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# 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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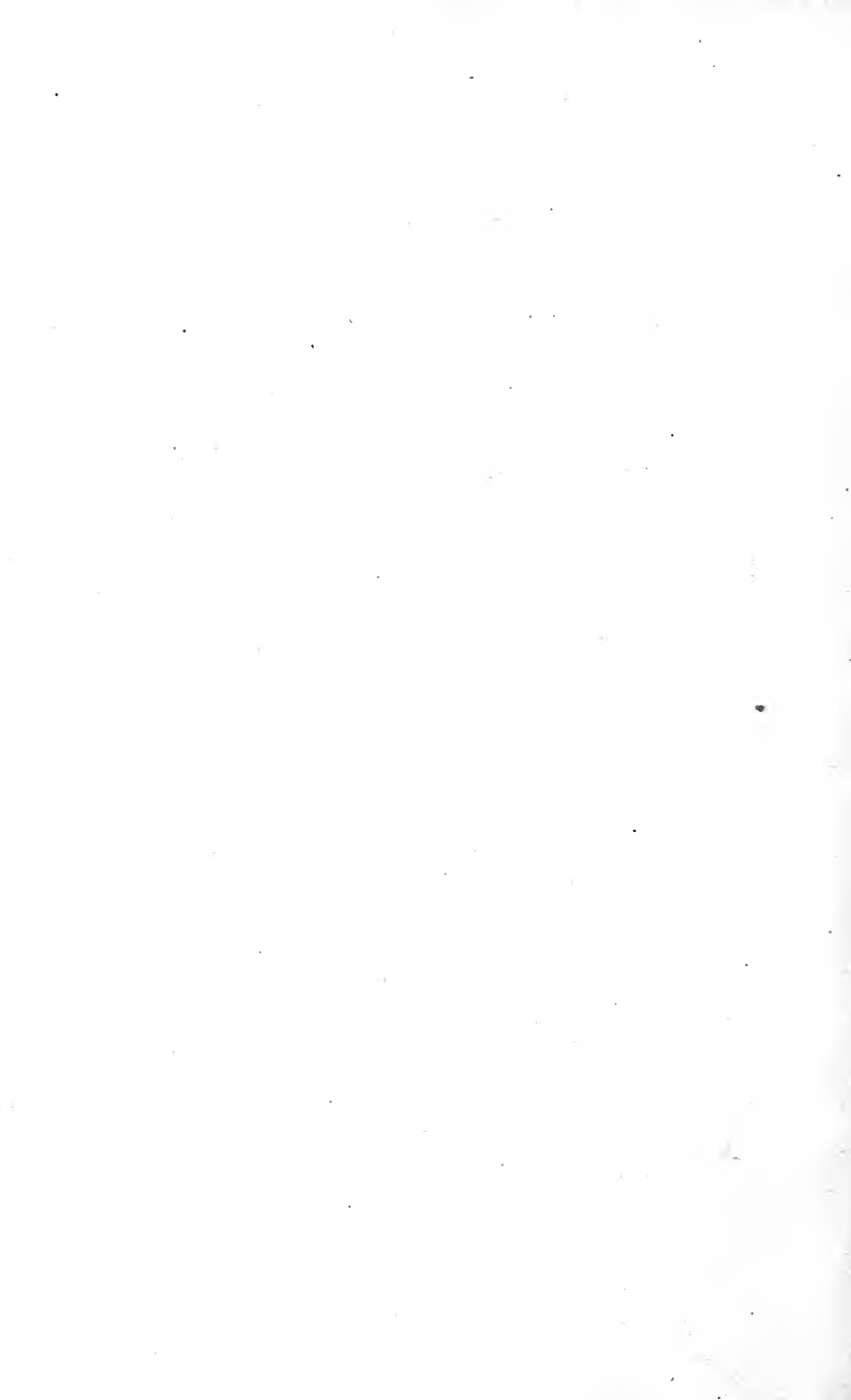
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## INTRODUCTION.

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In regard to the production and manufacture of our food material there is a prevalent ignorance among women to-day which is in 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 so highly prized as a memento of the olden times testifies to the fact that our grandmothers knew 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 farther and farther 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 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.*—1. 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. (2) In the majority of cases better products can be obtained, for the processes 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. (3) In recent years there has been a great extension of the open season, fresh fruits and vegetables are quite common in the city markets the year round. The variety of food also has been increased by canning. (4) 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, for example, oranges and other fruits, beet sugar and wines. (5) New and improved methods of food preservation have been largely studied, such as canning and the use of cold storage. (6) The co-operation with scientists has led to protection against certain diseases, tuberculosis from meat and milk, typhoid from the oyster, trichina from pork, etc.

(7) Articles of food are put up in better and more sanitary packages and better packing material is being used.

*Disadvantages.*—(1). The cost of living has been greatly increased. Foods may be roughly divided into permanent and perishable material. Among the permanent foods which include sugar and flour the cost has decreased. The great advance in price of our food material is found entirely in the perishable foods. Such material is being brought from a long distance thus adding cost of freight and preservation during transportation. The many hands through which food material must pass also increase the cost. The open market has led also to expensive tastes. Luxuries look attractive and the cost is great where such products have been brought from a distance. (2) The women of our country represent about ninety 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. 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. 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, potted veal for chicken, and the like. 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 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 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 excursions are not practical, illustrative material and demonstrations should be most freely used, accompanied whenever possible by the use of the stereopticon slides and motion pictures.

During the past four years of world war much greater interest in food production has been shown by the public. Partly driven by necessity and partly led by educational methods the householder has learned to put into practice many almost forgotten methods and old time economies. This era of high cost of food material which appears likely to last for some time will compel the householder to develop a keener interest in all phases of the food question than has been shown for some years past. Many forms of food formerly looked upon with disfavor, such as butter and wheat substitutes and glucose are now in common use without prejudice. Home canning and drying of perishable products are generally recommended and practiced where possible. Numerous bulletins on food preservation have been issued by federal and state authorities even to the point of seeming confusion but much good has resulted from these efforts and it is to be hoped that the benefits will not be too soon forgotten.

In revising the following pages it has been thought wise to eliminate the chapters on alcoholic beverages and use the space thus saved in expanding other and more necessary processes, at the same time correcting errors and adding new material.

## CHAPTER I.

### FOODSTUFFS.

Foodstuffs or food principles, as they are sometimes called, 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. They are essential to the human body since life's activities involve: (1) a continuous expenditure of energy; (2) a constant necessity for material from which tissue may be built; (3) a need for substances whose presence assists in controlling important physiological processes. Foods therefore serve in supplying energy, building tissue or for regulating purposes.

Locked up in the resources of nature is a vast wealth of energy. Man has only to seize that 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. Nature does not always give us these foods in a simple form. Most of the nutrient material requires more or less change in the digestive tract to bring it into the forms most useful in nutrition.

Although complex in their nature foods when analyzed have been found to be composed of comparatively few elements carbon, hydrogen, oxygen and nitrogen with small amounts of sulphur, phosphorus, iron, calcium, etc. As these elements are differently combined they fall readily into groups which are known as the food principles or foodstuffs; carbohydrates in which occur carbon, hydrogen and oxygen; fats, also composed of carbon, hydrogen and oxygen; proteins, containing carbon, hydrogen, oxygen, nitrogen, phosphorus, generally sulphur and occasionally such elements as calcium and iron; mineral matter, represented by sodium, potassium, calcium, magnesium, iron, sulphur, phosphorus, chlorine and minute quantities of iodine, fluorine and silicon.

The carbohydrates are the most abundant and the most economical source of energy. They include many well known foods,

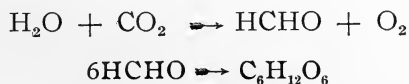
such as starch, sugar, cereals and vegetables. A still more concentrated form of fuel to supply energy in nutrition are the fats, also widely distributed in nature. They appear in different forms as liquids, semi solids and solids represented by olive oil, butter and suet. While the proteins serve as fuel to yield the required energy their chief function is to serve as material for the maintenance or growth of body tissue since they are essential constituents of animal cells. As this work of tissue building cannot be carried on by the carbohydrates and fats, protein is absolutely essential to life. In its most concentrated form it occurs in the white of egg, large amounts being also found in meat, fish, cheese, yolk of egg and milk. Usually we obtain our protein supply from animal life although it occurs also in the vegetable kingdom, relatively large amounts being found in beans, peas, lentils, cottonseed meal and smaller amounts in wheat, maize and other cereals. Plant life supplies mankind with most of the carbohydrate food, animal carbohydrate occurring only in such forms as milk sugar, glycogen and glucose. Fats occur frequently in both animal and vegetable life.

In the group of foodstuffs known as mineral matter, ash or salts has been placed those chemical elements not occurring in carbohydrates, fats or simple proteins but which have been found to be essential to the structure and function of the body. While existing in relatively small quantities they play an important part in human nutrition: (1) by supplying the bony structure with constituents necessary for rigidity; (2) as essential elements of organic compounds such as muscle, tissue and blood cells; (3) as soluble salts in the fluids of the body which influence many physiological processes.

Recent investigation of deficiency diseases has revealed the fact that energy producing and tissue building material alone do not meet all the requirements of nutrition. Occurring in foods are three as yet unidentified substances or groups of substances which are known as vitamins or as "fat soluble A" and "water solubles B and C." While these substances are little understood it is believed that they are essential in an adequate food supply.

**CARBOHYDRATES.**

The group of organic compounds which includes the celluloses, starches and sugars is one of the longest known and contains some of the most familiar substances that are now used as human food. They are known as the carbohydrates, a term which originated from an erroneous conception that they were compounds of carbon with water since hydrogen and oxygen appeared in the proportion of two to one. Later experimentation has shown that while important members of the group conform to this arrangement carbohydrates are known which do not. These compounds play an important part in the economy of plant life being synthesized in the cells of all chlorophyll bearing plants from simple inorganic substances. In the presence of sunlight the leaf cells of green plants bring about a reaction between carbon dioxide and water liberating oxygen and forming an organic substance (formaldehyde) from which a simple carbohydrate (glucose or fructose) can be built according to the following reaction.



Glucose,  $\text{C}_6\text{H}_{12}\text{O}_6$ , is found in the sap of growing plants and being soluble and diffusible is the form in which carbohydrate material is transferred from one part of the plant to another. During plant metabolism glucose undergoes constant transformation into the familiar forms of sucrose, maltose and dextrin until it finally comes to rest as starch or even cellulose.

*Classification.*—The classification of the carbohydrates is usually based on the action with hydrolytic agents, such as enzymes and acids. Those compounds which do not hydrolyze to simpler forms are known as monosaccharids or simply sugars, those yielding two molecules of simple sugars as disaccharids or double sugars. Trisaccharids yield three and polysaccharids many simple sugars. Only the more important members of these groups will be mentioned.

Monosaccharids  $C_6H_{12}O_6$ .

Glucose or grape sugar (dextrose).

Fructose or fruit sugar (levulose).

Galactose.

Disaccharids  $C_{12}H_{22}O_{11}$ .

Sucrose or sugar.

Maltose or malt.

Lactose or milk sugar.

Polysaccharids  $(C_6H_{10}O_5)_n$ .

Cellulose.

Starch.

Dextrin.

Glycogen.

*Glucose* occurs associated with fructose and sucrose in fruits and plant juices being especially abundant in grapes, corn and many of the garden vegetables. In digestion starch and most of the sugars are reduced to this compound before entering the circulation. It is present in the blood of all animals (0.1 per cent.) where it is ultimately burned to produce energy. When the body has more or less lost the power to burn glucose as in diabetes it accumulates and is eliminated by the kidneys.

*Fructose* accompanies glucose in most sweet fruits the largest amount being found in honey. It is formed together with glucose by the hydrolysis of sugar.

*Galactose* does not occur free in nature but results from the splitting of milk sugar during the process of digestion. The absorption from the digestive tract of any surplus of glucose, fructose or galactose results in the conversion of these compounds into glycogen which when needed can be broken down into glucose. Glycogen is therefore the form in which carbohydrates are stored in animal life.

*Sucrose* is known commercially as cane, beet or maple sugar. 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 car-



rot. The extraction and refining of the marketable products will be discussed in Chapter X.

*Maltose* has not such a wide distribution in plant life as glucose, fructose or sucrose. It occurs mainly during the germination of the plant being produced together with dextrin by the action of the diastatic enzyme. The most common commercial source of maltose is barley. In that form it plays an important part in the brewing industry, in malted milk and in the so-called malted breakfast foods.

*Lactose* occurs in the milk of all mammals constituting from three to seven per cent. of the fresh secretion. It is the most abundant of the animal carbohydrates.

As *cellulose* is the substance from which is built the framework of plant life, it occurs very abundantly in nature. Wood, cotton, hemp, flax and paper are important examples. Many of our foods, such as cereals, vegetables and fruit contain cellulose but as it is highly resistant to hydrolytic agents it passes through the digestive tract unchanged. Although it has no nutritive value it serves in giving bulk to the food residue.

*Starch* being the reserve food material of plant life is found in varying amounts in all plants in the seeds, roots, tubers, stem and leaves. As many food plants contain it in generous proportions it plays an important part in the human diet. For properties and extraction see Chapter IX.

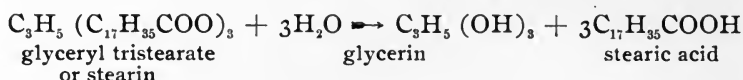
*Dextrin* is formed from starch by the process of hydrolysis. It occurs in plants as a transitory substance whenever starch is being acted upon by diastase. Except in germinating plants, however, the amount is small. For commercial purposes dextrin is prepared by either heating starch to a temperature of 200° C or by acid hydrolysis.

*Glycogen* serves as a food reserve in the animal kingdom. It occurs in small quantities in developing cells, muscle and blood and in larger proportions in the liver where it is stored. In plant life glycogen has a restricted distribution being found only in the fungi.

## FATS.

The fats and oils are compounds of great economic value since they serve not only as foods but for illumination, lubrication, soap manufacture and for a variety of other purposes. They have a wide distribution in nature occurring throughout the vegetable and animal kingdoms from the lowest organism to the most highly organized forms of vegetable and animal life.

Although the same elements are found as in carbohydrates a different state of combination exists. True fats and oils are essentially salt-like bodies in which the base is always the triatomic alcohol glycerin although the fatty acid may differ. Oleic, palmitic and stearic acids occur most commonly, butyric, caproic, caprylic and capric are characteristic of butter, while lauric is the principal acid of coconut oil. Where the splitting of a fat is brought about by hydrolytic agents the products resulting are glycerin and fatty acids in the following proportions



No natural oil or fat consists of one simple triglyceride. They must be regarded either as physical mixtures of various glycerides or loosely combined bodies in which more than one fatty acid appears.

**Properties.**—*Solubility.*—With the exception of the butter fats the commonly occurring fats and oils are insoluble in pure water. They dissolve readily in gasoline, ether, petroleum ether, chloroform and carbon disulphide, all of which may be used for cleansing purposes or for the extraction of fatty matter.

*Melting and Solidifying Points.*—The fats vary in consistency from oils to wax-like solids. In passing from the solid to the liquid state they do not alter in composition. As a rule the solid fats have a low melting point generally below the boiling point of water. This point is rarely a sharp one since natural fats are mixtures rather than simple substances.

*Crystallization.*—All fats are highly crystalline. This has served as a valuable means for determining the probable compo-

sition and source of fat, for example in differentiating between genuine lard and oleo stearin.

*Effect of Heat.*—On prolonged heating in the presence of minute quantities of water at a temperature above 250°C fats and oils dissociate. The separated glycerin loses water and is converted into acrolein.



Acrolein has a peculiar irritating odor characteristic of burning fat.

*Emulsification.*—Fats can be broken up into small globules by mechanical agitation. When coated with a substance similar to egg albumin these globules will remain in suspension. Familiar examples are cream, mayonnaise dressing and various medical preparations. Emulsification plays an important part in the early stages of fat digestion and in the manufacture of soap.

*Saponification.*—In a broad sense the hydrolytic process of splitting a fat into its constituents, fatty acid and glycerin, is called saponification. As a rule the term is used in a restricted sense designating the chemical change which takes place on boiling fats with a strong base resulting in the formation of glycerin and salts of the higher fatty acids (soap).

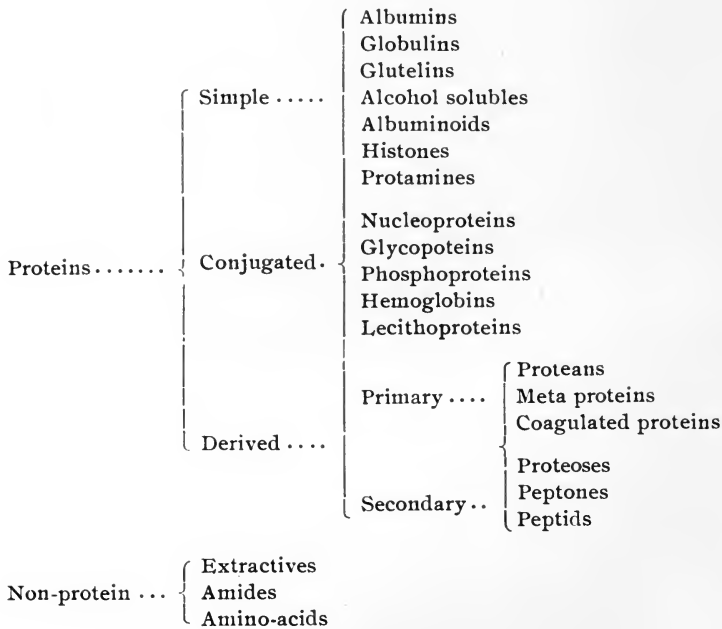
*Hydrogenation.*—Liquid fats contain certain fatty acid groups which absorb free elements, such as oxygen or hydrogen and pass into the group of solid bodies. When the absorption is due to hydrogen the process is known as hydrogenation. By adding hydrogen to oleic acid or its compounds they develop into stearic forms.

### PROTEINS.

The term protein is applied to a large variety of nitrogenous compounds differing greatly in composition and properties but all of which have a high molecular weight. They occupy a pre-eminent position in both vegetable and animal life due to the fact that they are the chief constituents of protoplasm. Plants are able to build these substances directly from inorganic material obtained from the air and soil; thus the fertility of soil especially with regard to nitrates is most important. Animals are prac-

tically dependent upon the digestive products obtained from the proteins of their food.

**Classification.**—The exact chemical structure of proteins has not been determined but they are regarded as anhydrides of amino acids since they yield these acids on hydrolysis. The classification which follows, recommended by the American Physiological Society and the American Society of Biological Chemists, is based on differences in solubility and hydrolysis.



**Simple Proteins.**—Under this heading are included proteins which yield only amino acids or their derivatives on hydrolysis.

*Albumins* occur in the juices of plants and in certain fluids of animals, such as muscle, blood and milk. In the most concentrated form it is found in eggs. Unlike other proteins these compounds are soluble in pure water.

*Globulins* are quite similar to albumins in many respects but differ from them in solubilities. They are readily soluble in neutral salt solutions but not in pure water. Animal forms appear in muscle and blood. Plant globulins are more abundant and frequently occur in fairly large proportions in such products as hemp seed, flax seed, peas, beans, peanuts and cottonseed meal.

*Glutelins and Alcohol Solubles* occur in cereals the best known forms being the glutenin and gliadin of wheat. The former type is soluble in dilute acids and alkalis, the latter in alcohol (79-80 per cent.).

*Albuminoids* formerly called scleroproteins are proteins of the skeleton and protective tissue of animal life occurring in the bones, hoofs, horns, nails and connective tissue. They are insoluble in all neutral solvents. Gelatin, a derived form, dissolves in hot water.

**Conjugated Proteins.**—On hydrolysis conjugated proteins yield protein decomposition products and some other body. This latter substance is nucleic acid in nucleoprotein, a carbohydrate group in the glycoprotein, phosphoric acid in phosphoproteins, hematin or similar compound in hemoglobins and lecithins or related substances in lecithoproteins.

*Nucleoproteins* are closely associated with nuclei of cells in both plant and animal life. They are found especially abundant in the tips of asparagus, the hearts of lettuce and in the internal organs—liver, heart, kidney and pancreas.

*Glycoproteins* are represented by the mucins secreted by the glands of the air passages and alimentary canal.

*Phosphoproteins* which occur as caseinogen of milk and vitellin of egg yolk are exceedingly important forms in human nutrition especially in feeding the young.

**Derived Proteins.**—As in the carbohydrates, proteins must undergo hydrolysis before such compounds can be assimilated by the body. The products of digestion or hydrolysis are known as derived proteins. Primary derived proteins are those which have been slightly modified, secondary forms those having been more

completely acted upon by the hydrolytic agents which may be heat, dilute acid or alkali and enzyme action. In this way are formed coagulated proteins, metaproteins, proteoses, peptones and peptids. Peptones for a long period were believed to be the final product of enzyme action in digestion but that process is now believed to be continued to the amino acid form.

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

**Properties.**—*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.**

Water is in no sense a food but it is necessary for all life's processes and is a very important factor in manufacturing processes. An intelligent appreciation of its physical and chemical properties adds, also, to the comfort of living. As far as life's processes go tissue building requires water as does blood the great carrier of the animal organism; it acts through its solvent quality as an eliminator, cleansing the tissues and carrying away waste material; through its hydrolysing power it brings otherwise insoluble matter into soluble and assimilable forms suitable for nourishing the organism; the unrivalled heat capacity makes water indispensable for temperature regulation externally and internally. Its services to all forms of life cannot be overestimated; next to the atmosphere it is the most essential compound in life.

