which was grown first in Southern India, the East Indies, Siam, Cochin China and in later ages in the West Indies. For a long period the Dutch nation controlled the trade and tried to confine its cultivation to the Island of Java and other Dutch possessions.

The berry is gathered before it is fully matured, is spread out on mats for several days, after which the outer skin is removed by rubbing with the hand. It is then cleaned by sifting and is usually ground before being placed on the market. White pepper is generally supposed to be produced from a different spice but is in reality the same fruit, prepared by a different method. It is generally considered better but the product has not as good a flavor and is more expensive, the only advantage being in the appearance (Fig. 75).

Mustard.—The mustard most commonly used is obtained by grinding to a flour, the small seeds of the mustard plant. The plant which may be found either in the wild state or under cultivation has a wide distribution in Europe, northern Africa, Asia, the United States, the West Indies and South America. It has been used for medicinal purposes from remote antiquity, but appears to have been unknown as a condiment until 1829, when a resident of Durham, England, placed it upon the market, keeping the manufacturing process a secret. The product was given the name of Durham Mustard, a brand which is still found in the market of to-day.

The two most common varieties of seeds used at present are brown and yellow in color, the brown yielding the highest grade product. Mustard is prepared by passing the interior of the seed through a winnowing machine, for the removal of foreign material and crushing the grain between rollers, after which the oil is removed by hydraulic pressure. The cake is then dried, powdered and bottled. The powder is frequently mixed with spices and oil when it is known as prepared mustard. Much adulteration has been practiced in the preparation of mustard, principally in the addition of wheat flour, turmeric, cayenne pepper, etc.

Cinnamon and Cassia.—Cinnamon is the inner bark of young shoots of a certain species of cinnamon tree, which is particularly rich in a volatile oil known as oil of cinnamon. It is apparently one of the oldest of the spices used by man and was the first sought after in the oriental voyages of the early merchantmen. The shoots are cut very carefully from the tree, the bark is slit longitudinally and is removed in strips by special knives. The strips are piled in heaps and allowed to ferment, after which the epidermis is removed. The bark shrinks on drying and is known as "the quills." These are then put up in bundles ready for exportation (Fig. 76).

Cassia in olden times was obtained entirely from the bark of other varieties of cinnamon trees. It was thick, comparatively coarse and was generally considered inferior to cinnamon. Much of the cassia of to-day, however, is obtained from China

Fig. 76.—Rolling Cinnamon Bark into Quills. (Courtesy of the Spice Mill Publishing Co.)

and the Dutch West Indies, from the fragrant bark of a plant known as the cassia. It has a much more pronounced flavor than cinnamon and is frequently used as an adulterant.

Cloves.—Cloves are the unopened flower buds of an exceedingly beautiful evergreen tree, which grows mainly in the Spice Islands. They were known to the ancients and were considered an important article of trade in the Middle Ages. The curing process is very simple. After picking, the buds are thrown on the ground on grass mats and are allowed to dry in the sun, care

Fig. 77.—Clove Tree of Zanzibar. (Courtesy of The Spice Mill Publishing Co.)

being taken to shelter them from the dew at night. In about one week, they are ready to be packed for export. Cloves contain about 16 per cent. of a volatile oil, which can easily be removed and is of considerable value. It is used largely in perfumery and in soaps (Fig. 77).

Allspice.—Allspice, known to the Spaniards as pimento, is the dried, unripe fruit of an evergreen tree native to the West Indies, Mexico and South America. The chief supply comes from Jamaica. The name allspice has been given on account of the fact that its very fragrant odor and flavor appears to be a combination of those obtained from cinnamon, cloves and nutmeg. The fruit is picked before it is ripe, is dried in the sun and usually ground on common burr-stones. It is used frequently for medicinal purposes to disguise the taste of nauseous drugs, and in the tanning of some kinds of leather. Allspice yields a volatile oil on distillation which is used as a flavoring in alcoholic solutions.

Nutmeg and Mace.—Nutmeg is the dried kernel of the fruit of a tropical tree somewhat resembling an orange tree. It is native to the Malay Archipelago, but is also grown largely in Asia, Africa, South America and the West Indies. The fruit is gathered when fully ripe and the outer part is discarded. The seeds are then dried in the sun or by artificial means. The thin outer seed coat is broken, and the kernal or nutmeg is ready to be cleaned and packed. Nutmeg is exported in the unground state in order to retain the flavor. The inner envelope which surrounds the nut is also dried, and exported under the name of mace.

Ginger.—Ginger is the only spice taken from the root. The original home of the plant is supposed to be China, but it is now grown in many tropical countries. The West Indies produce an excellent quality, that from Jamaica usually being considered the best. The root may be left unpeeled when it is simply dried in the sun, or it may be peeled after having been scalded. Preserved ginger is prepared very largely in China, especially Canton. After being peeled, the ginger is treated with a boiling solution of sugar, after which it is packed in jars or sent to the market in the dry state (Fig. 78).

Adulteration.—In former years, no article connected with our food supply was more largely subject to adulteration than spices, especially when they were placed on the market in the ground condition. Spices of a good quality were usually high in price, and many cheap materials could be found which to some extent resembled the real article. They were used frequently as dil-

Fig. 78.—Digging and Peeling Ginger in the Fields—Ginger Plantation, Jamaica. (Courtesy of The Spice Mill Publishing Co.)

uents and to some extent as complete substitutes. According to Bulletin 13 of the United States Department of Agriculture, a profitable business for many years was carried on in manufacturing of products known as spice mixtures. They consisted of a combination of various materials as ground coconut shells, wheat flour, crackers, charcoal, coloring and mineral matter, yellow cornmeal, mustard, husks, sawdust and other odds and ends.

Much misbranding has also been found especially among flavoring extracts.

VINEGAR.

Vinegar is used very largely in connection with food, the same as spices, to give flavor and as a preservative. Such articles as pickles depend largely upon vinegar for their keeping quality. It does not contain antiseptics as do the spices, but owes its preservative value to the acetic acid which inhibits the growth of putrefactive bacteria.

The manufacture of vinegar has been treated under the Fermentation Industries. See Chapter XII.

BIBLIOGRAPHY.

CHAPTER I.—FOOD PRINCIPLES.

Sherman, Henry C.—Chemistry of Foods and Nutrition.
Jordan, Whitman H.—Principles of Human Nutrition.
Vulté, H. T.—Household Chemistry.
Perkin and Kipping.—Organic Chemistry.
Thorpe.—Dictionary of Applied Chemistry.
Haas and Hill.—An Introduction to the Chemistry of Plant Products.

CHAPTER II.—WATER.

Mason, William P.—Our Water Supply.
Richards and Woodman.—Air, Water and Food.
Leffmann, Henry.—Examination of Water.
Frankland, E.—Water Analysis.
Wanklyn and Chapman.—Water Analysis.
Harrington, Charles.—Practical Hygiene.
Thorpe.—Dictionary of Applied Chemistry.
Buchanan, E. D. and R. E.—Household Bacteriology.
Schultz, Carl H.—Mineral Waters.

CHAPTERS III AND IV.—OLD AND MODERN MILLING PROCESSES.

Doudlinger, Peter Tracy.—The Book of Wheat.
Edgar, William C.—Story of a Grain of Wheat.
Amos, Percy A.—Processes of Flour Manufacture.
Grant, James.—The Chemistry of Breadmaking.
Wiley, Harvey W.—Foods and Their Adulteration.
Bulletin No. 57, Agricultural Experiment Station, Ottawa, Canada.—Quality in Wheat.
Trade Paper.—The Northwestern Miller.
Encyclopedias.—Britannia, International.

CHAPTERS V AND VI.—CEREALS AND BREAKFAST FOODS.

Burtt-Davy, Joseph.—Maize: Its History, Cultivation, Handling and Uses.
Freeman and Chandler.—The World's Commercial Products.
Harrington, Charles.—Practical Hygiene.
Wiley, Harvey W.—Foods and Their Adulteration.
Ward, Artemus.—The Grocers Encyclopedia.
Bulletin No. 131, Agricultural Experiment Station, Orono, Maine.—Indian Corn as Food for Man.
Bulletin No. 118, Agricultural Experiment Station, Orono, Maine.—Cereal Foods.

Bulletin No. 65, Agricultural Experiment Station, Orono, Maine.—Coffee Substitutes.