Water is of such universal utility that a knowledge of some of the chemical and physical properties is necessary in any study of the subject. Briefly it consists of the elements hydrogen and oxygen in the proportion of two to one by volume and one to eight by weight. Water is capable of existing in the states of gas (steam), liquid (water) and solid (ice) without change of composition. Moisture or aqueous vapor is the gas water existing in the atmosphere below the boiling point. The quantity is considerable and varies with temperature and pressure. Practically all substances, solids, liquids and gases dissolve in liquid water in varying proportions increasing with the temperature. This explains the ease of contamination of natural water. Above the boiling point and below freezing all solids drop out of solution while gases and some liquids remain soluble. Water also enters into chemical combination with many organic bodies in the process known as hydrolysis, important in the changes of carbohydrates, fats and proteins. In the hydrogenation of oils (see Page 11) water is used as a source of hydrogen as it is the most economical unit on account of the low initial cost, ease of development and high percentage yield. Water in the solid and liquid states is

practically incompressible. As a liquid it is used for operating hydraulic machinery. The expansibility as steam is practically unlimited and is universally employed for development of power. Dry steam is a perfect gas and obeys all the laws of gases. It is little more than half as heavy as air. Compared with other substances water is a poor conductor of heat but the differing forms of steam, water and ice show considerable variation in conductivity. Early snow protecting the winter wheat from severe frost and the tendency of humid air to retain heat are examples.

#### NATURAL WATERS.

Natural waters are never pure and the term pure water must always be accepted as defining a water free from harmful or undesirable ingredients. The following table will serve as a useful guide in studying the occurrence of water.

Atmospheric ...	<table> <tbody> <tr> <td>Rain .</td> <td rowspan="3">Contains very little dissolved solids but dust and gases of the atmosphere.</td> </tr> <tr> <td>Snow.</td> </tr> <tr> <td>Fog ..</td> </tr> </tbody> </table>	Rain .	Contains very little dissolved solids but dust and gases of the atmosphere.	Snow.	Fog ..					
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**Ancient Water Supplies.**—The Assyrians, Babylonians, Egyptians and Israelites built and maintained large water supply systems which were later enlarged and improved by the Greeks and Romans. Some of these, notably that of Jerusalem, are still in use. In later times, wherever Roman civilization penetrated, water supply systems were established. The continent of Europe contains many remains of the so-called Roman Aqueducts, some of which are in use at the present day. In fact there still exists on the Strand, London, England, what is known as the Old Roman Bath, used by a select few. At the celebrated watering place,



Bath, Roman remains are much in evidence. In Mexico and Peru are extensive ruins of prehistoric water systems constructed mainly for irrigation but probably used also for drinking purposes.

**Potable Waters.**—These waters are known as atmospheric, surface and sub-soil, the last of which may be shallow or deep.

*Atmospheric.*—Rain is the original source of all natural water. It results from the water-vapor rising from the earth's surface, being condensed in the upper air and again falling to earth. In its descent it purifies the atmosphere by taking up ammonia, oxides of nitrogen, carbon dioxide and other soluble gases and by washing down solid matter, such as dust, soot, industrial waste, spores and micro-organisms. Near the seacoast, rain water is found to contain an appreciable amount of salt due to spray. In districts containing a number of inhabitants and factories rain water is never pure even after prolonged washing. In certain localities where the water of springs and wells is hard a supply of soft water is secured by collecting rain water. This is not a safe source for drinking purposes. It must be remembered that the first fall of rain washes out not only the dust of the atmosphere but removes any soil on the collecting surface. This should be discarded in every case. Rain water is usually stored in underground tanks or cisterns of masonry provided with some simple ventilating device and in some cases furnished with an unglazed earthenware filter. Such devices furnish a satisfactory supply for detergent purposes but should be limited to these purposes unless further purification, such as boiling or use of effective porcelain filters is employed. In case vegetation starts in the cistern a very small quantity of a solution of chloride of lime or copper sulphate will check the growth and improve the quality of the water. The Chinese have found that water stored in copper vessels keeps sweet for a long period and improves in quality. This practice probably explains their immunity from water born diseases.

*Surface Water.*—After reaching the earth a portion of rain water runs over the ground to join streams or larger bodies of

water and is likely to be turbid due to suspended matter. In some cases, for example the Missouri River, this is difficult to clarify owing to the presence of clay. 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 waste matter if they are to be used as a water supply.

*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 and is usually clear owing to filtration through clay or sand. Subsoil water is greatly changed by the character of the strata through which it percolates. It passes to various depths according to the porosity 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 the mineral constituents of the soil. Thus we find in limestone regions a large amount of calcium and magnesium carbonates in the water supply making the so-called hard water. This condition greatly influences water to be used for detergent purposes. While it is generally supposed that hardness in water relates principally to cleansing or power operations it is also a serious problem for the manufacturer of food products. The presence of excessive amounts of lime increases the difficulties of sugar refining, canning operations, etc.

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 and inorganic ingredients and becomes impregnated with micro-organisms. Through the agency of the latter the organic matter undergoes very important chemical changes, gradually resulting in 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 sewage which contains excretory products. Organic matter in water tends to make it a better solvent for some mineral substances, notably iron. This is a serious drawback to its use in many food industries.

Shallow wells, fifteen to thirty feet deep, are dangerous unless properly placed and built. The excavation should be made sufficiently deep to insure constant supply and then lined with glazed drain tile up to and slightly above the surface. All joints in the tile pipe must be closed with Portland Cement. Cesspools, sinks and earth closets in the immediate vicinity must be made water tight and should drain to some point remote from the source of supply. No shallow well should be tolerated in any populous district. Even deep or artesian wells may develop dangerous qualities unless properly tubed through the limits of possible contamination. In certain localities they are unusable due to excessive mineral matter.

**Contamination of Public Water Supplies.**—The chief danger to a water supply comes from carelessness in regard to disposal of waste. Earth closets and cesspools too frequently have been placed along the water shed 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, such 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 water from a point above and discharge 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 taken 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.

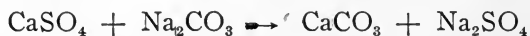
Cholera has its home in India and has been largely kept alive and scattered in all directions by the pilgrimages taken to sacred rivers, like the Ganges. The pilgrims from all parts of India travel in large companies for hundreds and even thousands of miles. Exhausted, filthy and many times diseased 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 unsanitary conditions there 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.

**Poisonous Metals, Notably Lead.**—The solvent effect of water on pure lead is due to any of the following: organic matter, alkaline salts, dissolved oxygen or increased temperature. The amount dissolved is diminished by free carbon dioxide and entirely removed by animal charcoal. All ordinary potable waters, however, possess some slight degree of temporary hardness which quickly deposits carbonate of lime and covers the lead surface, thus solving the difficulty.

**Industrial Supplies.**—Industrially water is of supreme importance furnishing power and heat for various mechanical operations, separating without change soluble and insoluble matter and under special conditions producing profound chemical change

(see glucose). In the form of ice it is still the most practical and generally adaptable method of food preservation. Pure soft water is essential for making steam as any large amount of mineral matter would be left as a residue (sediment or scale) and eventually clog the boiler unless frequently removed. In case good water is not available for steam making some process of purification is always adopted. Organic matter while less harmful has a tendency to attack the iron of the apparatus forming soluble ferrous compounds which later oxidize to insoluble ferric forms producing rust spots.

One of the most annoying troubles with water is "Hardness", temporary or permanent. The former is principally due to soluble bicarbonate of calcium  $\text{Ca}(\text{HCO}_3)_2$  which breaks down on boiling leaving insoluble carbonate of calcium  $\text{CaCO}_3$  as a hard stony deposit (incrustation on tea kettle). Bicarbonate of calcium readily combines with soap forming an insoluble greasy compound with no deterative power. When used in cooking peas, beans and acid fruits it toughens and destroys natural flavor. On the whole it is the more objectionable form of hardness but is rendered harmless by boiling. Permanent hardness is due mainly to calcium sulphate,  $\text{CaSO}_4$ , due to gypsum in the soil. It is not affected by gentle boiling but will deposit as a hard strong crust,  $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$  on prolonged boiling. The readiest means of removal is to add just enough sodium carbonate  $\text{Na}_2\text{CO}_3$  solution to cause the change.



On quiet standing the insoluble carbonate of calcium  $\text{CaCO}_3$  deposits and the clear water may be drawn off. Unless present in excessive amount permanent hardness is not troublesome, slightly hard water of this type is desirable in drawing tea, mixing bread dough and various other culinary operations. As a rule natural waters possess both kinds of hardness in some degree and it is only necessary to determine which is in excess and apply the remedy before using.

#### WATER SUPPLY.

Few realize that supplying water for general household purposes is an important industry. From the fact that it is carried

on by individuals and private or municipal corporations much variation in results is observed. The small water supply is almost always in poor condition while the larger units are invariably good. Such should not be the case but will be so as long as the general public ignore common sanitary precautions since it is from their neglect that trouble arises.

Small communities often derive their supply from a group of artesian or deep wells. The water obtained is purified if necessary and pumped into a tall stand-pipe or tower and from thence flows into the street main. On this plan only enough water need be pumped into the stand-pipe to supply that drawn from the main. The pumping machinery must be in duplicate to avoid interruption of service, thus the expense of storage reservoirs is avoided.

Reservoirs are frequently constructed by closing the narrow end of a deep valley by a dam. When the dam is properly designed and constructed to stand the pressure of the impounded water and is also safe against the unusual strain of freshets, no danger of flooding the lower level lands need be apprehended. Unfortunately in some instances too much parsimony, too little brains and too much dishonesty make conditions which invite disaster accompanied by loss of property and life but this should not condemn the reservoir system.

Small type alum filter plants are quite common. These consist of a series of closed cylindrical iron tanks in connection and a device by which part of the incoming water passes through and dissolves the solid alum placed in a separate chamber. From here the solution proceeds to the mixing cylinder and mingles with the main body of water. The mixture then passes through the filter proper which contains sand, gravel and possibly bone charcoal and thence to the main. The filter is cleaned by reversing the water current and allowing the washings to escape. Alum treatment increases the natural hardness of water.

The use of soluble double silicates for purifying purposes is finding much favor. A feasible method employs the soluble hydrated silicate of soda and alumina. In the presence of soluble compounds of lime, magnesia and iron, highly insoluble com-

pounds of these metals precipitate and are readily removed. By treating these insoluble compounds with sodium chloride the hydrated soluble double silicate is reformed and again ready for use.

The question of public water supply for large communities may conveniently be discussed under the following heads: (1) collection; (2) storage; (3) purification; (4) distribution. In a few cases the problem consists of factors three and four.

**Collection.**—Some large body of water preferably a fresh water lake in a hilly region surrounded by forests is ideal. Otherwise small but reliable streams are impounded by dams forming artificial lakes; here as before it is highly desirable to develop forests preferably of evergreens. The generally reliable rainfall of wooded hilly districts is well known. In some cases rivers of considerable volume even navigable streams are utilized but in these cases extensive purification is absolutely necessary at all times. The Great Lakes cities of the United States have for a long time drawn on these bodies of water in most cases relying blindly on the theory of dilution as a safeguard against contamination. Even deep wells are sometimes used as in Brooklyn, New York.

**Purification.**—In the past sunlight and natural aeration were relied on as cures for contamination but greater experience has shown these safeguards unreliable, hence at the present day purification is deemed absolutely necessary. Two methods are practical, namely preventive and absolute.

In preventive purification every possible precaution is taken to clean up and remove all sources of contamination from the water shed. Furthermore it is necessary to establish a constant and vigilant supervision over the area and all human habitations must be removed from the district. This is only possible where a community can go beyond its legal limits and purchase land available for such purposes. New York City which has partially followed this plan for the past sixty years has invested in many hundred square miles of state territory outside the city limits, has purchased and removed small villages and towns, in some cases build-



ing sewer systems for possible contaminating influences, all at great cost but worth the expenditure when the public *welfare* is considered. On the whole this method while very expensive has its advantages, adding to the territory under forest cultivation, helping to regulate the rainfall and adding to the city park area.

In the absolute purification methods the water is considered impure at all times and treated accordingly. The methods followed are mainly filtration, bacterial treatment and chemical purification. Distillation the most effective method is entirely too expensive for a large supply (one pound or pint of water requires one pound of coal for vaporization) and is confined to the mineral water and similar trades.

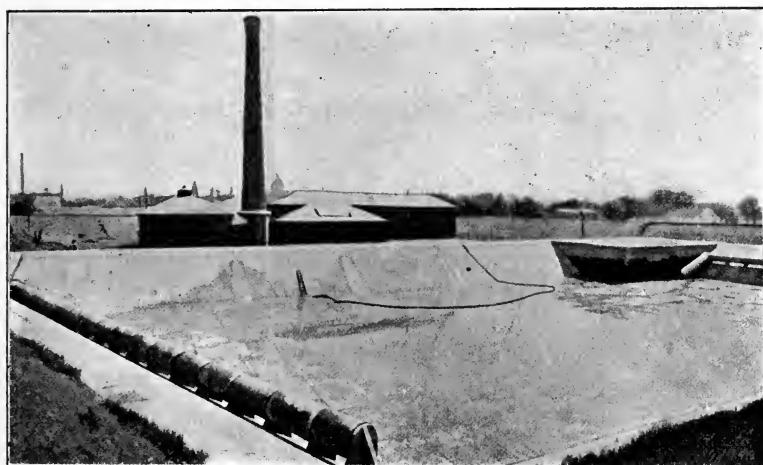
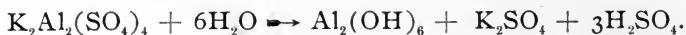


Fig. 1.—Sedimentation Basin.

*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, (Fig. 1), after which potash alum or aluminium sulphate is added, one-tenth of a grain to one 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. 2). Alum will readily ionize in water forming a heavy white flocculent precipitate of aluminium hydroxide, jelly-like in appearance.



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



Fig. 2.—View of the Interior of the East Albany, N. Y., Filter-plant.  
(Courtesy of John Wiley & Sons.)

then acts mechanically much as the bacterial layer of the English filter-beds. These processes do not remove mineral matter.

Where softening is necessary the process consists in adding definite amounts of slaked lime to correct temporary hardness. After sedimentation and filtration the water is ready for use.

*Bacterial Treatment.*—This method is used largely in England and is commonly spoken of as the English Filtering System. It consists of a filtration through beds of sand or other impervious materials 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

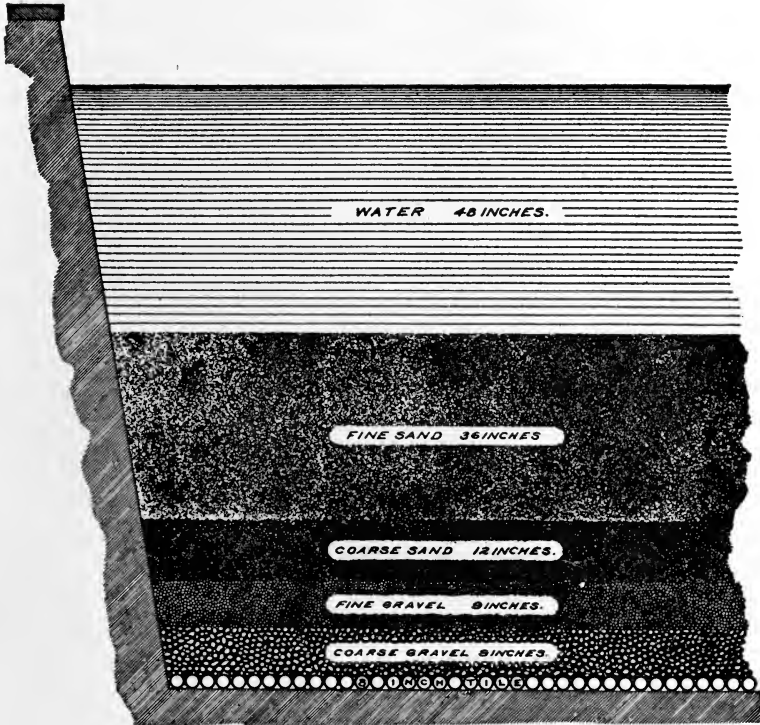


Fig. 3.—Section of an English Filter Bed. (Courtesy of John Wiley & Sons.)

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 beds which are built of 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 3). The water percolates through the layers of sand and gravel to

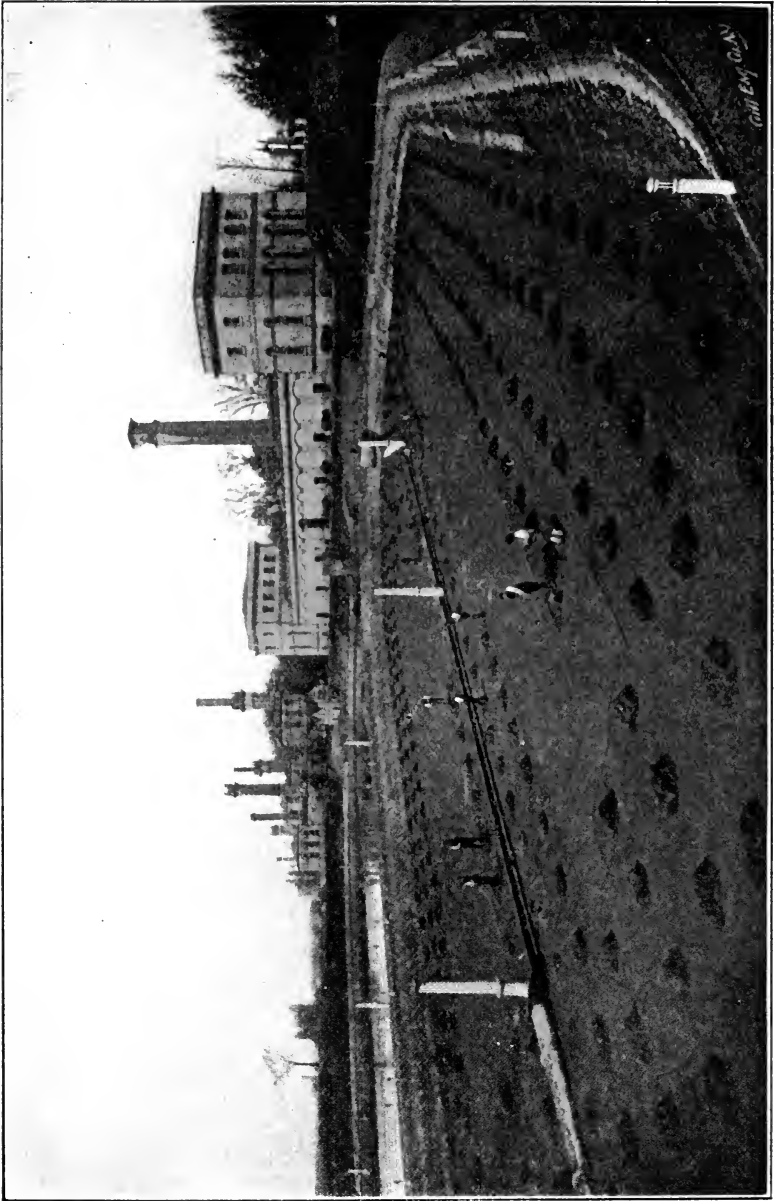
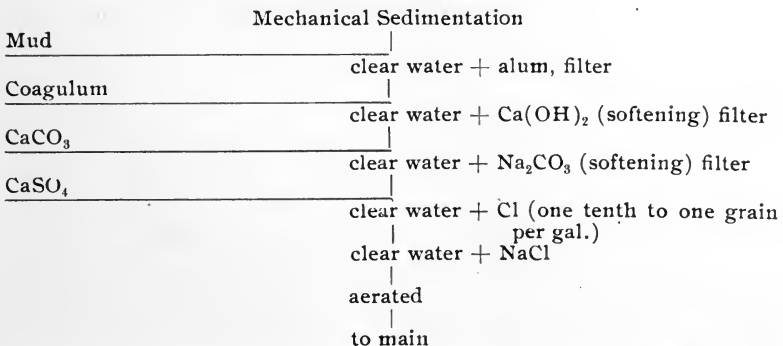


Fig. 4.—Cleaning London Filter-beds. (Courtesy of John Wiley & Sons.)

the drainage pipes which carry it away to the reservoir. Soon a slimy growth containing bacteria appears 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. 4). The scraped-off sand can then 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.

*Chemical Purification.*—These methods are very effective but tend to increase the amount of soluble mineral matter present. Some phase of chemical treatment, such as oxidation and sedimentation is frequently used in connection with the previously described methods. Chemical purification as a sole resort may be described as follows, it being assumed that the water is originally hard, turbid and polluted. The apparatus required consists of concrete tanks, pumps, filter presses and spraying apparatus.

GENERAL SCHEME.



Where  $\text{Ca}(\text{OCl})_2$  calcium hypochlorite (chloride of lime) is used in place of chlorine a subsequent treatment with  $\text{Na}_2\text{S}_2\text{O}_3$  sodium thio sulphate "Hypo" is necessary to destroy the disagreeable odor and taste of the chloride.

The water under treatment is run into the first basin and allowed to remain quietly until coarse sediment has deposited. It is then drawn off into a second tank and as the liquid enters, it is mixed with the required amount of alum. The first basin is now cleared for the next operation while the alum treated water undergoes filtration. As the filtered water returns to the tank it is mixed with milk of lime  $\text{Ca}(\text{OH})_2$ . The mixture stands for some time and is filtered into basin two, which has been cleaned in the interval. As the filtrate enters basin two, sodium carbonate solution  $\text{Na}_2\text{CO}_3$  is added; again follows a short period of rest and filtration, after which liquid chlorine is added in correct proportion and the purified water is aerated and delivered to the storage reservoir or distributing main.



In most communities a reserve store of water to tide over periods of drought is necessary. Furthermore as pressure is required in the distributing system gravity is still utilized to secure this pressure hence reservoirs are usually constructed at considerable elevation. If the aqueduct is of any considerable length considerable pressure is also required to overcome friction.