Bulletin No. 211, State Agricultural College Experiment Station, Michigan.—Breakfast Foods.

Bulletin No. 162, Dept. of Agriculture, Ontario Agricultural College, Ontario, Canada.—Breakfast Foods.

Farmers Bulletin No. 249, U. S. Department of Agriculture, Washington, D. C.—Cereal Breakfast Foods.

Farmers Bulletin No. 417, U. S. Department of Agriculture, Washington, D. C.—Rice Culture.

Encyclopedias.—Britannia, International.

CHAPTER VII.—UTILIZATION OF FLOUR.

Jago, W. and W. C.—Technology of Breadmaking.

Grant, James.—The Chemistry of Breadmaking.

Buchanan, E. D. and R. E.—Household Bacteriology.

Conn, H. W.—Bacteria, Yeasts and Molds in the Home.

Jordan, E. O.—General Bacteriology.

Farmers Bulletin No. 389, U. S. Department of Agriculture, Washington, D. C.—Bread and Breadmaking.

The National Geographic Magazine, March, 1908.—Making Bread in Different Parts of the World.

CHAPTER VIII.—LEAVENING AGENTS.

Thorpe.—Dictionary of Applied Chemistry.

Smith, Alexander.—General Inorganic Chemistry.

Harrington, Charles.—Practical Hygiene.

Bulletin No. 13, Part Fifth, U. S. Department of Agriculture, Division of Chemistry.—Baking Powders.

Bulletin No. 52, Agricultural Experiment Station, Florida.—Baking Powders.

CHAPTER IX.—STARCH AND ALLIED INDUSTRIES.

Sadtler, Samuel.—Handbook of Industrial Organic Chemistry.

Thorp, Frank H.—Outlines of Industrial Chemistry.

Thorp.—Dictionary of Applied Chemistry.

Olsen, John C.—Pure Foods.

Humphrey, H. C.—Descriptive Paper—The Corn Products Refining Industry.

Bulletin No. 202, U. S. Department of Agriculture, Washington, D. C.—Digestibility of Starch of Different Sorts as Affected by Cooking.

Bulletin, Department of Agriculture, North Carolina.—Starches Used in Cotton Mills and Their Adulterations.

CHAPTER X.—THE SUGAR INDUSTRY.

Sadtler, Samuel P.—Handbook of Industrial Organic Chemistry.
Thorp, Frank H.—Outlines of Industrial Chemistry.
Thorpe.—Dictionary of Applied Chemistry.
Wiley, Harvey W.—Foods and Their Adulteration.
Durr, Noël.—Sugar and the Sugar Cane.
International Library of Technology.—Manufacture of Sugar.
The School of Mines Quarterly, Columbia University, April, 1911.—The Chemistry of Raw Sugar Production; Sugar Refining.
The School of Mines Quarterly, Columbia University, January, 1913.—Manufacture of Raw Sugar in the Philippine and Hawaiian Islands.
The School of Mines Quarterly, Columbia University, July, 1913.—By-Products of Sugar Manufacture, and Methods for Their Utilization.
Farmers Bulletin, No. 52, U. S. Department of Agriculture, Washington, D. C.—The Sugar Beet.
Report of the Eighth International Congress of Applied Chemistry, Vol. 27-29.—The Status of Cane Sugar and Manufacture in the Hawaiian Islands.
Trade Paper.—Sugar.

CHAPTERS XI AND XII.—ALCOHOLIC BEVERAGES.

Thorpe.—Dictionary of Applied Chemistry.
Sadtler, Samuel.—Handbook of Industrial Organic Chemistry.
Thorp, Frank H.—Outlines of Industrial Chemistry.
Harrington, Charles.—Practical Hygiene.
Accum, Frederick.—A Treatise of Adulteration of Food and Culinary Poisons.
Buchanan, E. D. and R. E.—Household Bacteriology.
Conn, H. W.—Bacteria, Yeasts and Molds in the Home.
Fowler, G. J.—Bacteriological and Enzyme Chemistry.
Osborn's Annual Guide, December, 1903.—Vintage and Production of Wines and Liquor.
Bulletin No. 13, Part Third, U. S. Department of Agriculture, Division of Chemistry.—Fermented Alcoholic Beverages.
Bulletin No. 239, Agricultural Experiment Station, Ottawa, Canada.
Trade Paper.—The American Brewer.

CHAPTER XIII.—FATS.

Sadtler, Samuel P.—Handbook of Industrial Organic Chemistry.
Thorp, Frank H.—Outlines of Industrial Chemistry.
Thorpe.—Dictionary of Applied Chemistry.
Wing, Henry W.—Milk and Its Products.

Ward, Artemus.—The Grocers Encyclopedia.

Leffmann and Beam.—Food Analysis.

Wiley, Harvey W.—Foods and Their Adulterations.

International Library of Technology.—Cottonseed Oil and Products.

Bulletin No. 13, Part First, U. S. Department of Agriculture, Division of Chemistry.—Dairy Products.

Bulletin No. 163, Agricultural Experiment Station, Fort Collins, Colo.—Farm Butter Making.

Farmers Bulletin, No. 241, U. S. Department of Agriculture, Washington, D. C.—Butter Making on the Farm.

Farmers Bulletin, No. 131, U. S. Department of Agriculture, Washington, D. C.—Household Tests for the Detection of Oleomargarine and Renovated Butter.

CHAPTER XIV.—ANIMAL FOODS.

Wiley, Harvey W.—Foods and Their Adulterations.

Harrington, Charles.—Practical Hygiene.

Hutchison, Robert.—Foods and Dietetics.

Jordan, Whitman H.—Principles of Human Nutrition.

Wilder, F. W.—The Modern Packing House.

Ward, Artemus.—The Grocers Encyclopedia.

The National Geographic Magazine, March, 1913.—Oysters: The World's Most Valuable Water Crop.

Bulletin No. 114, U. S. Department of Agriculture, Bureau of Chemistry.—Meat Extracts and Similar Preparations.

Farmers Bulletin, No. 391, U. S. Department of Agriculture, Washington, D. C.—Economical Use of Meat in the Home.

Farmers Bulletin, No. 183, U. S. Department of Agriculture, Washington, D. C.—Meat on the Farm.

Farmers Bulletin, No. 85, U. S. Department of Agriculture, Washington, D. C.—Fish as Food.

Farmers Bulletin, No. 128, U. S. Department of Agriculture, Washington, D. C.—Eggs and Their Uses as Food.

CHAPTER XV.—THE PACKING HOUSE.

Wilder, F. W.—The Modern Packing House.

International Library of Technology.—Packing House Industries.

The Chemical Engineer, December, 1906.—Chemical Engineering in the Packing House.

Morris & Co.—The Pictorial History of a Steer.

Wiley, Harvey W.—Foods and Their Adulteration.

CHAPTER XVI.—MILK.

Winslow, K.—The Production and Handling of Clean Milk.
Rosenau, M. J.—The Milk Question.
Wing, Henry H.—Milk and Its Products.
Harrington, Charles.—Practical Hygiene.
Buchanan, E. D. and R. E.—Household Bacteriology.
Conn, H. W.—Agricultural Bacteriology.
Conn, H. W.—Storrs Agricultural Experiment Station, Report 1895—Bacteria in the Dairy.
Leffmann and Beam.—Food Analysis.
Bulletin No. 161, U. S. Department of Agriculture, Bureau of Animal Industry.—A Study of the Bacteria which Survive Pasteurization.
Bulletin No. 104, U. S. Department of Agriculture, Bureau of Animal Industry.—Medical Milk Commission and the Production of Certified Milk in the United States.
Bulletin No. 107, U. S. Department of Agriculture, Bureau of Animal Industry.—The Extra Cost of Producing Clean Milk.
Farmer's Bulletin, No. 363, U. S. Department of Agriculture, Washington, D. C.—The Use of Milk as Food.

CHAPTER XVII.—MILK PRODUCTS.