Storage reservoirs are usually formed by damming some narrow steep valley. Great care should be taken to insure freedom from drainage of a dangerous character and it is usual to stock the water with bass or similar variety of clean water fish and to control the undue growth of marine plants which might affect the taste of the water. This latter trouble is most often experienced in shallow reservoirs and is best controlled by aeration or periodic change of the stored water. Copper sulphate  $\text{CuSO}_4, 5\text{H}_2\text{O}$  blue vitriol in minute quantities is sometimes used to overcome the difficulty. The outlet pipe of the reservoir should be well beneath the surface as this device helps to mix the remaining water.

Provision must be made also for sudden rise of level due to protracted rain or sudden sharp shower. The older method of relief by allowing the water to flow over the dammed end is still largely in use but in most cases the water may be saved by drawing off into reservoirs at lower levels. All storage reservoirs should be so constructed that the water may be drawn off safely for cleaning purposes or in cases of emergency. Loss of life and damage to property have frequently resulted from neglect of proper precautions.

It can readily be realized that a large community using several hundred millions of gallons of water daily must invest a large amount of money as capital and for maintenance of a reservoir system. There is no escape from this charge but it may be considerably reduced by at least two plans. One would be to limit the use of pure water to certain necessary purposes and furnish a less pure form for fire, steam and street cleaning. This would certainly require duplicate street mains but in some of our large cities it has actually been put into practise for fire extinction. Even salt or brackish waters serve well. The other alternative is the so-called "high pressure system" where in large well constructed street mains constant pressure is maintained by a powerful system of pumps. These pumps are usually electrically driven and respond to the increased drain on the mains. The fire pressure system mentioned above is constructed on this system.

*Distribution.*—One of the most complicated problems of municipal engineering is the well balanced street main system. A full and complete explanation of this problem would be too intricate for the scope of this book but some simple essential facts are necessary. In the first place a complete detailed map of streets within the service area is required. This should show differences of level and density of population and also indicate the sections used for residence, business and manufacturing. Fire extinguishing needs must not be left out of the problem and the hydrants usually serve for street cleaning purposes. In order to meet these needs there must be one feed main with shut-off valves at regular intervals to provide for cases of accident. From this main care-

fully planned branches lead off and these in turn flow into smaller service mains. At all necessary points valves are installed to control and equalize the flow. The owners of buildings along the service mains are allowed certain sized openings or taps proportioned to their probable needs and in order that no one may get more than his share meters are usually installed which compute the amount of water consumed.



## CHAPTER III.

### CEREALS.

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. At present the term is applied to the plant as a whole and to the grain itself.

In all ages cereals have been extensively cultivated throughout the world. With the exception of the Arctic region few countries can be found which do not raise grain in some form as a staple food. The reason for the extensive utilization of cereals can readily be seen: 1st, being easily grown they are comparatively cheap; 2nd, there is little refuse as compared with meat, fish and similar products; 3rd, they contain a fair proportion of nutritive value; 4th, if properly protected from dust and insects the keeping quality is excellent; furthermore, on account of dryness, they are not readily attacked by micro-organisms; 5th, they can be easily prepared for the table, are palatable and when properly cooked are not difficult to digest.

The most important varieties are wheat, maize, rice, oats, rye and barley; those of secondary importance, buckwheat, sorghum and millet. Rice is the leading cereal of the orient but to it must be added the seed of millet which is largely used by the people of Southern Asia. Rye and barley are grown chiefly in Europe while maize occupies the largest part of the cultivated area in the Americas. Among the cereals wheat has occupied the leading place in Europe and America for a long period. This is undoubtedly due to the fact that it can be converted so readily into bread-stuff. For a brief history of wheat and milling processes, see Chapters IV and V.

**Composition.**—The following table published by the United States Department of Agriculture shows the average composition of the chief grain products available for human consumption as milled and sold in the United States:

A very significant fact is the general similarity of composition of these grain products, although they have been based on scattered analyses made at different times. As regards digestibility, there seems to be no marked differences aside from those which might arise from the use of various processes of cookery.\* The sameness in composition and digestibility were important factors which led to the replacement of wheat by an equal weight of barley, corn, rice, etc., during that period of the World's War, when the Allied Nations looked to the United States to supply them with bread-making material. As a result of these substitutions large consignments of wheat and wheat products were released for shipment abroad.

Description	Moisture Pct.	Protein (Nitrogen x 6.25) Pct.	Fat Pct.	Carbo-hydrates Pct.	Ash Pct.	Calories per Pound
Barley meal.....	11.9	10.5	2.2	72.8	2.6	1603
Barley, pearly.....	11.5	8.5	1.1	77.8	1.1	1615
Buckwheat flour.....	13.6	6.4	1.2	77.9	0.9	1577
Corn meal.....	12.5	9.2	1.9	75.4	1.0	1620
Hominy.....	11.8	8.3	0.6	79.0	0.3	1608
Oatmeal.....	7.3	16.1	7.2	67.5	1.9	1811
Rice.....	12.3	8.0	0.3	79.0	0.4	1591
Rye flour.....	12.9	6.8	0.9	78.7	0.7	1588
Wheat flour, avg. high and medium grades..	12.0	11.4	1.0	75.1	0.5	1610

#### INDIAN CORN OR MAIZE.

Indian corn or maize is indigenous to the tropical countries of America. It is believed to be a native of Central America and Mexico and to have passed through the same stages of cultivation and dissemination as other cereal foods. It resembles the sugar cane of the tropics rather than the other cereals and has the most beautiful and luxuriant growth of all the grains.

The records of the early voyages to the Western World prove that maize was cultivated on this side of the Atlantic from the St. Lawrence to Chili at the time of the discovery of America. It was the great bread plant of the New World. Later in his-

\* Columbia War Papers. Series 1, No. 15.

tory many varieties were found, some under cultivation, others as preserved specimens in the ancient tombs of Mexico, Peru and New Mexico thus leading to the belief that it had been in use for possibly two thousand years. This cereal proved to be the salvation of the early settlers, preserving them and their stock from starvation. The chronicles of Virginia and other colonies contain many descriptions of its cultivation, the white man first receiving the food from the Indian, then learning the secrets of its successful growth from his red brother. It was called by the English colonists corn, the European term for any hard edible seed. So exclusively was the grain grown in the New World that in time the word lost its original meaning and came to be applied only to this type cereal. The term maize appears to have been derived from mahiz, the name used for corn by the natives of the Island of Hayti.

Indian corn was introduced into Europe after the discovery of America. It was later carried into Asia by the Portuguese merchants and into Africa by the missionaries. In the Western World the cultivation advanced with the progress of the white race.

**Cultivation.**—Maize is now one of the staple food crops of the world, the quantity produced is greater than that of any other cereal. Climatic conditions alone limit its more widespread distribution. These include temperature, sunshine, rainfall and such physiological features as soil. In the United States where two-thirds of the world's crop is cultivated, maize growing has become one of the leading industries exceeding in value that of wheat and cotton. Although grown to a greater or less extent throughout the states "the corn belt" appears to have the best combination of climatic conditions for the production of maize. About fifty-eight per cent. of the cereal is grown in this belt which includes Iowa, Illinois, Nebraska, Kansas, Missouri, Indiana and Ohio.

Aside from the United States the most important maize producing countries are Hungary, Roumania, Italy, Russia, Mexico, Argentina, South Africa and Egypt. Of late years the greatest

development has been in Argentina, which has the largest area of undeveloped land adapted to maize growth. About fifty per cent. of the crop was exported but less is now being sent abroad owing to local demands for stock feeding.

In the export trade the United States plays an important part. While a small per cent. is exported compared to that of wheat, the amount is large and is increasing. Roumania and Russia are also represented in the export trade. South Africa has great opportunities for competing for trade in the world's market, a fact not appreciated up to 1907. Until that date local markets took all that could be produced but in 1907 a bumper crop lowered local prices while high maize prices prevailed in Europe. Other factors influencing maize exportation were a financial depression due to the Boer War which put business men on the *qui vive* for new openings and government assistance by offering reduced railroad rates and other facilities.

**Composition.**—The corn kernel contains a comparatively low percentage of ash, which consists principally of the phosphates of potassium and magnesium. While a relatively small amount of lime is present it is important where corn is fed to growing pigs. The mineral matter also furnishes valuable fertilizing material. Several varieties of protein have been identified of which zein (alcohol soluble) is the most important. These proteins, however, have not the property of forming gluten when mixed with water. The chief constituent of the kernel is starch. This fact is taken advantage of in the United States by the starch manufacturer who uses corn for the extraction of starch. See Chapter IX. The germ yields an oil of great commercial importance.

**Varieties.**—Popcorn, flint, dent, soft maize and sweet corn represent the chief bulk, although there are some seven hundred varieties of corn grown in the United States. As a rule the kernel is yellow or white but various colors are found, red frequently occurring in dent corn and blue, purple and black in the sweet varieties.

*Popcorn* is characterized by the small size of the kernel and the property of popping. When partially dry the grain will explode if exposed to a high temperature, resulting in a white fluffy palatable mass.

The cultivation of *flint* corn has largely given away to the *dent* variety in this country. It represents the bulk of corn grown in Argentina and is raised to a limited extent in Canada and our northern states. The European markets prefer flint which has a small kernel for the feeding of poultry, stock and game.

Most of the field corn grown in the United States and nearly all the maize exported is the *dent* variety. It can be recognized by the indentation at the apex.

*Soft maize* was apparently largely grown by the Indians on account of the ease with which it could be crushed. It is still used in parts of South America but is not cultivated in our country.

In *sweet corn* part of the starch has been reduced to sugar. It is extensively raised for use as a green vegetable and forms the basis of the largest canning industry in the North Atlantic and North Central States.

**Uses.—Food.**—As a food for domestic animals the importance of corn cannot be overestimated. This constitutes its chief value although much of it is used for human consumption and for manufacturing purposes. The grain is largely utilized as food for horses and maize ensilage forms an important element in the production of dairy products. It is still more important in the pork industry where it has been found to be the most desirable material for fattening hogs. Notwithstanding the fact that enormous quantities of corn can be grown in the country, comparatively little is exported. The greater part of the crops produced never leaves the farms on which it is grown, it having been found to be more profitable to utilize it to fatten cattle, sheep and swine brought from our western stock ranges.

As food for man Indian corn is the leading cereal of the Americas. It plays an important part in the dietary of most of the South American countries where it is made into various

forms of bread and cake. In the United States the relative importance is less than wheat but the actual amount consumed is high, especially in the Southern States, where corn is served in some form daily at one or more meals. Corn may be eaten, cracked or crushed as hominy and finely ground, either bolted or unbolted as flour or meal. It is frequently used in manufacturing the so-called breakfast foods. As popcorn it furnishes a delicacy used throughout the states. Sweet corn makes a palatable article of diet as does also the canned varieties.

*Other Uses.*—The kernel, which contains the starch in comparatively large amounts, furnishes the source of supply of most of the American starch industry. Corn is largely used in the preparation of alcohol and alcoholic beverages. On account of its porosity and power of absorption, corn pith is used in the construction of war vessels. Compressed blocks of corn pith cellulose are placed behind the outer armor where in case of being pierced during battle, the water will be quickly absorbed. Another use for pith is in the manufacture of explosives. The stems are used in the preparation of paper and the husks for mats and mattresses. The dried cobs furnish a fuel and a material for making pipes.

**Early Methods of Preparation.**—Hulled corn or lye hominy 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 when 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 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 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, and either 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 as well.

#### RICE.

Of the cereal crops grown in the Orient rice was considered to be the most important as early as 2800 B. C., and it still continues to be the leading grain of the Eastern World. It is supposed to have been carried into Persia from Southern India and later into Spain by the Saracens. Although introduced into the Virginia Colonies in 1647 its culture on this side of the Atlantic did not begin until 1694, when the captain of a sailing vessel from Madagascar presented a bag of "paddy rice" to the Governor of South Carolina. It soon became an important industry

of that state and continued as such until the breaking out of the Civil War.

**Geographical Distribution.**—While this cereal is grown throughout the warmer parts of Asia, the rice fields of India, China and Japan produce not only the largest crops but are especially noted for their high state of cultivation. Other rice producing countries are Spain, Italy, Egypt and Central America of which Honduras is the most important. In the United States rice is still regarded as a secondary crop, although its cultivation has increased considerably in recent years due to the development of the prairie regions of Louisiana and Texas. While it is also grown in the Hawaiian and Philippine Islands the quantity is not sufficient to meet the local demand. In the export trade British India occupies the leading place, about three-quarters of the rice of commerce is being sent out by that country.

**Composition.**—Rice is especially noted for its high percentage of starch and a correspondingly low percentage of other substances. In the East the deficiency of protein is supplied in some cases by the addition of fish or eggs, at other times by the soya bean with which it forms a cheaper complete food than wheat and meat. In its natural unpolished state rice is believed to be one of the best of cereals. That the human body can utilize it to advantage was proved by its use in the Russo-Japanese War in which rice formed the principal food of the Japanese soldiers.

**Cultivation.**—Rice is a tropical or semitropical plant and attains its best development in a moist insular climate. It is one of the most extensively cultivated grains. 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 and will grow best on soil ill adapted to other grains. Numerous varieties are found, among the most important of which are the upland rice and the lowland rice. The cultivation of the former variety is quite similar to that of other cereals. Lowland rice requires a moist soil which can be irrigated, drained



out promptly and which will become solid enough after draining to harvest to advantage. Japan grows large quantities of rice on terraces of hills and mountain sides by flooding from reservoirs built on a higher elevation. In the United States the delta and inland marshes of the South Atlantic States have long been used for rice culture. Here tidewater free from salt can be utilized for flooding at high tide and drained at low tide. Alluvial land along the Mississippi and prairie soil of Louisiana and Texas are favorable for rice production.

**Milling.**—The primitive method of milling rice, still used in many of the oriental countries, is very simple. Rough rice is placed in a hollow stone or block of wood and pounded with a pestle until the hull and cuticle are sufficiently loosened to be removed by the process of winnowing. In modern milling the preparation of rice for the market necessitates not only a thorough cleaning and separation of undesirable material but a polishing of the surface of the rice kernel. The process is long and complicated but mills are now being used which combine all operations in one machine, receiving the rough rice from the thresher and turning out clean rice ready for use. Briefly the processes are as follows: Rough rice is screened to remove dirt and foreign material of all kinds. The chaff is loosened by rapidly revolving mill-stones after which the broken grains and chaff are separated by screens and blowers. In order to remove the outer skin of the kernel the grain is put through a huller or into huge mortars and pounded with heavy pestles; a separation of flour, fine chaff and clean rice is effected by screens which remove the flour and by fans which blow out the fine chaff. The clean rice which has become heated where friction is used must remain in cooling bins from eight to nine hours. After passing through brush screens to remove the last of the rice flour, rice is ready for the final process of polishing which is accomplished by friction with moosehide or sheepskin rolls. The polishing of rice gives to the marketable product a 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 and mineral matter. Unpolished rice is more economical, has greater food value and has a richer flavor which makes the rice served in Oriental countries so much superior to much that is obtainable in this country.

*Uses.*—Rice furnishes a starch supply more easily digested than that of other cereals and many of the vegetables. It is said to enter into the dietary of more than one-half of the human race and to form more than fifty per cent. of the substance of people in some parts of the orient. In rice growing countries where it is eaten whole or in soups it is used as a substitute for wheat bread and potatoes. On account of the low gluten content it is not used alone for the preparation of bread or pastry, but is sometimes mixed with wheat flour in the preparation of the former.

Large quantities of rice are used for starch manufacture, rice starch being a desirable thickening medium for use in laundries and muslin factories. Rice is the source of the chief alcoholic drink of India and the national beverage of Japan. Lower grades of the cereal known as brewer's rice, are used in Europe and America for the production of malt and alcoholic liquor. Fresh rice bran can be used for stock food, rice hulls for fuel, material for packing breakable articles and for similar purposes. Rice polish is sometimes fed to cattle and pigs or it can be used in the manufacture of buttons and in the preparation of sausages.

#### RYE.

The cultivation of rye is not nearly as ancient as that of wheat and barley. History contains no evidence of its having been used by primitive people, specimens never having been found in Egyptian tombs or among Swiss lake dwellings. Its early home appears to be around the Caspian Sea, although original species occur from Spain and Morocco to Central Asia. During the Middle Ages it furnished much of the bread material for the great body of people in Europe. In fact it was not until after the middle of the nineteenth century that its use was gradually superseded by wheat. Among the peasantry it is still extensively used in Continental Europe. Russia is the leading country to-day in rye production, the crop doubling that of wheat and being the

largest of any one crop in the world except that of maize in the United States. Austria-Hungary, North Germany and the Scandinavian countries also furnish large quantities of rye. Formerly it was more important in England and the United States than it is at present.

**Composition.**—Rye is more closely related to wheat than any other cereal although differing from it in several particulars. The general structure is similar, a difference being detected only in the microscopic appearance of the starch granules and cells of the aleurone layer both being slightly larger in the case of rye. The percentage of protein and fat is less than wheat. While the proteins do not appear to be identical in all cases with those of wheat sufficient gluten-forming elements are present to make rye flour adapted for the production of a porous bread.

**Uses.**—Rye is used chiefly for the manufacture of flour, as food for domestic animals and in the preparation of alcohol and alcoholic beverages. As a world's bread material, rye is second only to wheat. The flour is either bolted by modern milling processes or used as a coarse meal similar to Graham. Rye bread is highly nutritious but is less pleasing to the eye than wheat bread. It is darker in color, more 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 greater yield of gluten and makes a larger and more palatable loaf of bread. In the United States rye flour is not in great demand. It is used principally by those who have acquired the taste in European countries.

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. It also forms a satisfactory food for animals and may be fed as a substitute for maize. The bran is used for feeding and the straw for the manufacture of paper, as a packing material and for the bedding of domestic animals. The demand for straw is largely responsible for the production of rye in this country.

### OATS.

All evidence points toward Eastern Europe and Western Asia as the place of the first cultivation of oats. No mention is made of their use in any of the ancient nations so they could not have been important in the early history of our race as were wheat and barley. Oats did not occupy a prominent place in man's diet until civilization was carried into Central and Northern Europe. In time they became an important crop in the British Isles particularly Scotland and Ireland.

**Cultivation.**—Oats are grown to the greatest extent to-day in Europe, the annual production in bushels exceeding that of wheat. In the United States it is exceeded only by that of maize, the largest yield being in the North Central States, particularly Illinois, Iowa and Wisconsin. The harvesting, threshing and storage of oats are similar to those of wheat. The quantity exported is still small compared with wheat and maize but it is increasing more rapidly than the other cereals. Both the grain and oatmeal are shipped abroad, the largest quantities being sent to Great Britain and South Africa.

**Uses.**—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 domestic animals. Oats furnish the chief grain food for horses and are desirable for cattle and sheep. They are used in this country interchangeably with maize, the amount of each depending on the relative cost of the cereals. As a human food they are the most nutritious of the cereals, the kernel being richer in protein and fat than the corresponding part of the other grains. About the only form in which it appears on the market for use in our diet is oatmeal, the consumption of which has increased enormously in recent years and has led to the introduction of many forms of breakfast food.

**Oatmeal.**—Although used for a long period in Scotland oatmeal did not appear on the American table until about fifty years ago. It is now our leading breakfast food. In the manufacture this grain is thoroughly cleaned to remove foreign matter of all

kinds, kiln-dried to loosen the outer husk and to develop flavor, then screened to remove husks. The kernel thus freed is known as groats. All forms of oatmeal are produced from groats. The outer husk is closely adherent to the grain and cannot be entirely separated from the kernel by the ordinary method of grinding. Oatmeal, therefore, consists of not only the kernel but a great deal of cellulose in the form of small sharp particles. These act as a stimulant to the intestines but are irritating to some people. On account of the large amount of fat oatmeal is frequently spoken of as a "heating food" and its use is discouraged during the summer months. In the American dietary, however, oatmeal is not eaten often or in large quantities, so this cannot be a serious consideration. It is particularly adapted to people living in cold climates or for those who take plenty of out-door exercise. In parts of Scotland it is said to furnish the chief article of diet among the plowmen. For further information, see Chapter VI, Breakfast Foods.

#### **BARLEY.**

Barley is generally supposed to have originated from the wild species native to Western Asia. It is undoubtedly one of the earliest cereals used by mankind, for preserved specimens have been found in the lake dwellings of Switzerland, in deposits belonging to the Stone Age and in the earliest Egyptian monuments. In the books of Moses barley is mentioned, early Greek and Roman writers frequently referred to it and the sacred barley of antiquity figured on many of the ancient coins. Its use may have preceded even that of wheat. Among the Greeks particularly it was held in such high esteem that their athletes were fed on barley while in training for their games.

**Cultivation.**—The general appearance and habits of growth are quite similar to wheat. Although it is best adapted to a warm, dry climate it is cultivated in a wider range of climate than any other cereal. Its limit extends from the subtropics to the extreme north where the soil melts only a few inches deep. While it is an important crop in Northern Russia, Norway and Sweden, it was formerly the bread plant of the people bordering on the

Mediterranean. Russia, Germany and Austria-Hungary are the principal barley producing countries of to-day. In the New World it can be cultivated from Alaska to semi-tropical California, grows freely in Chile and matures in the Andes at an elevation of eleven thousand feet. It is produced in the United States to the greatest extent in California, Minnesota, Wisconsin, Iowa, the Dakotas, Washington, New York and Nebraska. As it requires a smaller annual rainfall than other cereals it can be successfully grown more seasons in the semi-arid regions of our Western States and requires less water where irrigation is employed.

**Composition.**—Barley contains all the nutritive properties of the other cereals. The seed has more crude fiber than wheat, otherwise its composition has been found to be almost identical. It differs from oats in having less fat and more starch and from maize in less fat and more crude fiber.

**Uses.**—Where the population was dependant on native crops barley formed an important article of diet in most of the northern countries until comparatively recent years and it is still used in the north of Europe among the peasantry. In England it was the leading cereal of the early days, the traditional goosepie and bag pudding of the Christmas feast being made of barley. It was used until very recently by ninety per cent. of the laboring class but gradually wheat has taken its place throughout Great Britain although barley cakes are to some extent still eaten. In Japan rice is generally supposed to be the only cereal but barley is so largely used among the poorer classes that a social line is frequently drawn between the rice-eating and barley-eating natives.

The chief uses of barley in recent years are for malting purposes and as a food for domestic animals. It is grown extensively in Europe for horses, cattle and pigs, its use there being similar to that of maize in this country. In the United States where maize and oats furnish the chief food for animals it is not raised to any extent for that purpose except in the Pacific Coast States where for climatic reasons maize and oats cannot be grown to

advantage. Its chief use in America is for malting purposes as it has the greatest diastatic and peptonizing power of all the cereals. It germinates quickly, uniformly and completely, qualities essential to malting.

As a human food barley has been little used in this country. Until quite recently the only milled products found on the market were meal and pearl barley which were used for thickening soups, making cool drinks for invalids and for infant feeding. Recent improvements in milling have added to the list a limited amount of barley flour for use in the preparation of bread, biscuits and similar products. Not having the gluten-forming elements it cannot be employed alone for breadmaking but it has been found to be one of the best of the substitutes for mixing with wheat when necessity demanded a conservation of that cereal.

#### CEREAL CROPS OF MINOR IMPORTANCE.

*Buckwheat.*—Compared to other food grains buckwheat is of comparatively recent cultivation. It was introduced into Europe through Russia in the Middle Ages and in the American colonies early in their history. From a botanical point of view buckwheat is not a cereal but the seed is used as such and under that name it enters into commerce, so it is customary to class it with the cereal crops. Buckwheat is grown to-day in Russia, France and other parts of the continent and in the United States, especially New England, New York, Pennsylvania and Michigan. The nutritive value as compared to wheat is low, there being more crude fiber and less protein, but sufficient nourishment is present to form a satisfactory food. As a human food it is used in our country in the form of flour from which the well known buckwheat cakes are prepared. The marketable product in Russia is more frequently groats from which porridge or various types of compact cakes are made. The white flower of the buckwheat is highly prized for bees, a dark honey of peculiar flavor being produced which has a recognized place in our market. Buckwheat is also utilized as food for hens, swine and milch cows.

*Sorghum.*—Sorghum is an extensively cultivated cereal known under many names—Kefir corn, Guiana corn, African and Indian

millet, durra, etc. It was used in prehistoric times in parts of Africa, India and China and is now raised in all the drier, warmer countries of the world. Three principal groups are recognized: 1st, sweet or saccharin; 2nd, broom corn; 3rd, varieties cultivated for the grain. The first and second varieties have been grown in the United States for a long period, the former on account of the high sugar content from which a sirup is prepared and the latter for the production of raw material for the manufacture of brooms. The development of the third variety in recent years has been largely due to the fact that a crop can be produced on less rain than maize and it is not affected so disastrously by hot winds. These drouth resistant qualities make it a certain crop in our semi-arid land where maize frequently fails. As compared to maize, sorghum contains a smaller percentage of protein and fat, in other respects the composition is quite similar. Sorghum, however, is not the equivalent of maize; it is less palatable and cannot be used so exclusively or continuously as food for live stock. Although used in the United States and Europe only as fodder the seed enters the dietary of the human family of a large proportion of the people of Africa and Asia.

*Millet.*—The term *millet* is applied to a large number of cereals the seeds of which are smaller than those of wheat, rice, oats and barley. The word means little to us for millet is not used in the United States except for live stock. It is used, however, so extensively in India, China, Japan, Korea and parts of Africa and Europe that it is estimated that one-third of the human race utilizes millet as a staple food. Where it is employed in the dietary of man it is milled into flour from which bread and cakes are prepared. They are considered nutritious and are palatable when fresh but become dark in color and crumbly when kept.



## CHAPTER IV.

### 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 completely 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.

It is impossible to tell how long it has been utilized as a food by mankind for archaeologists claim that its record begins in pre-historic times. The most ancient languages mention wheat 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 three thousand 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 six thousand years.

**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 of 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 suitable lodging place along the shores of the Mediterranean. The climate was favorable 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 wars were for the purpose of capturing the harvest from their more successful wheat growing neighbors.

The spread of wheat culture from those early days was closely connected with the migration of the human race. The cultivation, eventually extending throughout the greater part of Europe, reached its height in Russia where climatic conditions and a rich fertile soil were most suited for its growth. The crops harvested were so much in excess of local demands that Russia became a great exporting country and in time 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 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 immense undeveloped areas that would make ideal wheat fields and much is being looked for in the Siberian wheat-growing area. It would be difficult to predict, however, what part Russia 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 one of the greatest wheat producing countries of the world largely due to the Siberian wheat fields.

France and the Balkan States also occupy an important place in European wheat production followed by Germany, Spain and Italy.

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 great western plains this cereal was again to find most favorable conditions for growth. With large areas of fresh land easily brought under cultivation, with reduced cost of production and handling due to the introduction of labor-saving machinery and extensive railway construction, the progress of wheat production has been rapid. Before the close of the nineteenth century the United States had become the greatest wheat producing nation on the globe.

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 irrigation and the development of drought resistant varieties it is also hoped that more of the semi-arid land of the west can be used.

Canadian history of wheat production is quite similar to that of the States. Soft varieties have been cultivated in the Maritime Provinces for a long period but with the opening of the Central Plateau in recent years it has been found that thousands of acres which were considered waste land can be utilized for wheat growing. Although only a small percentage is now under cultivation the virgin soil is producing large crops of superb spring wheat much needed for blending with soft varieties.

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, agri-

cultural 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 abroad.

Although Asia must be looked upon as the great rice growing section of the world, in British India wheat production has long been an important industry. An enormous stimulus was given to wheat culture when the Suez Canal was completed, thus giving a water way for the exportation of wheat to European markets.

In recent years Australia has become an important factor in wheat production. Climatic conditions are not favorable for hard wheat but soft varieties are grown which have a high flour yield and valuable qualities for blending.

While the United States, Russia, India, 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. It is said that should man disappear from the earth wheat would follow in three years. 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 find 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 great national importance.

Hand in hand with the progress of agricultural methods is found the progress in motive 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 ox 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 motive power so in implements can the progress of the world be seen, by a comparison of the sickle as seen on Egyptian monuments, with the modern combined harvester of the great western farm-lands.

**Structure of the Wheat Grain.**—(Figs. 5 and 6.) *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.

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

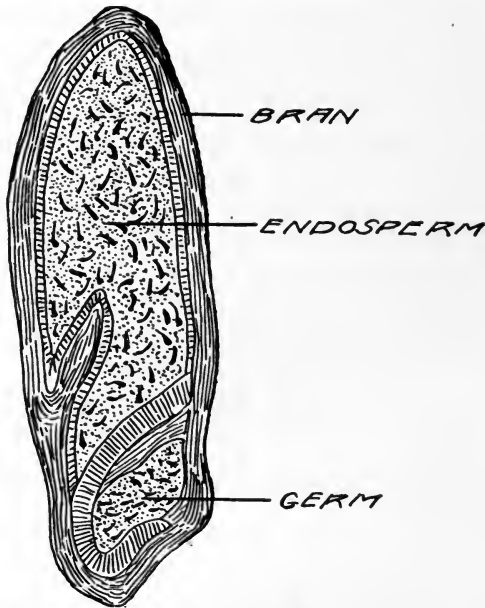


Fig. 5.—Longitudinal Section Through a Grain of Wheat.

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.

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 differing climates and soils, the ease of cultivation, a quick and abundant harvest, rapid improvement under cultivation 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.

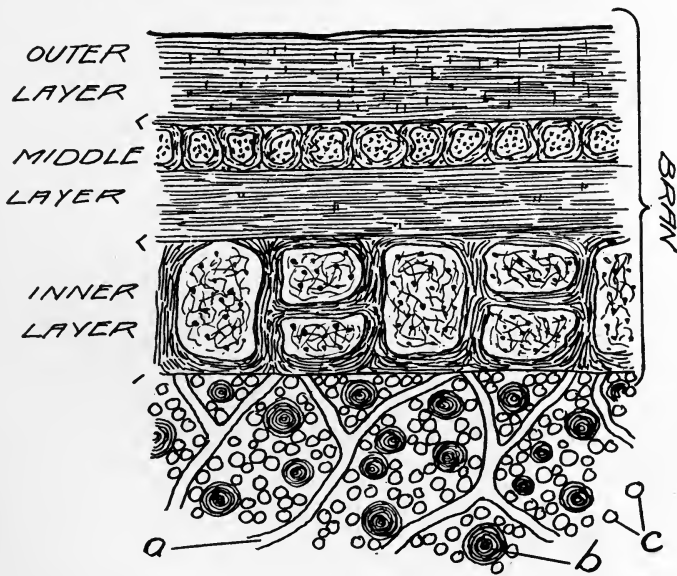


Fig. 6.—Section Through Part of a Grain of Wheat. -  
*a*—Cellular Structure. *b*—Starch Granules. *c*—Protein.

Osborne and Voorhees 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, four and twenty-five hundredths per cent. of the entire grain. In the presence of water these proteins unite to form gluten to whose peculiar physical properties wheat bread owes its porosity. The other cereals contain similar proteins but not in the right proportion to form

gluten with the exception of rye flour which does not make as light or 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. A collection of over one thousand samples obtained from the wheat countries of the world was experimented upon by the United States Department of Agriculture. After five years' trial it was decided that in all the species and subspecies of wheat there were about two hundred and forty-five which might be regarded as leading varieties of the world.

The different species of wheat are usually placed under two headings—winter and spring wheats. Winter varieties are planted in September and harvested early in the summer. On account of slow growth and high percentage of moisture a maximum of starch and minimum of protein are developed in the endosperm. Flour made from these wheats is soft and having low gluten content does not make desirable bread; yet it was the flour used largely for breadmaking by civilized nations until the latter half of the nineteenth century. The spring wheats are planted in the early spring, develop rapidly in the summer heat and are ready for harvesting in the fall. Being high in protein they are excellent for milling into bread flours. The development of the spring wheat area in our country led not only to agricultural reforms, but to new milling processes which were 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 there can be produced 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. 7. 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



Fig. 7.—Hand-stone.

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 Ninevah, 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 on 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 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. 8). 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 was led captive 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.



Fig. 8.—The Mortar and Pestle.

**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 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 upper one of which revolved. They were very heavy, sometimes weighing fifteen hundred 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. 9). When the two stones touched in revolving it was spoken of as "low milling." The grain was fed from above and the grinding motion con-



Fig. 9.—Roughening Burr-Stones. (Courtesy of the Washburn-Crosby Co.)

tinued 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 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, and the hopper-bag were invented and finally the middling purifier.

With the invention of the middling purifier, "high milling" or the gradual reduction process 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.

As hard spring wheat, however, appeared in quantity other improvements were necessary. When millers visited Hungary they were surprised to find the progress that had been made along mechanical lines. There the grain was being crushed by means of hard porcelain rollers. Americans were very quick to see the advantage of this process and a roller-mill outfit was shipped from Hungary to Minneapolis. Many changes in machinery were necessary to meet new conditions, but from 1881 roller-milling rapidly increased and before the dawn of the twentieth century, the 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 the Old Processes.**—(1.) They were not economical on account of slowness of operation and wastage of power: (2) In low milling friction caused heat which would bring about chemical changes, thus affecting the keeping quality of the flour; (3) The stone-mill was never as effective in separating the parts as the roller mill.

## CHAPTER V.

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### 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. Dust, which is always produced during the cleaning and milling operations, is one of the most serious dangers in a modern milling system and strenuous attempts are made in all departments to efficiently cope with it. Neglect of this important process caused a serious explosion which wrecked one of the first roller mills of Minneapolis during 1877-78. That disaster led to the development of the dust-collecting system, consisting of a large rotating diaphragms which by suction collect dust in its many forms 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 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, in order to extract the coarsest refuse and the worst of the sand and dust, thus preventing the choking of handling bands and elevators. From the wheat fields as well as during transportation, impurities of many types have been gathered—foreign seeds, powdered earth, heavy sandy dust full of germs and sometimes filth, weevils, minute insect life—all of which will attack the grain and either kill or materially damage it. Strong aspiration and screening treatments must be applied before wheat can be safely stored for any length of time.

**Cleaning of Wheat.—Receiving Separators.**—These separators consist of a preliminary screen and two main sieves contained in

one frame. All are made of perforated zinc, are slightly inclined and kept constantly in motion. The preliminary screen removes only the coarsest rubbish and allows the finer refuse to fall through on the head of the first main sieve which separates large seeds, sticks, stones, etc. Sandy dust and fine seeds are removed by the second main sieve. By means of a large and powerful fan operating within the separator, fine dust is drawn away and discharged with the dust-collecting system.

*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. Although a preliminary cleaning has taken place wheat is still classed as dirty for at best only the grossest impurities have been removed. Small foreign seeds, smutted and immature grains must be extracted, to prevent the possibility of the contents of diseased grains spreading. This is effected by mill separators, a series of sieves constantly shaking, the perforations of which are smaller than those of the receiving separators—wheat is held back while foreign and imperfect grains pass through.

*Scourer.*—While much of the foreign matter has been removed by aspirations and screening operations, the individual wheat berry in some cases is smeared with mud and other impurities, the beard and light shrivelled tissue often present on the grain must be extracted and the berry polished. In the scourer wheat grains are scoured and brushed repeatedly, aspiration being carried on at every possible place within the system.

*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 removed or the quality of the flour will be impaired. As it follows the wheat kernel in the receiving and mill separators, a special device known as the cockle cylinder has been invented for their removal.

*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 con-

tamination. Some millers, however, prefer to wash all wheat afterwards carrying it through a drying process.

**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 toughening the bran coats so they can be removed in larger particles, leaving the middlings as free as possible from impurities for regrinding. 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.

**Separation of the Middlings.**—*Roller Mill.*—The mill consists of two or four steel rolls in one cut or frame about two feet long and having small teeth, twelve to twenty-eight to the inch, on the outer surface for the purpose of disintegrating the berry



Fig. 10.—Section of Roller Mill.

(Fig. 10). They rotate at different speeds. 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 (Fig. 11).

**Scalper.**—As the grain passes from the first roll 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 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.



*Second Roll or Break.*—The first separation is very crude for the bran coats still carry much of the interior with them. To separate 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.

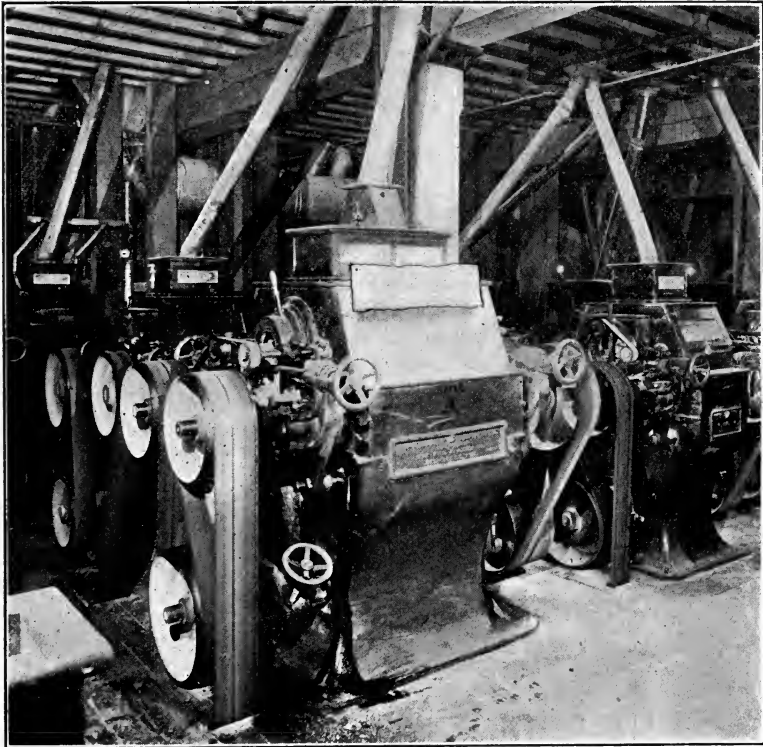


Fig. 11.—Roller Mills. (Courtesy of the Washburn-Crosby Co.)

*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.

**Reduction of the Middlings.**—The material obtained from the various sifters of the break rolls, known as middlings, is mixed and constitutes the part that is to be made into flour. There are three important machines met with in this operation—the purifier, the smooth rolls or pulverizer and the bolter.

*Purifier.*—The middling purifier (Fig. 12) is very complicated in its mechanical structure, but simple in principle. It consists of

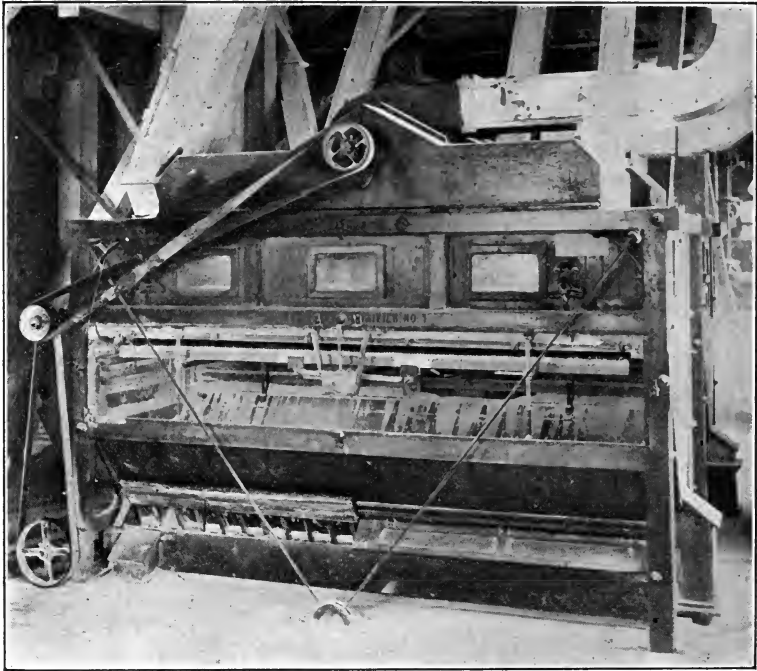


Fig. 12.—Middlings Purifier for Taking Impurities from the Crushed Grain.  
(Courtesy of the Washburn-Crosby Co.)

an incline sieve divided into eight sections, each covered with a different mesh of heavy grit gauze silk. While operating a current of air passes upward through the screen in order to remove light particles of bran. The heavy middlings pass down through the sieves and are caught in a receptacle from which they are conveyed to the smooth rolls.

*Smooth Rolls.*—These are made of chilled iron case hardened, one moving faster than the other causing a disintegrating or grinding motion. They are really pulverizers. The purified middlings passing through the smooth rolls 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.

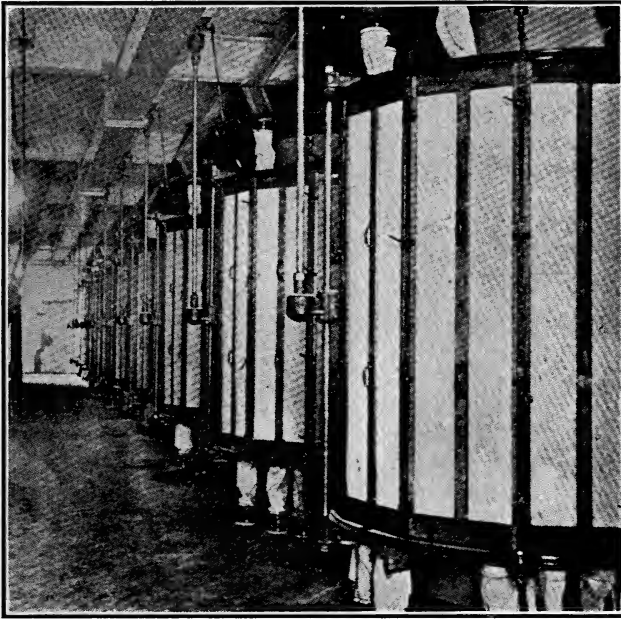


Fig. 13.—The Modern Sieve or Bolter. (Courtesy of the Hecker-Jones-Jewel Milling Co.)

*Bolter.*—The bolter (Fig. 13) is a large machine containing some three hundred and sixty sieves made of silk bolting cloth with varying mesh. The machine moves with a rotating 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 flour. All coarser parts again go through the purifier and smooth roller repeatedly, finally being separated by the bolter. When the

separation is complete the flour is ready to be automatically packed in bags or barrels. As it gives a yellow appearance to the flour and impairs its keeping qualities, the germ is removed by bolting and purifying during the early stages of the refining process.