Van Slyke and Publow.—The Science and Practice of Cheese-making.
Wing, Henry H.—Milk and Its Products.
Wiley, Harvey W.—Foods and Their Adulteration.
Leffmann and Beam.—Food Analysis.
Luchsinger.—History of a Great Industry. Address at the State Historical Society of Wisconsin.
The National Geographic Magazine, December, 1910.—A North Holland Cheese Market.
Bulletin No. 13, Part First, U. S. Department of Agriculture, Division of Chemistry.—Dairy Products.
Bulletin No. 203, New York Agricultural Experiment Station, Geneva, New York.—A Study of Enzymes in Cheese.
Bulletin No. 219, New York Agricultural Experiment Station, Geneva, New York.—Some of the Compounds Present in American Cheddar Cheese.
Bulletin No. 236, New York Agricultural Experiment Station, Geneva, New York.—Conditions Affecting Chemical Changes in Cheese-making.
Bulletin No. 237, New York Agricultural Experiment Station, Geneva, New York.—The Role of the Lactic Acid Bacteria in the Manufacture and in the Early Stages of Ripening of Cheddar Cheese.
Farmer's Bulletin, No. 487, U. S. Department of Agriculture, Washington, D. C.—Cheese and Its Economical Uses in the Diet.

CHAPTERS XVIII AND XIX.—PRESERVATION OF FOODS.

Appert, Nicholas.—The Art of Preserving All Kinds of Animal and Vegetable Substances.

Duckwall, E. W.—Canning and Preserving.

Thresh and Porter.—Preservatives in Food and Food Examination.

Rideal, Samuel.—Disinfection and the Preservation of Foods.

Wiley, Harvey W.—Foods and Their Adulteration.

Green, Mary E.—Food Products of the World.

Bulletin No. 13, Part Eighth, U. S. Department of Agriculture, Division of Chemistry.—Canned Vegetables.

Bulletin No. 151, U. S. Department of Agriculture, Bureau of Chemistry.—The Canning of Foods.

Farmers Bulletin, No. 375, U. S. Department of Agriculture, Washington, D. C.—The Care of Food in the Home.

Farmers Bulletin, No. 359, U. S. Department of Agriculture, Washington, D. C.—Canning Vegetables in the Home.

Farmers Bulletin, No. 521, U. S. Department of Agriculture, Washington, D. C.—Canning Tomatoes at Home and in Club Work.

Farmers Bulletin, No. 203, U. S. Department of Agriculture, Washington, D. C.—Canned Fruit, Preserves and Jellies.

CHAPTER XX.—TEA, COFFEE AND COCO.

Freeman and Chandler.—The World's Commercial Products.

Thorpe.—Dictionary of Applied Chemistry.

Ward, Artemus.—The Grocers Encyclopedia.

Harrington, Charles.—Practical Hygiene.

Fowler, E. J.—Bacteriological and Enzyme Chemistry.

Whymper, R.—Coco and Chocolate; Their Chemistry and Manufacture.

Harris, W. B.—Paper on Coffee as Affected by the Food and Drug Act.

Count Rumford.—Essay on The Excellent Qualities of Coffee and the Art of Making it in the Highest Perfection.

Leffmann and Beam.—Food Analysis.

Pan-American Union Bulletin, 1912.—The Cacao of the World.

The National Geographic Magazine, October, 1911.—A Visit to a Brazilian Coffee Plantation.

Bulletin No. 13, Part Seventh, U. S. Department of Agriculture, Washington, D. C.—Tea, Coffee and Coco Preparations.

Farmers Bulletin, No. 301, U. S. Department of Agriculture, Washington, D. C.—Home Grown Tea.

Trade Paper.—The Tea and Coffee Trade Journal, New York.

CHAPTER XXI.—SPICES AND CONDIMENTS.

Ridley, Henry N.—Spices.

Gibbs, W. M.—Spices and How to Know Them.

Freeman and Chandler.—The World's Commercial Products.

Leffmann and Beam.—Food Analysis.

Wiley, Harvey W.—Foods and Their Adulteration.

Ward, Artemus.—The Grocer's Encyclopedia.

Conn, H. W.—Bacteria, Yeasts and Molds in the Home.

Hoffman and Evans.—Journal of Industrial and Engineering Chemistry. The Use of Spices as Preservatives.

Bulletin No. 13, Part Second, U. S. Department of Agriculture, Division of Chemistry.—Spices and Condiments.

Trade Paper.—The Spice Mill. Spice Mill Publishing Co., New York.

INDEX

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