**Advantages of the New Process.**—1st. Increased capacity due to greater strength of the parts and consequent greater speed of revolution; 2nd, much less power is required to run the machinery on account of less weight of the parts; 3rd, present day process

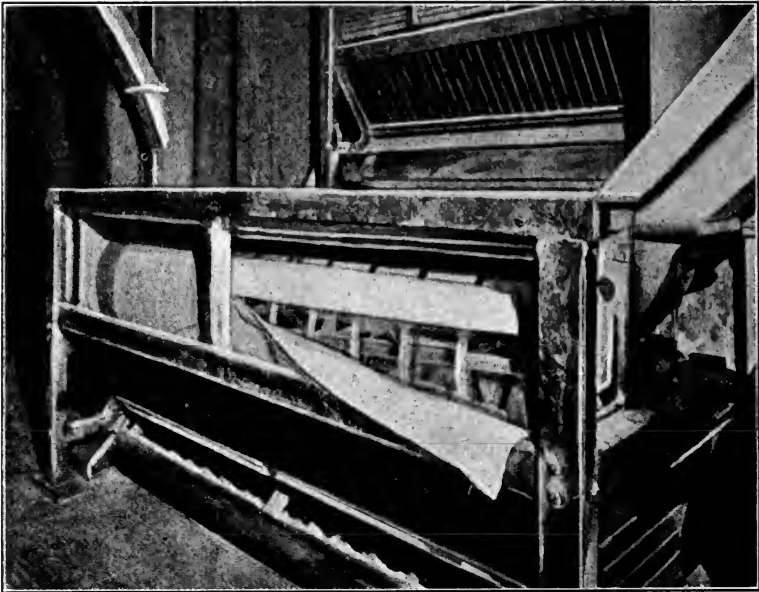


Fig. 14.—Bolting Reel for Separating the Flour from the Bran.  
(Courtesy of the Washburn-Crosby Co.)

is much cleaner, foreign matter is removed in different siftings, brushing and washing. The purifier shows 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; 4th,

the separation is much more perfect, only the part or parts which are desired are found in flour; 5th, 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 eight per cent. on each bushel. The price of flour is cheaper now than in former years; 6th, the rolls 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; 7th, by eliminating the germ oil, refined Patent Flour is put in a keeping condition.

**Testing of Flour.**—The material is tested at different stages of the process and again as 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.

**Bleaching.**—There are three methods of bleaching: (1) by treatment in cleaning, conditioning and milling; (2) by storage;

(3) by artificial means, using electrical or chemical methods. The last custom was for a period forbidden in the United States under the Food and Drugs Act, but this question has not yet been definitely settled.

#### 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 the following grades: (1) first patent; (2) second or standard (bakers); (3) straight; (4) first clear; (5) second clear; (6) red dog; (7) shorts or midds; (8) bran.

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 biscuits 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 wheat flour mixed with corn or rice flour, salt and such ingredients as are found in baking powders. 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 eight per cent. protein and three per cent. mineral matter. This was the kind of flour that started experimentation by Leibig, 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 pro-

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

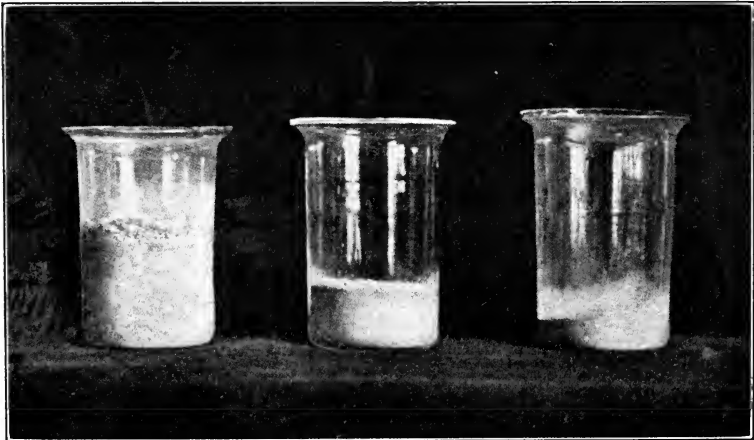
Upon investigation it has been found that entire wheat bread also acts as a laxative, although not to the same extent as Graham bread. This is now believed to be due to the peculiar character of the protein and mineral matter of the aleurone layer. Possibly this is the main cause in Graham bread although 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. 15). 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. By repeated washings the starch content is reduced to fifty per cent. The product is then





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

Fig. 15.—Bread Made from Entire-wheat, Patent, and Graham Flours, and Character of Feces from Same. (Courtesy of the U. S. Dept. of Agriculture.)

dried and ground 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 twenty-two cents per pound. A cheaper product is sometimes found on the market selling for seven 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.

**Semolina.**—The preparation from wheat of a coarse meal known as "Semolina" is now largely carried by the miller. Semolina is used in the preparation of macaroni. See page 104.

## CHAPTER VI.

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### BREAKFAST FOODS.

A canvas 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 as did also toasted bread crumbs. Oatmeal was later introduced by the Irish and Scotch immigration and finally barley, rye and rice, but their use for a long period was more or less limited to the foreign born population.

It was not until the latter part of the nineteenth century that a new interest was awakened in this class of foods. Much experimenting was done on the cereals, improved 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.

Undoubtedly their popularity is not due alone to attractive and widespread advertising but to a growing tendency to save time in the preparation of meals and to the guarantee of cleanliness furnished by the manner of packaging. They are moreover nutritious and appetizing and where the question of cost in relation to food value is not of importance they are to be highly recommended. To that large class of consumers, however, who are compelled by circumstances to consider expenditure from the standpoint of nutritive value many of the breakfast foods must be looked upon as luxuries rather than staples. This is particularly true of those varieties which are puffed or flaked, the cost of

which is several times greater than cereals, such as oatmeal and hominy, which are sold in the uncooked state.

**Classification.**—Although the list of breakfast foods is long and varied they fall very readily into four classes :

Uncooked  $\left\{ \begin{array}{l} \text{Whole grain.} \\ \text{Part of grain.} \end{array} \right.$

Partly cooked.

Cooked.

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 bringing 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.

*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 rolls are supposed only to take off the outer husks. These are removed 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, granu-

lated particles of wheat usually taken from the first or second breaks 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.

*Partly Cooked.*—By far the largest number of the breakfast foods of to-day belong to this class; ninety per cent. of the oatmeal consumed in the United States is the partly cooked variety, 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 moist 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 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 cooked 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.

*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, such as Puffed Wheat, 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. This idea was undoubtedly taken from the old-fashioned custom of popping corn. A special variety of corn is cultivated with a hull strong enough to resist internal steam pressure. During the period of heating the starch is thoroughly cooked; eventually the hull bursts and releases the cooked starch.

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 one of the first breakfast foods 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 sliced, 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 gradually being introduced in the commercial centers of foreign lands.

*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 the product. To further aid digestion it was suggested several years ago that the cereal starch be subjected to the action of malt. Malt is rich in diastatic enzyme, a substance 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. Such a cereal has a pleasant taste relished by many people and adds variety to the diet, but it is not completely predigested.

*Comparisons 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 the consumer was not paying for water which had been added during manufacturing processes, and being condensed in form they occupied less bulk and were not so deceiving to the eye. Uncooked cereals which have been thoroughly cooked in the home digest just as easily as predigested kinds and are equally nutritious and variable in flavor. 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.

Furthermore the statement that certain prepared cereals act as special stimulants to functional development is indefensible. They act merely as general food for the whole organism.

On the other hand much can be said in favor of the use of prepared breakfast foods for they are palatable, wholesome, nutritious and variable in flavor. They save much time, labor and fuel in the home and are well suited for the use of the housekeeper who must depend upon gas or electric stoves. From a sanitary standpoint there is an advantage, being sold in cardboard boxes well lined with air-tight paper, they are protected from air, moisture, dust and micro-organisms. Unless carefully packed a cereal will not keep well. Moist climates make 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. A calculation has been made, based upon the result of work done at the North Dakota Agricultural Experiment Station, that wheat costing one dollar and eighty cents per bushel represents a selling price in the form of certain breakfast foods of twenty-seven dollars. It must of course be left to the purchaser to judge whether he is prepared to pay so considerable an increase in price for advantages which do not necessarily increase the nutritive value. The cereals, nevertheless, pound for pound are the cheapest complete food that can be found in the market and they form a legitimate and valuable food.

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.



## 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 foodstuff that it is known almost universally as "The staff of life." With the possible exception of milk and eggs, there is no article in the diet that is more generally used by human beings and that is so well able to sustain life. It is to the constant use of bread that we owe the wonderful development along the lines of the cultivation of wheat and the equally marked progress found in 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 eighty-one 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 readily digested.

**Primitive Breadmaking.**—Crude methods of breadmaking can be studied not only in 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 bear testimony to its early use and again we find evidences of bread 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 grind grain between two stones, make it into a paste with water, then bake the mass 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; the product 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 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 coals. A similar product is made by the poorer classes from cornmeal, millet, barley or a coarse, hard grain known as ragi. In Palestine and Syria women are still the millers and bakers, grinding the meal in small stone hand-mills after the same custom that 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 in 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 progress from these primitive breads to the modern white loaf used by the civilized world has needed as much study and experimentation as the development of all other industries. Probably the most marked change was the use of leaven and it is generally supposed that the world owes this important step to the

Egyptians. They seemed to have carried the art of breadmaking to a high state of perfection, as did also the early Greeks who are known to have had at least sixty-two 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 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, such 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 V. In times of stress as in the late war it was found advisable to use mixtures of wheat with various other cereals, such as barley, corn, rice, etc., popularly known as war bread. Although they do not possess the pleasing flavor and texture of straight wheat bread they are equally nutritious and digestible.

*Water.*—It should be free from dirt or contamination of any kind. See Chapter II, Water. Until recently it was supposed that in bread making, hardness or softness of water made no material difference. According to the research work of Dr. Kohman (see page 86) it is now believed that salts of lime stimulate the growth of yeast. 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, for the flavor it imparts for without it the dough would be insipid, and as a soluble mineral food for the yeast. 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 lest the delicate aroma and flavor of the bread 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.

*Yeast.*—Yeast was the first leavening agent in the world's history and is still by far the most important. How it first came to be used is not told us 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 thus discovering that it made a lighter loaf. From this simple custom of exposing dough to the air, we might readily 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. Through his research work it is now believed that yeast, mold and bacteria are living organisms. 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. Cider when fresh has a decidedly sweet taste which in time gradually disappears and is replaced by an unmistakable flavor 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 turn 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 round or oval cell. 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 reproduction 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 under the microscope. Pasteur states that on one occasion he watched two cells for two hours; during that time they multiplied into eight.

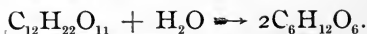
Under unfavorable conditions some yeasts are reproduced by the formation of spores. These spores can resist many adverse circumstances, such as a lack of moisture, insufficient food and marked changes in temperature. It is to their hardy nature that we owe the constant presence of yeast in the atmosphere. In this state it has been discovered yeast can live on the earth for some little time, until wind carrying it 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 above 32° 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 bakers seldom, if ever, take advantage of this fact.

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

Carbohydrates are important foods 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 maltose into glucose, or sucrose into glucose and fructose by the process of hydrolysis:



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 glycerin.



According to the research work of Dr. Kohman\* carried on at the University of Pittsburgh, the effect of adding soluble salts of lime and ammonia to the dough results in the increased growth

\* The effects of the mineral salts contained in natural water upon the fermentation of bread, By Henry A Kohman, Ph. D.

and stimulation of the yeast organism to a remarkable degree. The Arkady yeast food containing these salts has recently come into use. It is claimed that the use of this food has the following advantages: 1st, it stimulates the gas production of the yeast so that half the quantity of the yeast regularly used will suffice for leavening the dough; 2nd, it helps to conserve the gluten of the flour thereby giving the dough greater stability; 3rd, less carbohydrate is consumed by the yeast because of the smaller quantity of yeast used; 4th, the flavor is improved due to the conservation of the natural substances, such as gluten and sugar in the flour, and to the fact that because of the lesser quantities of yeast used, fewer objectionable by-products are produced; 5th, the bread made by the process has less acidity.

The opinion that the addition of lime is harmful or in any sense an adulteration is not in accordance with the results of the research work of Emmerich and Loew.† These authorities definitely state that this is the most feasible method of maintaining the lime balance in the diet. It is now the custom of the best German bakers to combine with the dough previous to baking definite quantities of soluble lime salts in the form of chlorides.

Micro-organisms also need oxygen, some taking it in the form of atmosphere 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 regulate the supply of oxygen.

In fact one of the largest and best known breadmaking concerns in the United States makes its bread under a process patent, based on the idea of mixing 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 contain-

† Calcium Bread and Its Virtues, By Emmerich and Loew.

ing all the necessary compounds—carbohydrate, protein and mineral matter. If this material be 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 mass.

**Yeast Preparations.**—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, potatoes and water is used and when the yeast has developed part of this material is added to the dough. A similar practice can be found in Scotland. 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 particularly in France and Switzerland this ancient method is used by bakers and poor country people. The bread has a sour taste, which is relished by many, due to the development of lactic and butyric acid bacteria. 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.

A distinct advance over the old leavening process was obtained by the use of brewer's yeast. During the fermentation of beer especially where a high temperature was used much of the yeast was carried to the top of the vats by the escaping carbon dioxide. 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 almost entirely been superseded by distiller's yeast which at the present time is sold in the form of the compressed yeast cake.

**Compressed Yeast Cake.**—So popular has the use of the compressed yeast cake become in America that its preparation has become an industry of no small importance. For manufacturing purposes a mixture of grains, such as corn and rye with barley malt are employed in various proportions according to the formula of the manufacturer. After being subjected to cleaning processes by which all dust and foreign substances are removed, these grains are ground separately in regular milling machines. The ground corn and rye are cooked in filtered water in order to soften the starch and to dissolve material that is to nourish the yeast cells. Malt extract is added at a lower temperature in order that the diastatic enzyme present may convert the starch of corn and rye into sugar. As lactic acid has a beneficial effect in yeast making and also renders soluble and digestible the nitrogenous substances present pure culture lactic acid bacteria are added. With carefully controlled temperature these bacteria develop during a period of sixteen hours a distinctly sour taste. Upon completion of the lactic process the mash is filtered, cooled and conducted to the fermenters where pure culture yeast is introduced. Here growth and reproduction of yeast takes place under favorable conditions. When a large amount of yeast substance has been formed it is separated by centrifuge, filtered, thoroughly mixed by machinery and packed by hydraulic pressure.

*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 soon develop giving rise to undesirable flavors in bread. For people who live in isolated districts,

another type of compressed yeast, called dried yeast, prepared by the addition of starch and the removal of a large part of the water is put on the market. 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 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.

**Steps 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.

**FERMENTATION.**—The methods of fermenting dough are somewhat varied but there are only three in common use: 1st, straight or off-hand dough; 2nd, ferment and dough; 3rd, 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.

**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 three to ten 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.

*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 five 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.

*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 two to twelve 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.

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 such a high temperature since dough is a poor 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, bacteria and enzymes present in the dough are destroyed during the baking. This sterilizes the bread.

**COOLING.**—As soon as completely baked the loaves of 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 unsanitary 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 temperatures, 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 touch the product from the time that the raw materials enter the building until the finished loaf is ready to be carried

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, pure 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 is removed. When needed the

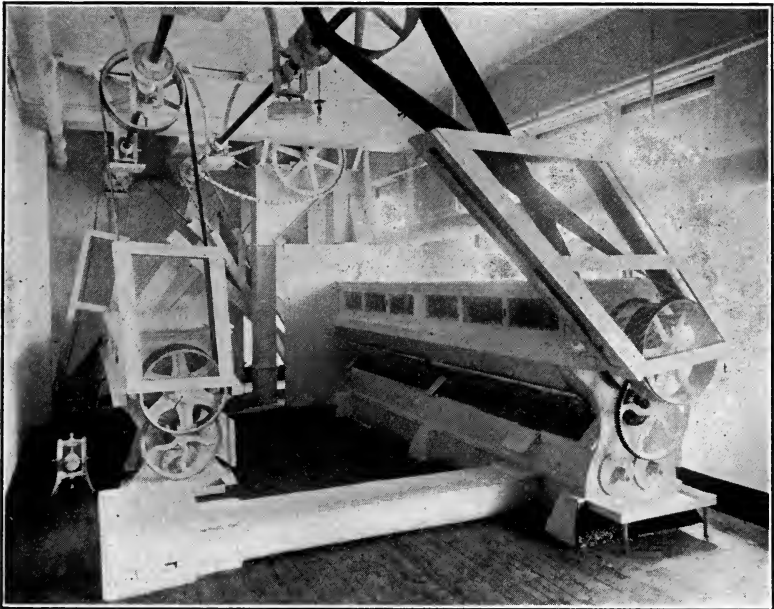


Fig. 16.—Flour Sifter and Blender.  
(Courtesy of Ward Baking Co.)

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 twenty-five 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 for three 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

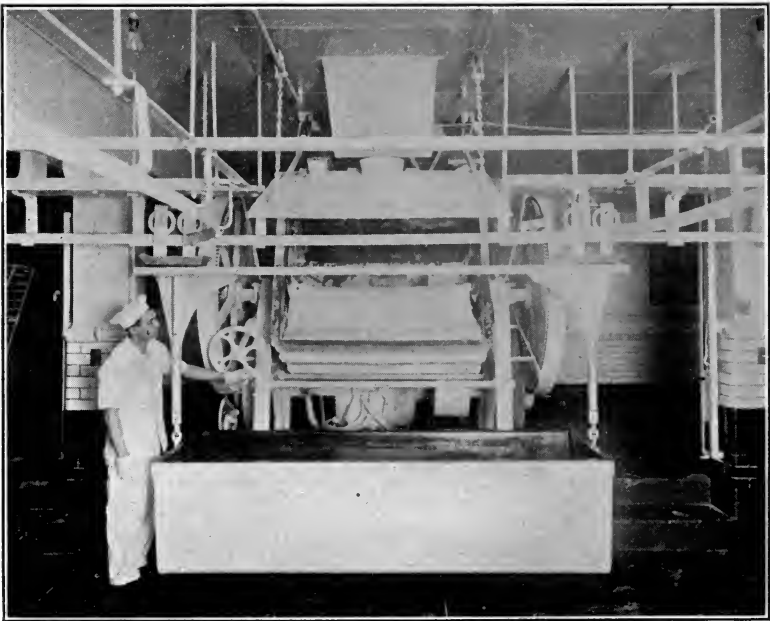


Fig. 17.—Mixing Machine with Dough About to be Lowered Into Rising Trough.  
(Courtesy of Ward Baking Co.)

drops into a pan ready for the second rising. The pans are removed to an apartment heated to  $110^{\circ}$  F., and the bread is allowed to rise. It is then baked in a traveling oven at a temperature of  $450\text{--}550^{\circ}$  F. After being removed from the oven the bread falls on racks from which place it proceeds by an incline to the floor below where after cooling, it is wrapped and sealed in paraffin paper.

**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 undesirable ferments an

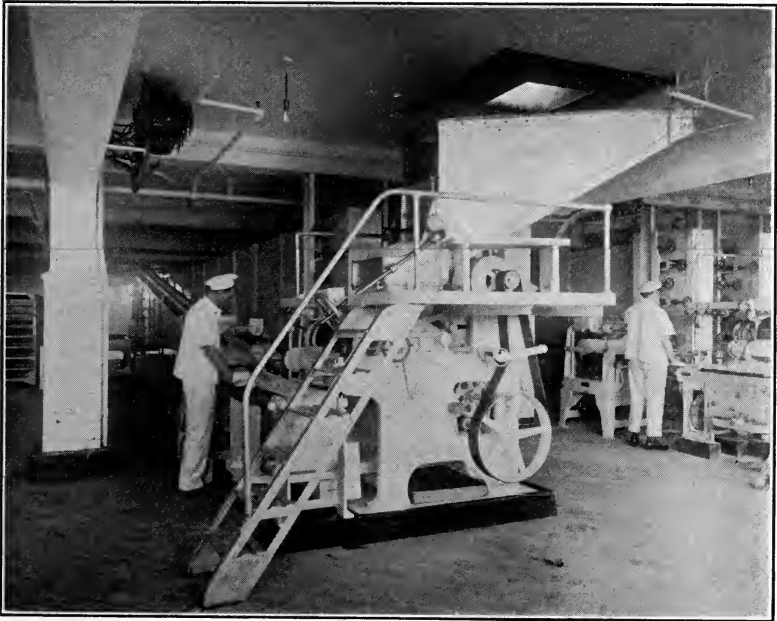


Fig. 18.—Machine for Dividing Dough Into Equal Parts of Equal Weight.  
(Courtesy of Ward Baking Co.)

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.

**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 are driven off to a large extent at the temperature of baking so have no nutritive effect. Estimates of this loss have been made and as a rule it has been found to be approximately two per cent. although it may be much higher under favorable conditions. Liebig calculated that the loss in Germany daily would



Fig. 19.—Front View of Dough Divider.  
(Courtesy of Ward Baking Co.)

supply four hundred thousand persons with bread and it has been estimated that three hundred thousand 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 have been invented few of which have been successful. A brief description of these leavening agents will be given in the following chapter.

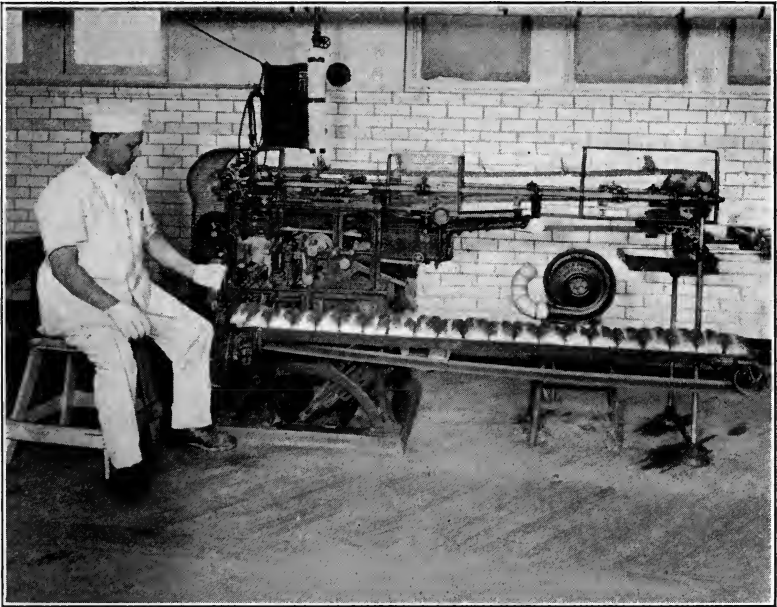


Fig. 20.—Machine for Wrapping Bread with Paraffin Paper.  
(Courtesy of Ward Baking Co.)

*Aerated Bread.*—In this process cold water is saturated with carbon dioxide. 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 in the United States although it is still made in Great Britain.

**Salt Rising Ferment.**—An old and crude process of breadmaking in American practice, known as the salt-rising method, can be carried on by mixing a convenient quantity of wheat meal and cornmeal with a little salt and hot milk. If set in a warm place for a few hours fermentation takes place and the whole mass becomes porous. A similar process has long been in use in Northern Europe in making the native sour rye bread. This

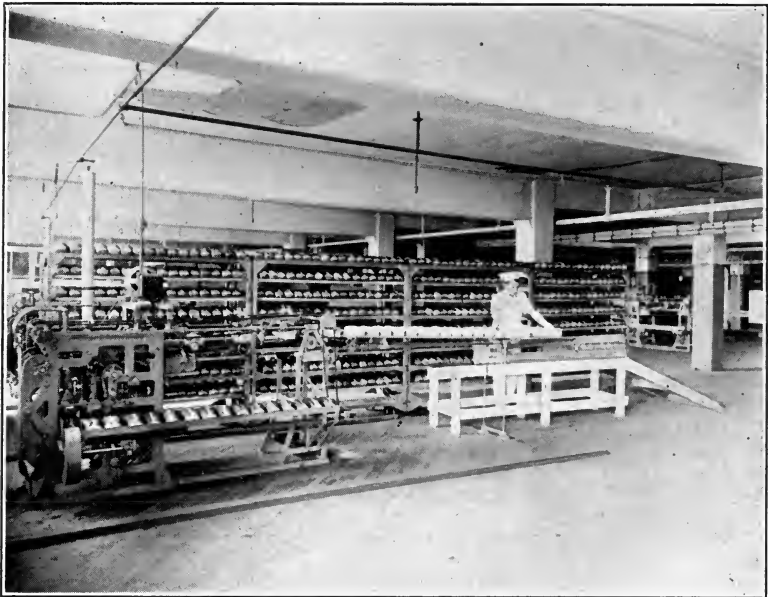


Fig. 21.—Bread After Leaving Wrapping Machine.  
(Courtesy of Ward Baking Co.)

method of leavening was formerly imputed to wild yeast but it has been definitely determined to be due to the growth and development of certain gas forming types of lactic acid bacteria. Unlike the yeast these forms develop a mixture of hydrogen and carbon dioxide at the same time producing lactic acid which accounts for the difference in flavor so highly regarded by some people. This form of leaven in the dry state has now become a

commercial product and can be bought similarly to yeast preparations.

#### THE CRACKER AND 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.



Fig. 22.—A Baking Floor showing Ovens. (Courtesy of National Biscuit Co.)

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 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 unsanitary cracker bin and barrel of the grocery store, such as were formerly 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 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.**—There is no food industry which uses such an enormous variety of foodstuffs and from so many parts of the

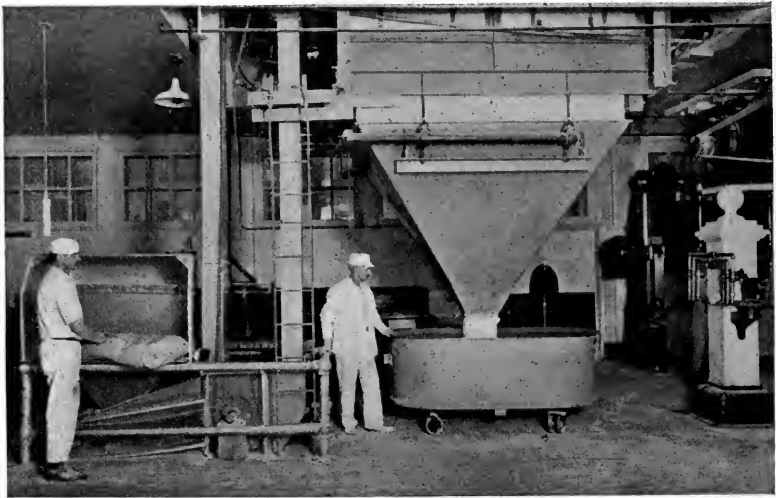


Fig. 23.—Flour Bolter, Blender and Automatic Weigher. (Courtesy of National Biscuit Co.)

world as the biscuit industry. The basic ingredient is a flour; the ideal flour for most biscuit is one made from rich soft winter wheat although for special purposes Graham, whole wheat, corn, rye and arrowroot flour are used. Oatmeal and other cereal products enter into the manufacture of special kinds of biscuit. Eggs are used in many of the sweet varieties of crackers and cakes, and butter, lard, coconut and other vegetable oils form the

principal shortening. About twenty different kinds of sugars may be used according to the purpose for which they are intended. These range in grain from the 4X sugar which is an impalpable powder up to the crystallized sugar whose grains may be a quarter of an inch long. Some of the sugar comes from the refineries while other kinds are brown sugars straight from the plantations and impart to the biscuit a rich taste of molasses which is so delicious. High grade molasses itself and honey are also largely used, while whole milk or filtered water supply the moisture for the dough.



Fig. 24.—Baking Floor for Sweet Goods showing Sweet Cracker Machine and Pans being placed in the Oven. (Courtesy of National Biscuit Co.)

The above are the basic ingredients used in the manufacture of biscuit. In addition there is almost an infinite variety of accessories, such as fruits and nuts of all kinds, flavors, spices, cheese, chocolate, etc. These are worked into the biscuit in many different ways, for example: The fruits may be mixed with the dough or they may be used as a topping; the dough may be rolled into thin sheets with a layer of fruit between forming a sort of fruit sandwich; the fruit may be made into a jam and applied to the cake after it is baked. Similar variety of processes may be used in the case of nuts, spices, chocolate and other accessories.

**Manufacturing.**—The manufacture of biscuit may be divided into sponge, sweet and iced goods. The sponge goods are those commonly known as soda crackers, oyster crackers and the like. These are all raised with yeast. The greatest care must be taken throughout the process to keep all the conditions exactly uniform. In modern factories the temperature of the room in which the doughs rise is kept at about 80° F. If the temperature falls below this a valve is automatically opened which introduces warm air to all parts of the room. In the summer time cold air is automatically supplied in the same way. Even the humidity of the room is mechanically controlled in some cases. This great care is necessary in order to insure a uniformly high grade product.

The first operation consists in taking the temperature of the flour. From this the temperature of the water can be calculated which will bring the sponge after mixing to a temperature of about 72° F. The yeast, flour and water are then mixed by machinery and the product which is called a sponge is allowed to lie in the proofing-room twelve hours or more. During this time the yeast acting on some of the carbohydrates of the flour produces carbon dioxide gas which raises the sponge to about three times its original size; at the same time the gluten is made more soft and elastic. The peculiarly appetizing taste of soda crackers which can be developed in this way and in no other, is formed at this time in some unknown manner. After reaching its maximum height some of the gas escapes and the surface of the sponge drops several inches. It is then ready to be mixed into the dough. Soda, salt, shortening and more flour are added and the whole is remixed for about five minutes. It is then allowed to stand several hours more. During this time the soda neutralizes the acidity developed by the yeast and the whole dough rises again. When ready it is wheeled in its clean, steel car to the dough brakes where by being rolled and folded between great rollers, it is kneaded into the proper thinness, and is made 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 upon the dough. It is now ready for the oven, where

it is baked at a temperature of from 500° to 600° F. Fig. 24. After being baked and taken from the oven the biscuit are cooled and packed.

The variety of sweet goods is almost infinite, depending not only on the ingredients used but upon the stiffness of the dough and the method of treating it. Some doughs are made with very little wetting. These doughs are rolled out, cut and baked on machines such as those described for sponge doughs and form the familiar hard sweets. Other kinds of dough are much softer ranging in stiffness down to that of heavy cream. The last type is the cake dough. The dough is poured into the hopper of a so-called "wire cut-cake machine" and is forced thence through small holes. When the proper amount has come through it is cut off automatically by a moving wire and falls on a pan which is supported on a travelling apron below. This pan may be sent immediately to the oven or the pan with the unbaked dough upon it may be dipped in sugar, nuts, raisins, etc.

The ovens used in the biscuit industry are of a type developed especially for this industry and are of very interesting construction. They are large hollow structures with a capacity of about that of an ordinary room but are nearly two stories in height. The walls are of brick several feet in thickness. The oven is heated by hard coal, fuel oil or natural gas from two fire boxes located in the bottom of the oven. The oven heats up slowly owing to the great thickness of the walls but once heated through, the bricks radiate a steady, "solid" heat on the crackers from every side. This is very necessary in order to secure a thorough even bake. Movable shelves are hung inside the oven, on a structure similar to a gigantic "Ferris Wheel" which can be started and stopped automatically, bringing the shelves one after the other to the oven's mouth, which is situated in the upper part. As each shelf comes to the oven's mouth pans full of baked goods are withdrawn and their places are taken by other pans full of fresh dough. These pans are carried on the movable shelves around the circumference of the "Ferris Wheel" inside the oven and are then brought back again to the mouth of the oven thoroughly baked.

In the icing room, marshmallow, jams, jellies, chocolate and other sweetmeats are applied to the already baked goods. The work is now being done more and more by machinery, thereby insuring perfect cleanliness and uniformity. These jellies, marshmallows, etc., may be deposited on the top of the cake or the whole cake may be dipped into them so that they form a complete covering. The cakes then go to the trolleys. These are large structures equipped with many hundreds of movable trays or wires. The cakes either resting on the trays or pinned on to the wires, are carried up and down and back and forth throughout the length of the trolley, until they are thoroughly dried and ready for packing. The trolleys as a rule are shut in to protect them from dust and dirt; temperature and moisture within are carefully controlled.

Biscuits of all kinds as soon as they are finished are packed in the modern moisture and dust-proof packages. These may be cartons lined with waxed paper and carefully wrapped or the familiar glass front can. The biscuit are then ready to start, often the same day that they are packed, on their journey to the ultimate consumer.

#### 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 fourteenth century, Italy was the only European nation that understood the 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 nineteenth century that this product could be equalled 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 north-western 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 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 until the dough has a smooth and tough appearance. After kneading the dough is transferred to a cup shaped press provided with a perforated bottom. As the piston descends the dough flows through the holes and forms rods, strings or tubes. 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 known as 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 twelve 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 constantly 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 lands. 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 readily replaces 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 made spongy before it was baked. This could be accomplished best by a gas with subsequent expansion by heat. Carbon dioxide was the first gas used, obtained through the agency of yeast and nothing has ever been found that can equal its efficiency as a leavening agent.

ADVANTAGES.—(1) Carbon dioxide is generated by the action of the yeast enzymes on the carbohydrate of the meal or flour so no foreign substance is introduced into the dough; (2) The slow liberation of the gas causes it to have full effect as a leavening agent; (3) The by-products produced during fermentation give a pleasant taste; (4) Bread made by yeast is more easily digested.

DISADVANTAGES.—(1) The time required for leaving is long; (2) Careful watching and studying of favorable conditions for the growth of yeast are necessary or the result will be sour or sodden bread; (3) It involves a loss of carbohydrate in the formation of products which are volatile at the baking temperature.

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

ADVANTAGES.—1. <sup>with care</sup> 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; (2) No loss of the carbohydrate is involved; (3) It is possible to calculate the amount of gas which may be produced if the composition of the chemical reagents is known. *if the grade*

DISADVANTAGES.—(1) The taste is not as good as that of bread raised by yeast; (2) The product is not as readily digestible; (3)

The residue resulting from the chemical action remains in the loaf. As these residues have no nutritive value, they can only be regarded as waste products and may retard digestion.

**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 serious drawbacks. The acidity of the milk was apt to be over-estimated. Lactic acid is formed by the action of bacteria in milk on the lactose or milk sugar.



When 0.9 per cent. is present the action stops, 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, this excess becoming strongly alkaline by formation of alkaline carbonates due to heating.



This affected the taste and interfered with protein digestion. 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 four-fifths of the amount suggested. In some old cook books may also be found the recipe for cream of tartar soda biscuit, conforming closely to the proportions used in the modern tartrate powders.

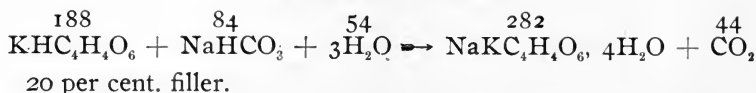
**Baking Powders.**—Some eighty years ago the first attempt to put a working formula into practice was made, following the suggestion of Prof. Liebig, the earliest chemist to handle the subject scientifically. Hydrochloric acid and bicarbonate of soda were used, giving a residue of sodium chloride a perfectly harmless product. The bicarbonate was found to be so satisfactory, that its use has continued to the present time but hydrochloric acid being in the liquid form and frequently containing impurities,

proved to be troublesome. The history of the baking powder industry from that time, centers in the endeavor to obtain an acid ingredient which would be effective, comparatively cheap, would have good keeping qualities and would give a harmless residue.

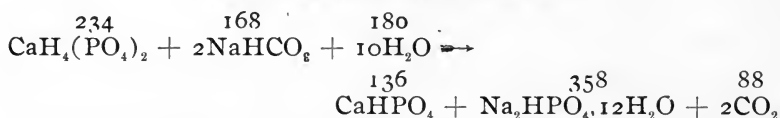
In the early sixties Prof. Hosford of Cambridge patented a powder, the acid ingredient of which was calcium acid phosphate. Later taking advantage of the old housewife's recipe of cream of tartar and soda, a similar product known as the tartrate powders was put on the market. About 1880 a powder containing alum and mixtures of alum and phosphate appeared. The latest improvement in powders has been the use of sodium acid phosphate.

Important forms of powders on the market are known as tartrate, calcium phosphate, sodium phosphate and alum phosphate. Tartrate powders consist of mixtures of cream of tartar, bicarbonate of soda in proportion of two to one by weight and dry starch about one-fifth. In a few instances the cream of tartar is partially replaced by tartaric acid. Calcium phosphate powders consist of soluble acid calcium phosphate, bicarbonate of soda and starch as filler. Sodium phosphate powders contain monosodium phosphate, bicarbonate of soda and starch. Alum phosphate powders consist of sodium aluminium sulphate, popularly known as S. A. S., acid calcium phosphate, bicarbonate of soda and starch filler. On account of the indefinite composition of S. A. S. it is impossible to give a quantitative working formula for this powder. For this reason the formula for alum phosphate powders on Page 110 has been worked out with ammonia alum which is definite in composition.

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?" The qualities demanded in a satisfactory baking powder are: (1) Efficiency as a gas producer; (2) that the gas be generated gradually and only completely at the temperature of the oven; (3) that the powder should keep well either on the grocer's shelf or in the kitchen; (4) that it should be sold at a reasonable price; (5) that it should leave a harmless residue.

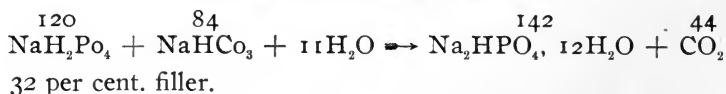
**TARTRATE POWDER.**

1 level T. of powder weighs 3.00 grams and contains 20 per cent. of starch. This yields approximately 0.4 gram CO<sub>2</sub> or 200 c.c. at 0° C., which becomes 273 c.c. at 100° C., the highest temperature of the oven. The residue of crystallized Rochelle Salts amounts to 2.5 grams.

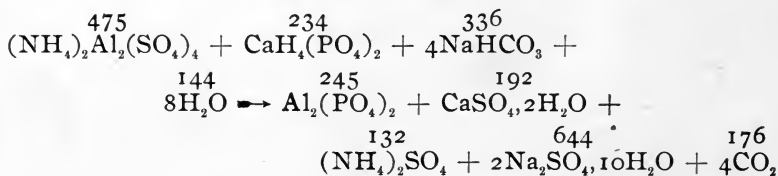
**CALCIUM PHOSPHATE POWDER.**

CaHPO<sub>4</sub> 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<sub>2</sub> or 355 c.c. at 0° C. which becomes 485 c.c. at 100° C. the highest point of the oven. The residue of phosphates weighs 4.05 grams.

**SODIUM PHOSPHATE POWDER.**

1 level T. of powder weighs 3.75 grams and contains 32 per cent. of starch. This yields approximately 0.545 gram CO<sub>2</sub> or 274 c.c. at 0° C. which becomes 374 c.c. at 100° C. the highest point of the oven. The residue of soluble sodium phosphate weighs 4.41 grams.

**ALUM PHOSPHATE POWDER.**

1 level T. of powder weighs 2.85 grams and contains 33⅓ per cent. of starch. This yields approximately 0.32 gram CO<sub>2</sub> or

160 c.c. at 0° C. which becomes 218 c.c. 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 <sub>2</sub>	Volume of CO <sub>2</sub> at 0° C.	Volume of CO <sub>2</sub> at the oven temperature	Weight of the residue	Remarks
Tartrate	3 grams	2.4 grams	0.4 gram	200 c.c.	237 c.c.	2.5 grams All soluble in water.	Residue contains water of crystallization.
Calcium 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.
Sodium phosphate	3.75 grams	2.5 grams	0.545 gram	274 c.c.	374 c.c.	4.41 grams All soluble 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.**—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 one-half pound of cream of tartar, one-quarter pound of bicarbonate of soda and one-quarter 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.

Calcium phosphate and alum phosphate powders are cheap, but they do not keep well and leave a residue which is largely insoluble in water. They cannot be successfully made in the household. Of the phosphate powders the sodium compound is undoubtedly the least harmful and the most efficient.

Until a conclusion was drawn by the Referee Board of the Department of Agriculture, alum in foods was considered detrimental to health. It is the belief now that aluminium compounds

in such quantities as would be found in bread, do not affect injuriously the nutritive value or render it detrimental to health. Dr. Taylor calls attention to the fact, however, that the regular ingestion of sodium sulphate which acts as a cathartic cannot be recommended. Since alum phosphate powders leave such a residue, biscuit prepared from them should not have a place in the daily diet\*.

**Ammonia Powders.**—Bakers have been using ammonium carbonate very effectively as a leavening agent. As a rule, it is used in addition to yeast to make a lighter or larger loaf, or to overcome the sourness of bread when it has been over fermented. According to the following equation, ammonium carbonate appears to have a great advantage as it leaves no residue.



Moreover the gas is not liberated until the dough is heated. It must be used, however, in very small quantities or the product will taste of ammonia.

**Cream of Tartar.**—Much of the cream of tartar and tartaric acid used in this country are imported, the largest amounts coming from France, Italy and Germany. Domestic products are obtained from California. They are by-products of the wine industry, being obtained from a certain variety 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, pass out with the juice. There is no tendency for them to become insoluble and precipitate in crystalline form, until the grape juice reaches from five to six 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 "argols." There is also a dark deposit, called "the lees", at the bottom of a full

\* See U. S. Bulletin 103. Alum in Foods.



barrel of new wine after it has stood long enough to settle. From argols, cream of tartar is made. "Lees" contains a larger amount of calcium tartrate and is used more extensively for the production of tartaric acid.

Argols 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 argols 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 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 before being marketed.

**Tartaric Acid.**—Tartaric acid is usually prepared from crude calcium tartrate, occurring in the lees and argols. The calcium is removed in the form of an insoluble sulphate.



By filtration and concentration of the clear liquid tartaric acid crystallizes in large glassy crystals. While the aerating power of tartaric acid is more than double that of cream of tartar, since it has two acid radicals it is not preferable since its reaction with sodium bicarbonate is rapid and takes place in the cold. The keeping quality of the powder is correspondingly poor. Tartaric acid is used in the preparation of soft drinks, in pharmacy and in the textile industry as the acid or as tartar emetic in certain dyeing processes and in calico printing.

**Soluble Acid Phosphates.**—Until a few years ago the acid used in all phosphate powders was monocalcium phosphate,  $\text{CaH}_2(\text{PO}_4)_2$ , a deliquescent, crystalline substance. It does not occur in nature but can be obtained by the action of sulphuric acid on the mineral known as apatite or rock phosphate.



The mixture of calcium phosphate and sulphate is separated by filtration, soluble phosphate being found in the liquid portion from which it can be crystallized. Monosodium phosphate has been substituted for the calcium compound in one of the new baking powders found on the market. Many advantages are claimed for the sodium compound in regard to effectiveness as a baking agent, healthfulness and the purity of the product. Monosodium phosphate is prepared from disodium phosphate by treatment with sulphuric acid under conditions which render sodium sulphate insoluble, the reaction being



Disodium phosphate is manufactured in large quantities from phosphoric acid which in turn is usually obtained from apatite or other mineral phosphate.

**Alum.**—Double aluminium alkaline sulphates are commonly known as alums. They are prepared by mixing aluminium sulphate with correct proportions of sodium, potassium or ammonium sulphate and allowing the mixture to crystallize. S. A. S. is a similar mixture with an excess of aluminium in the form of an oxide.

**Bicarbonate of Soda.**—The preparation of soda constitutes today one of our largest and most important industries. In its various forms it is used as an essential raw material in the manufacture of many products, among which may be mentioned chinaware, glass, leather, paper, paint, porcelain, pottery, soap, starch, dye-stuffs, varnish etc. It is also used in many manufacturing processes, such as bleaching, scouring wool, tempering steel, rectification of oils, purification of gas and tanning of leather.

The original alkali used was potassium carbonate, obtained from potassium salts which are widely spread throughout plant life. The 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 was used for the preparation of soft soap. By further evaporation the lye yielded flat, pearly crystals of carbonate of potash commonly known as pearl ash. Being hygroscopic on exposing to

air, pearl ash absorbs moisture and in this condition is very attractive to carbon dioxide, eventually resulting in bicarbonate of potassium or saleratus.† This operation was usually conducted in the cooler portion of the chimney flue. For many years the manufacturer copied the housewife's process on a larger scale. Later when mineral deposits of potash compounds were discovered, it became possible to prepare potassium salts from that source, increasing the yield and lowering the cost of production. The largest deposits occur on the western coast of South America and in the region of North Germany which has Stassfurt as the center.

It was not until the beginning of the eighteenth century that a stronger alkali, sodium carbonate, was found to take the place of the potash compound. The preparation of this substance, known commercially as barilla, was carried on in Spain by the burning of sea-weed to ash. Being cheaper as well as stronger, the new compound was readily received by manufacturers who used it until the latter part of that century. The interruption to commerce through warfare at that period, resulted in the cutting off of the French manufacturers' supply of the Spanish alkali. This led to the offer of a prize by the French Academy, for the discovery of an inexpensive method for the preparation of sodium carbonate.† The process proposed by Nicholas Le Blanc proved so satisfactory, that upon it was founded an industry that was to supply the world with soda, until it was superceded in 1861 by the Solvay Process.

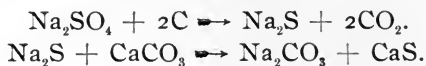
*Le Blanc Process.*—This process consists in decomposing salt obtained by the evaporation of sea water with sulphuric acid. The product of this treatment is an impure sodium sulphate known as "the salt cake."



The hydrochloric acid liberated passes through towers containing running water in which it is absorbed. This valuable by-product was at first wasted but its subsequent recovery did much toward making the Le Blanc method a commercial success. In time it was found profitable to utilize part of the hydrochloric

acid for the production of chloride of lime, thus placing on the market a valuable disinfectant and bleaching agent.

The next step in the Le Blanc process consists in heating the sodium sulphate with powdered coal and limestone until the mass has fluxed. When the mixture has become a semi-fluid pasty mass, the following reactions take place rapidly, resulting in an impure product known as "black ash."



Sodium carbonate is extracted from the black ash by a systematic treatment of the ash with water. By evaporation and recrystallization, the commercial forms soda ash and sal soda are obtained. Bicarbonate of soda, baking soda, can be prepared by mixing the calculated quantities of soda ash and sal soda in a moist state, forming the product into porous blocks and subjecting them to the action of carbon dioxide.

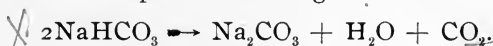


*Solvay Process.*—The first patent for the manufacture of soda by the ammonia soda process, was taken out in 1861 by Ernest Solvay of Brussels, who was one of many European chemists searching for a solution of that problem. For many years little attention was paid to the products which he manufactured and exhibited in Paris, but by 1872 the success of the process was assured. It has many advantages over the Le Blanc method; the process is cheaper, a purer product is obtained and salt is utilized in the form of brine. This has been a great benefit to countries like America, whose salt deposits frequently occur in the form of brine wells. Brine is also much easier to handle. It is conducted into a closed vessel, thoroughly saturated with ammonia and then with carbon dioxide, resulting according to the following equation, in insoluble sodium bicarbonate and soluble ammonium chloride.

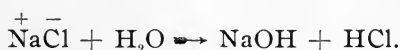


Sodium bicarbonate is separated by filtration. The ammonium chloride furnishes a fresh supply of ammonia gas on treatment

with lime. If sodium carbonate is desired the bicarbonate is heated until it decomposes according to the following equation:



*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 run into partitioned tanks containing electrodes. When the current passes ionization of the salt occurs.



Sodium hydroxide collects at the negative pole, and hydrochloric acid at the opposite pole. Caustic soda can readily be utilized in the preparation of the carbonate and the bicarbonate.



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

**Starch.**—Unless used in excess starch in baking powders is not considered an adulteration. In most climates, the addition of such a substance is necessary to keep the acid and alkali from a too intimate contact, and to absorb the moisture of each. Before this addition was made, it was customary to place baking powders on the market in two packages. Phosphate powders were particularly hard to keep since the acid ingredient had a strong affinity for air moisture. A recent method of mixing liquid phosphate with starch and drying the product has been found to be very satisfactory.

## CHAPTER IX.

### STARCH AND ALLIED INDUSTRIES.

Starch is one of the most widely diffused substances in the vegetable kingdom, occurring more or less abundantly in every plant that has up to the present time been examined. Larger quantities are found in some families of plants than in others, the starch having been deposited in different parts in different plants. It always occurs in great abundance in the seeds of cereals and legumes, in the tubers of potatoes and the roots of many plants. In smaller proportions starch is found in the pith of trees and shrubs, in unripe fruit and in leaves, but its presence in these parts is not constant for while the tissues may contain starch at certain seasons, little can be found at other periods. For the formation of starch in the living plant, see Chapter I, Foodstuffs.

**Physical Characteristics.**—To the naked eye starch has the appearance of a glistening white powder. It has no odor or taste, does not crystallize and has a harsh feeling when rubbed between the fingers. Under the microscope it is seen to consist of granules of various forms, round, oval, etc., differing widely in size according to the source. 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 consisting of a substance closely resembling cellulose while within the granule or package is found the true starch. These physical differences are the principal means by which the various starch of commerce may be identified.

**Physical and Chemical Properties.**—Unchanged starch is insoluble in cold water from which it readily separates, alcohol or any other known solvent. It is neutral to litmus, gives a characteristic blue color with iodine and is a highly hygroscopic substance, having the power of absorbing approximately eighteen per cent. of water under ordinary conditions. If exposed to a damp atmosphere, it is capable of absorbing as much as thirty-five per cent. of moisture. When heated to 200° C., air dry starch undergoes decomposition, becoming converted to a greater or less ex-

tent into dextrin and reducing sugars. If 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 content forms a viscous mass which is slightly soluble in water. Both the insoluble and soluble forms of starch respond to the iodine test. When heated in the presence of dilute acid starch is rapidly converted into soluble starch, then into dextrin and maltose, and if the action be sufficiently prolonged into glucose.

**Uses.**—While its place in the diet would make starch an important article of commerce the manufacturer finds many another market for his product. According to its use the preparation of starch may be classed under two heads: 1st, for laundry and manufacturing purposes, such as the sizing of paper and of cotton goods, the thickening of mordants and colors in calico printing, the preparation of cosmetics, asbestos and adhesives, the manufacture of dextrin and glucose, in the brewing of beer, as a filler for baking powder etc.; 2nd, for edible purposes, such as pudding sauces and fillers, candy manufacture, preparation of tapioca and various other food materials.

**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 manufacturer. In looking for his raw material the starch producer takes into account the following facts: 1st, the ease with which the plant can be grown in his locality; 2nd, the amount of starch yielded by the plant and the yield per acre; 3rd, the ease of extraction; 4th, the presence of other constituents, such as protein and oil, which make the process difficult.

The raw materials most extensively used in Europe and America for the preparation of starch are potatoes, rice, maize and wheat. Potatoes are largely employed on the continent, rice principally in England and maize almost universally in America. Wheat was formerly very important but it has now been largely replaced by other substances. The cassava furnishes the chief source of starch in Brazil, the East and West Indies and various

parts of Africa. Arrowroot is utilized in the West Indies and sago in the Philippine Islands and parts of India.

#### POTATO STARCH.

The potato is a valuable source of starch on account of the great ease of extraction. The starch content is 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 the manufacturing processes. As a rule only about twenty per cent. of starch is found in the potato but with the use of improved methods the starch content is being raised from twenty-five to twenty-nine per cent.

Formerly potatoes were grown extensively for the starch industry in England and Ireland but its use has been almost entirely replaced by rice in late years, due largely to disease of the potato crops. The manufacture of starch from this source has reached its highest development in France and Germany. Large quantities of potato starch are exported yearly from those countries. In the United States, Maine produces a high quality potato, while Wisconsin and Colorado also grow potatoes for the starch industry.

**Processes in Manufacture.**—In Europe the manufacture of starch includes the following operations: steeping, washing, separation of stones, rasping, straining, settling, removal of the starch, purification, second straining, washing, draining, drying in the air or in a centrifugal machine, drying in an oven, packing.

*Steeping and Washing.*—As potatoes are grown in clay or loam it is necessary to soak them for several hours in order to remove adherent earth. They are then placed in a wash drum which consists of a hollow revolving cylinder faced with wood or iron bands, the distance between each band being sufficient to allow dirt, sand or stones to escape while the potatoes are retained. The cylinder is partly immersed in water and revolves at the rate of about fifteen revolutions per minute. Further purification takes place in the stone catcher where the remainder of the stones and sand are washed off. From the stone catcher the potatoes fall into the hopper of the rasping machine.



*Rasping and Straining.*—By this means the potatoes are reduced to a pulp and the cells containing the starch are ruptured, thus facilitating in the extraction of the starch. The rasper consists of a hollow cylinder, furnished with saw blades on its inner surface, against which the potatoes are forced to rub by a fork-shaped scoop during the rapid revolution of the machine. The pulp consisting of a mixture of starch and fiber is separated by wire sieves of different degrees of fineness which allow the starch granules to pass through with the liquid and retain the coarse particles of the fiber.

*Removal of the Starch.*—The starchy liquid from the sieves is run into a large vat where it is allowed to stand for several hours during which time the starch settles at the bottom. After the water has been siphoned off, the impure starch is agitated with fresh water, passed through a sieve to remove impurities and again allowed to settle after which the operation is repeated.

*Drying and Packing.*—The starch is taken from the settling vats in the form of a thick paste, from which the greater part of the water must be removed in the air, in ovens or by centrifugal force. As it comes from the centrifuge, starch contains from thirty-five to forty per cent. water so must remain for a period in the drying room, until sufficiently dry to be packed for shipment.

Most root starches follow the same principle as used in the extraction of potato starch.

#### TAPIOCA.

Tapioca is an important food product prepared from the starch of the cassava, a plant largely grown 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 temperature is gradually raised until the starch granules burst and adhere, 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.

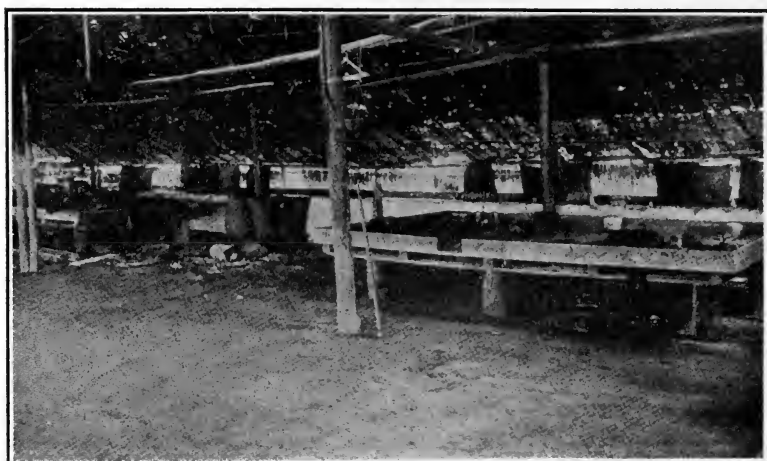


Fig. 25—Sheds and Board Used for Drying the Tapioca. (Courtesy of The Spice Mill Publishing Co.)

As genuine tapioca, however, is always prepared from cassava starch, other imitative forms must be classed as substitute products.

#### **Outline of the Corn Products Industry.—**

Cleaned.

Kernel softened by steeping.

Crushed.

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

Dextrin

{	1. By process of roasting.
	2. By use of a dilute acid.

Glucose by process of hydrolysis

{	Boiled with dilute acid 0.06%
	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.

**Processes in Manufacture.**—*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.

*Steeping.*—In order to separate the kernel into its component parts the hard, dry grain must first be softened. This is accomplished by steeping in water for approximately forty 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 preservative, 0.005 per cent. sulphurous acid, is added to prevent fermentation. This is afterward removed by thorough washing. When the grain has absorbed sufficient



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

moisture to cause a loosening and softening of the various parts, the steep water is drawn off leaving the kernel of corn in a moist, soft condition. The liquid is evaporated and the solubles of the corn are incorporated with the gluten feed. The steeped corn is run to the crushers (Fig. 26).

*Crushing.*—The softened grain is passed through a mill called the crusher (Fig. 27) which consists of two large disks, set face to face, having projecting teeth and rotating in opposite direc-

tions. The crusher is supposed to grind only to a coarse meal thus leaving the germ and hull intact.

*Separation.*—The resulting mass is fed to a long, narrow tank about twenty-five feet long, four feet wide and eight feet deep, filled with starch liquor approximately 8° Baumé, 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

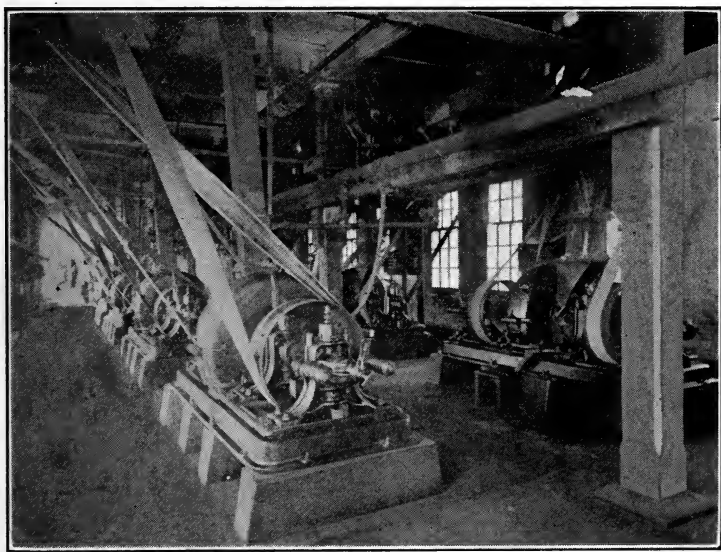


Fig. 27.—Crushers. (Courtesy of Corn Products Refining Co.)

hulls sink to the bottom and flow off with the starch liquor (Fig. 28). The germs are passed through cylindrical rotating screens where they are washed free from starch.

This operates as a continuous working process. The washed germs are dried, ground and passed through a press which works on the principle of the familiar household fruit press. During the pressing steam is employed to keep the oil more fluid. The press cake is discharged in the form of their shavings and may be ground at once into meal and sold as a valuable stock feed. The

oily liquid is settled, filtered and clarified. 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 employed as a rubber substitute in the preparation of such articles as shoes, rubber specialties and automobile tires.

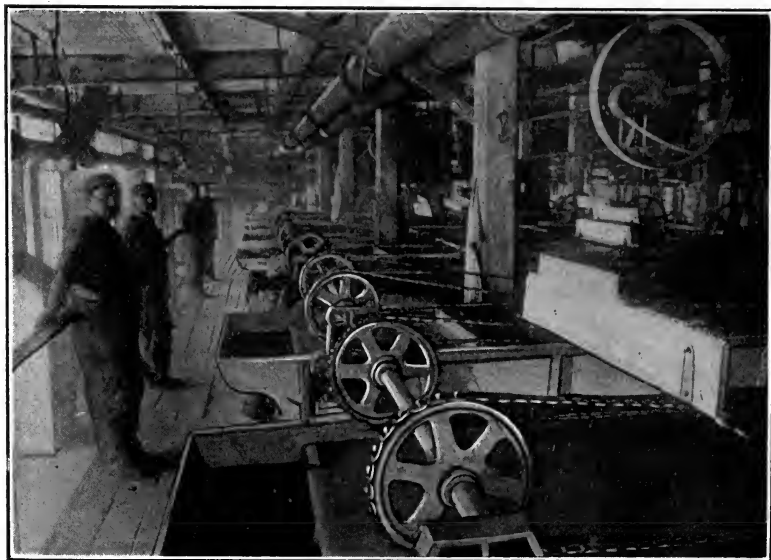


Fig. 28.—Separators. (Courtesy of Corn Products Refining Co.)

*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 through cylindrical screens, the starch liquor uniting with the starch liquor of the germs. The hulls being coarse are ground in burr mills, passed through screens and become 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 removing the starch liquor screened from the germs, hulls and ground hulls, directly upon tables from sixty to one hundred and twenty feet long, three feet wide with an incline of about four 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

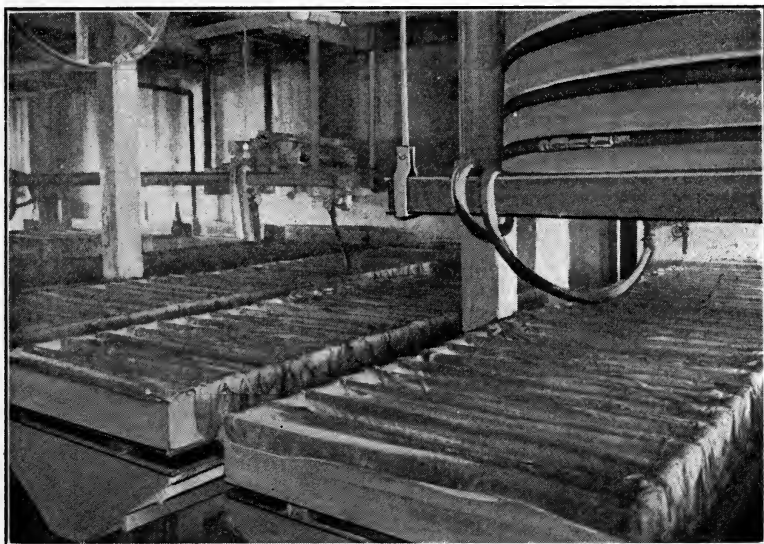


Fig. 29.—Dripping Boxes. (Courtesy of Corn Products Refining Co.)

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 a strong current of water. 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 protein are removed. Pearl starch, to be used for baking powder and for certain classes of food starch, is prepared by breaking up the starch from the table and depositing it

on trays which are placed on 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. 29). 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. 30). 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.

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

**Use of 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 nineteenth 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. The commercial forms containing fifty per cent. or less of actual glucose are known as glucose. Corn sugar includes the solid forms of glucose containing more than fifty per cent.

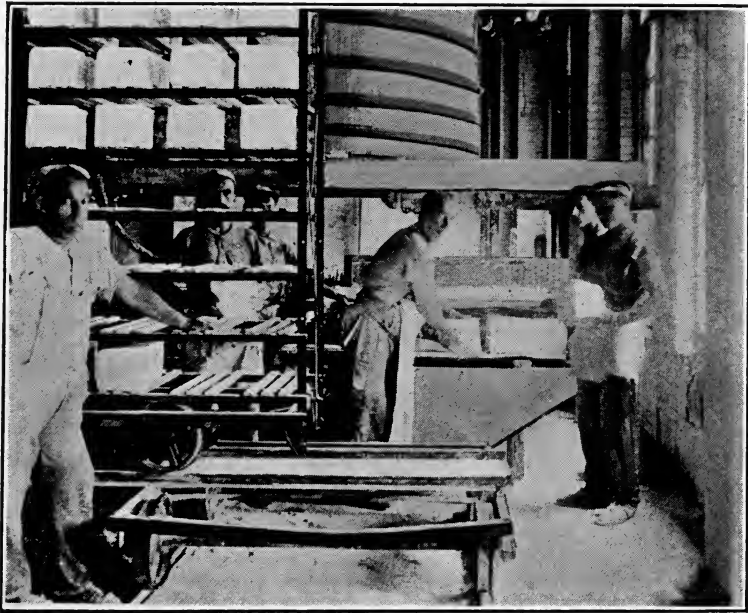


Fig. 30.—Emptying Starch from Drip Boxes. Breaking into Cubes.  
(Courtesy of Corn Products Refining Co.)

**Uses for Liquid 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.

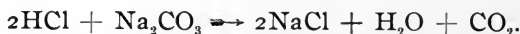
**Uses for Corn Sugar.**—In the manufacture of caramel (sugar coloring); in brewing of beers, porters etc.; for vinegar; in the manufacture of lactic acid; in bread making.

**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 digester, with a minute quantity of muriatic acid (commercial hydrochloric). 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 thirty-five pounds is maintained and the operation at that pressure is finished in about five to ten minutes.

On the continent and in England sulphuric acid 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.



The American manufacturer prefers the use of hydrochloric acid 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 a trace of sodium chloride.



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 eighty-six 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.

The dissacharid  $C_{12}H_{22}O_{11}$  known as sucrose or saccharose is found in a large variety of plants. It is so apt, however, to be accompanied by the characteristic flavor 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.**—Cane is the primitive source of sugar. 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 the use of sugar until the thirteenth and fourteenth 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 the sugar cane 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 beet sugar industry dates only as far back as the early days of the nineteenth century. A half century before its introduction, the German chemist Marggraf had called the attention of the Berlin Academy of Science to the fact, that sugar could be extracted from the beet

but he did not carry the work beyond the laboratory stage. His pupil and successor, Achard, applied Marggraf's discovery to industrial purposes and in 1802 a small sugar factory was erected in Lower Silesia.

At that period the nations of Western Europe were involved in warfare and a continental blockade had cut off the supply of cane sugar from the New World. A search was made 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. Napoleon's attention being attracted to a treatise, written on the extraction of sugar, from the beet appointed a commission composed of scientists to investigate Achard's factory. A long series of experiments followed which had for their final outcome the birth of the beet sugar industry in France. It was established 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 thirty to forty 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 again 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. Its success here is largely due to: 1st, the Bureau of Chemistry and Plant Industry which investigated conditions throughout the country under which the sugar beet could be successfully grown; 2nd, numerous Bulletins and Reports of these departments giving results of their experimentation; 3rd, the immense irrigating works which the Federal Government constructed at great cost.

**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. India, Java, Cuba, Hawaii, Porto Rico and the Philippine Islands, 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.—

- Cane cut in the green stage.
- Cane crushed { begasses  
                  { crude juice.
- Crude juice screened { woody fiber.  
                          { juice.
- Juice treated with milk of lime; residue removed.
- Juice concentrated.
- a. Boiled down in open kettles.
- Drained in hogsheads or casks { molasses.  
  { muscovado.
- b. Boiled down in vacuum.
- Separated in centrifuge { molasses.  
                                  { raw sugar.

*Cutting.*—When the crop is ready, the sugar cane is harvested by cutting the stalks as close to the ground as possible. Considerable care must be given that the plant is 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. 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 crushing by means of heavy mills. Cane-mills of to-day are of various types ranging from the crude ox-driven mill of primitive countries (Fig. 31) 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 a high crusher (Fig. 32) which reduces the stalks to a pulpy fiber and extract much of the juice. The 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

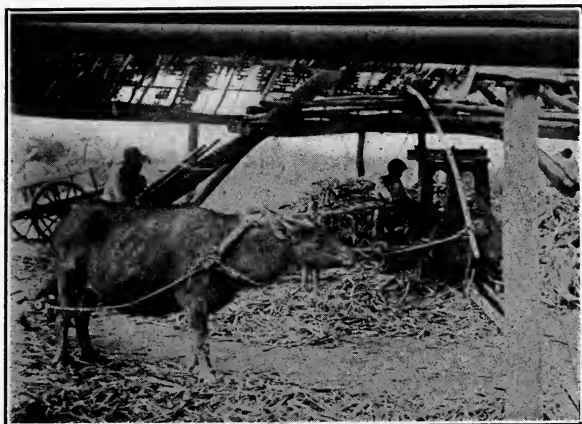


Fig. 31.—Cane Mill, Philippines.

(Courtesy of the School of Mines Quarterly, Columbia University.)

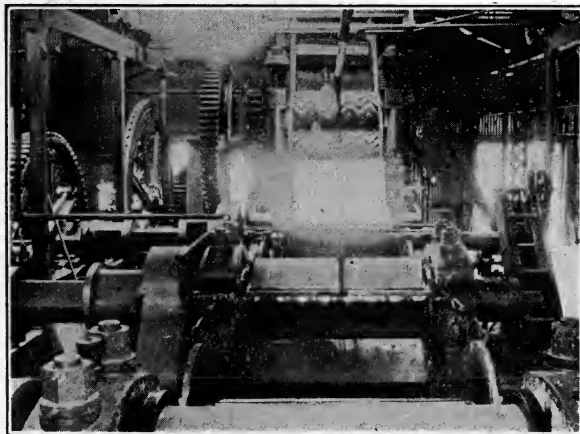


Fig. 32.—Cane Crusher, Hawaii.

(Courtesy of the School of Mines Quarterly, Columbia University.)

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. Two or more mills are sometimes used, more and more of the juice being extracted by each roll. It is customary to spray the pulp 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. With modern machinery the extraction of juice by this method is almost perfect. From ninety to ninety-five per cent. of sugar present is obtained and the *begasse* can be used directly as fuel.

*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 universally employed and the mass is heated to boiling.

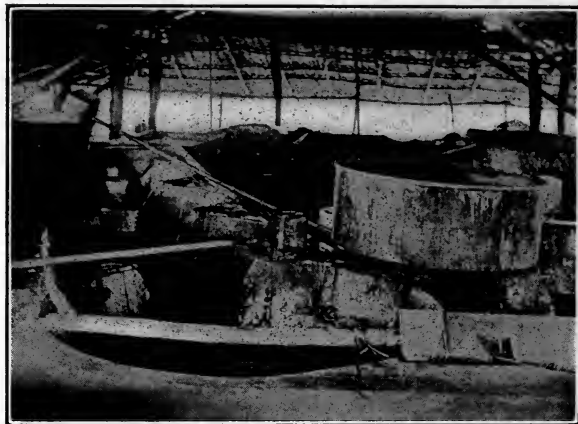


Fig. 33.—Open Pan Evaporator, Philippines.  
(Courtesy of the School of Mines Quarterly, Columbia University.)

This prevents fermentation, neutralizes the free organic acids of the juice and assists in the coagulation of the dissolved matter. A thick scum of impurities rises to the top and sediment deposits on the bottom. The former consists of lime salts and albuminous matter and is known as “the blanket scum.” On standing the clear juice is drawn off and the impurities are



passed through filter presses and washed to remove sugar, the washings being added to the clarified juice.

*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. 33). 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  $212^{\circ}$  to  $240^{\circ}$ - $250^{\circ}$  F. and resulted in the formation

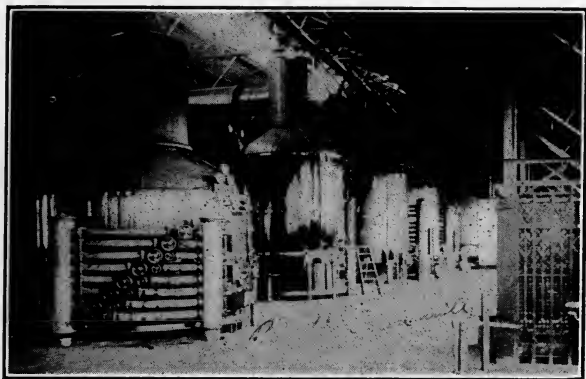


Fig. 34.—Vacuum Pans, Hawaii.

(Courtesy of the School of Mines Quarterly, Columbia University.)

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. 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,  $160^{\circ}$ - $180^{\circ}$  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. 34). 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

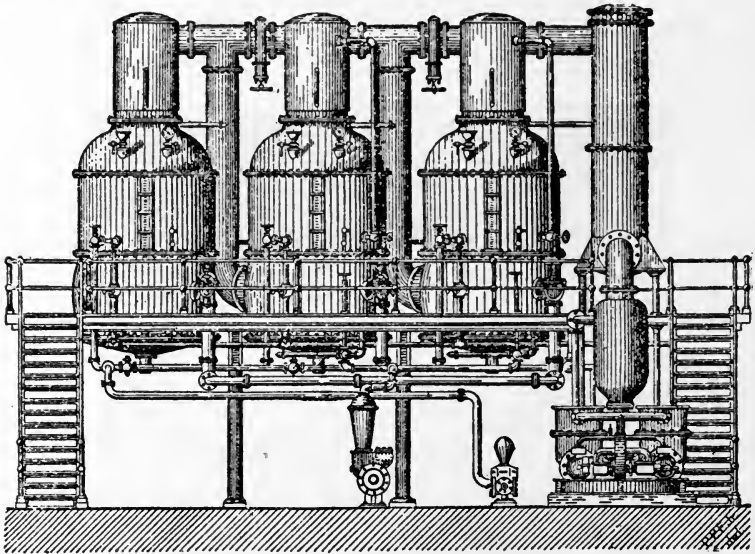


Fig. 35.—Multiple-effect Evaporating Apparatus.

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. 35). When arranged in series, a low 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

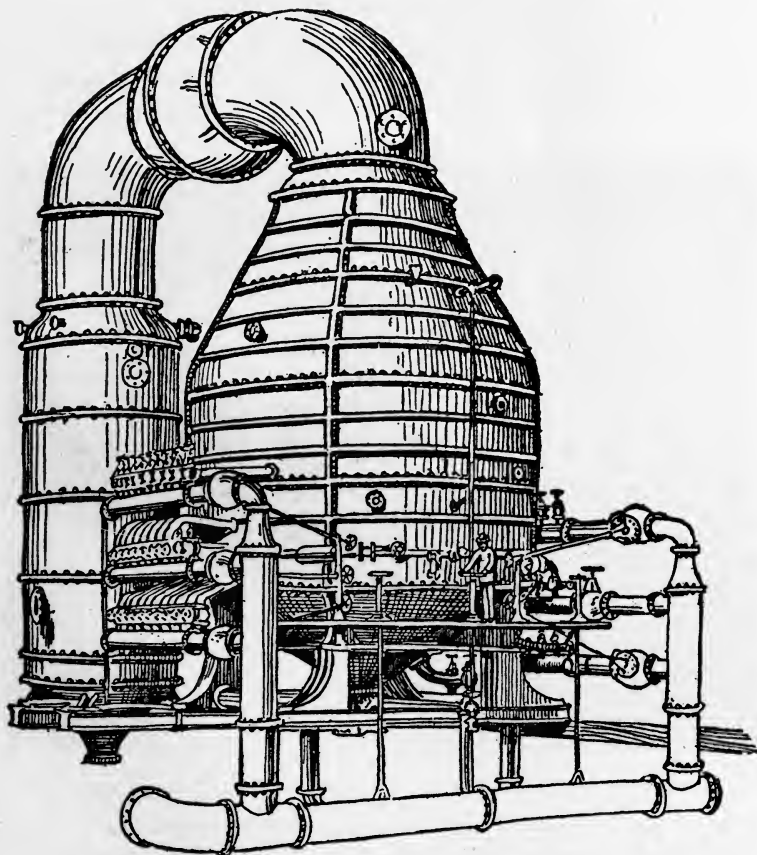


Fig. 36.—Vacuum Strike Pan.

vacuum is maintained (Fig. 36). 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 mixture of crystals and syrup is known as "massecuite." The vac-

uum 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 which increases the yield of sugar crystals. 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. 37). It can be rapidly rotated during which the sugar mass is thrown against the

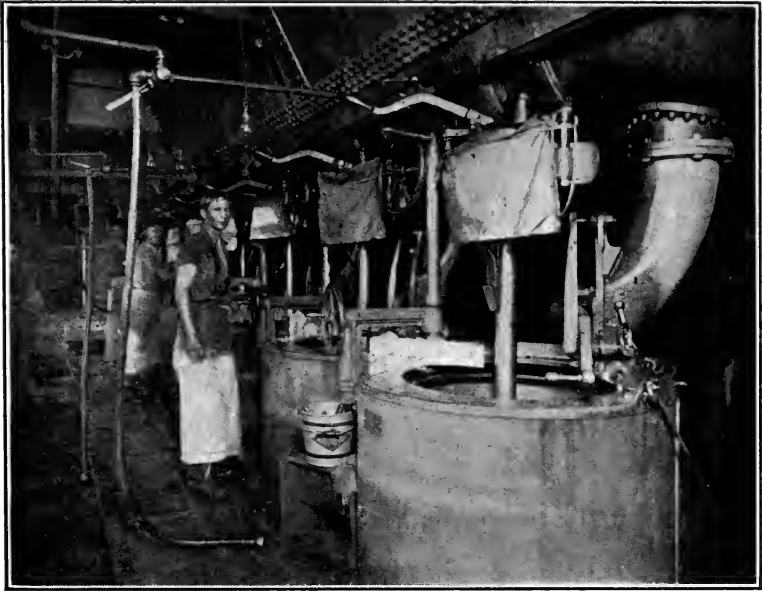


Fig. 37.—Centrifugal Machines. (Courtesy of *Sugar*, Chicago, Ill.)

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.

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 thirty per cent. sugar it contains so many impurities that the sugar will not crystallize.

#### THE BEET SUGAR INDUSTRY.

GROWTH.—Unlike the cane the sugar beet reaches its highest development in a north temperate climate although where the soil has exceptionally good qualities it has been grown successfully in sub-tropical regions but is not apt to contain as much sugar. Moisture also plays an important part in the 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 can also be grown successfully in irrigated areas and large tracts of 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. 38 and 39). The average percentage of sugar is thirteen to fourteen per cent. while on irrigated area it has been increased to sixteen to eighteen per cent. The yield per acre is still low, not exceeding eight tons, while in Europe twelve to thirteen tons are obtained (Fig. 40).

#### OUTLINE OF THE PRODUCTION OF RAW BEET SUGAR.—

Beets are grown, harvested, topped.

Washed.

Sliced.

Diffused    { pulp.  
                  { crude juice.

Crude juice is screened.

Defecated.

Filtered    { albuminous matter, etc.  
                  { juice.

Concentrated in vacuum.

Centrifuged    { molasses.  
                      { raw sugar.

*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



Fig. 38.—The Wild Beet. (Courtesy of *Sugar*, Chicago, Ill.)

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 accom-



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

plished in long troughs each containing a revolving shaft which carries pins set in the form of a screw. These push the beets

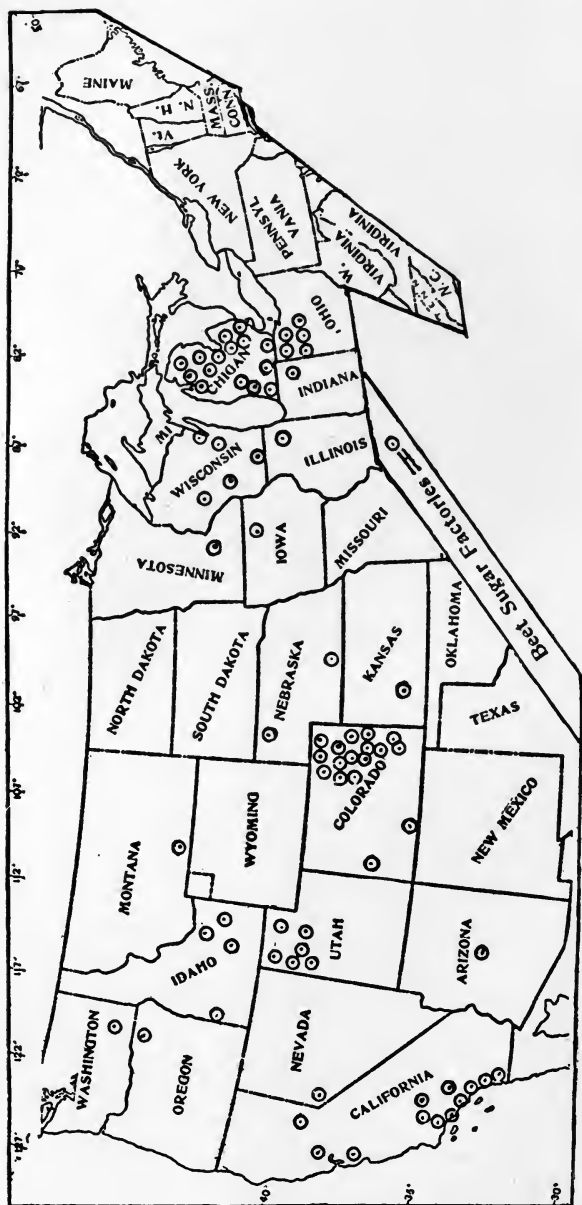


Fig. 40.—Distribution of Beet Sugar Factories. (Courtesy of the U. S. Dept. of Agriculture.)



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 cane
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 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. 41). They are usually arranged in a series of ten to twelve 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.

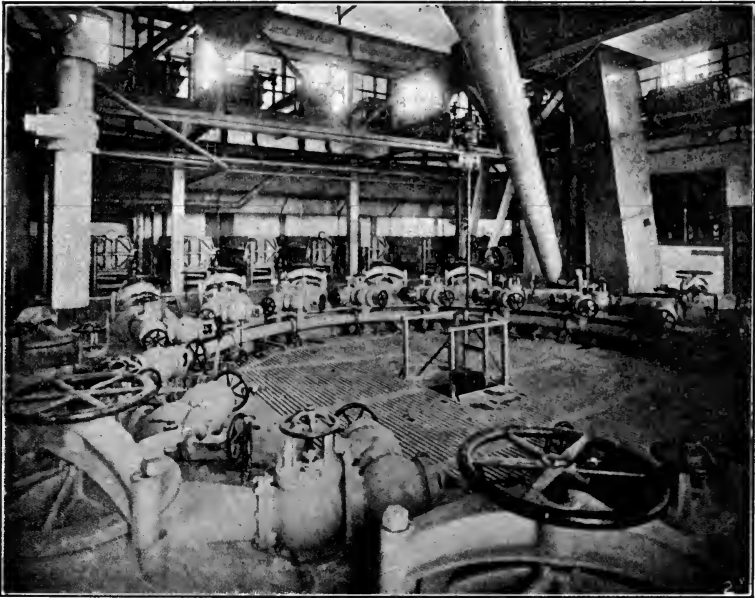


Fig. 41.—The Circular Diffusion Battery. (Courtesy of Sugar, Chicago, Ill.)

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  $140^{\circ}$  F. is passed through the system. The 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 proc-

ess is continued until practically all the sugar has been removed from the beet chips. There is rarely more than one-half of one 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 eight to ten 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 carbon dioxide. 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 one tenth of one 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 two or three one hundredths of one 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 on 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 fifteenth and sixteenth centuries. As early as 1689 there was a refinery in New York City which is still the center of this industry in the Western World. 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 and pure 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.—

Raw sugar washed.

Centrifuged { wash syrup.  
                  { washed raw sugar.

Washed raw sugar melted.

Defecated.

Filtered through bags { mud, etc.  
                                  { liquor.

Liquor bone-blackened.

Boiled down in vacuum.

Centrifuged { syrup { syrup.  
                  { sugar { yellow sugar.

*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 ninety-nine to ninety-nine and one-half 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  $30^{\circ}$  B $\acute{e}$ . it is pumped into defecators or “blow-ups.”

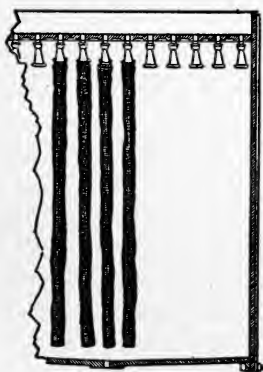


Fig. 42.—Filter Bags.

*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 carrying with it suspended matter and some of the coloring.

*Filtration.*—The impurities are removed by a mechanical filtration through filter presses or cotton-twill bags enclosed in coarse, strong netting sheaths. They are six to seven feet long and five

to six inches in diameter. The open end is tied tightly around a metallic nipple by which the bag is suspended (Fig. 42). 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 twenty 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 the power of removing color and must be revived by being 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.

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.

Block sugar may be made in two ways: 1st, 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 large slabs of sugar can be freed in a few minutes from the syrup, and the sugar after drying can be cut into blocks; 2nd, 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.

**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 in the sun or by 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 bagasse 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 bagasse. 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 with ordinary methods chemical means are being devised for its extraction. Beet sugar molasses contains fifty per cent. of sucrose. By treatment with calcium, strontium or barium hydroxides it is possible to precipitate the sucrose as insoluble trisaccharate which after filtration may be decomposed by carbon dioxide 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 bagasse 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. See page 47.

**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 twenty-five to thirty per cent. of the water remains which is sufficient to prevent the crystallization of the sugar.

## CHAPTER XI.

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### FRUITS, VEGETABLES AND NUTS.

Among the most important commercial food products of the world are fruit and vegetables. Whenever obtainable, wild varieties of fruit seem to have been among the earliest foods used by primitive man, and it cannot be told now with any degree of certainty when their cultivation was started. So long a time has elapsed, however, that with a few exceptions the cultivated products of to-day bear little resemblance to the very small, woody, inferior fruits of the wild parent. Whether savage or civilized every nation has also cultivated plants for use as vegetables and those that are most highly prized are the result of long cultivation, the origin of most being lost in antiquity.

**Importance in the Diet.**—In temperate climates fruits have been used largely on account of the pleasant flavor and the custom has long prevailed to look upon them more as an agreeable addition to the diet than as staple food. It has been left to modern science to show the important part that fruit and vegetable acids and mineral salts, especially those containing lime, phosphorus and iron, play in maintaining the chemical equilibrium of the body. Fruits and vegetables supply the organism with much of the necessary mineral matter in an acceptable form. For percentages of individual ash constituents in the edible portion of important fruits and vegetables see Sherman's "*Food Products*," pages 347-9. The peculiar type acids present produce by combustion bicarbonates which assist in maintaining the alkalinity of the blood thus having the tendency to correct the ill effects of a diet high in protein.

With certain exceptions fruits are mildly laxative due to certain elements which they contain and to the cellulose which acts as a diluent and irritant to the intestinal tract. Many of the ordinary foods are too concentrated; they lack bulk. This deficiency can readily be supplied by fibrous fruits and vegetables, such as prunes, figs, apples, berries, lettuce, spinach, corn, beets, squash, tomatoes, cucumbers, etc. Most of these can be con-

sumed either in the raw or cooked condition. According to recent investigation some raw or uncooked foods, notably lettuce, tomatoes, celery, nuts and similar products, appear to be essential in the diet since certain small components known as vitamins are destroyed during the cooking and canning processes. While not as yet well understood it is now believed that vitamins are essential to health and their absence may be the cause of certain diseases, for example, scurvy and beri-beri.

Fisher and Fisk\* recommend that the diet in middle life should decrease in the consumption of meat and all flesh foods as age advances and that fruits and vegetables, especially those of bulky character and low food value be increased.

From an economic standpoint fruits and vegetables are reasonably cheap sources of energy when compared with many other foods. Their agreeable flavor, great variety, comparatively low cost, composition and importance in maintaining the chemical equilibrium of the body place them among our staple foods rather than as pleasant accessories to the diet.

**Definition and Classification.**—To define the terms fruits and vegetables with any degree of accuracy seems almost an impossibility. An attempt has been made to differentiate between these two food products by the acid and sugar content classifying those that contain both as fruits, all others as vegetables. On the whole that arrangement does not appear to be as satisfactory as the distinction current at the present day which depends largely on the usage. As a general custom vegetables are consumed together with meats, while those products which precede or follow the meal and form a separate course are known as fruits. It is apparent from these customs that fruits are largely considered as appetizers and stimulants of digestion.

Fruits are generally divided into three classes: 1st, stone, which include peaches, plums, cherries and apricots; 2nd, seed, such as apples, pears, grapes, oranges, lemons and kindred fruit; 3rd, small, in which berries of all varieties are placed. The principal exceptions to these divisions are melons, cucumbers and tomatoes

\* How to Live, by Fisher and Fisk.

which are more nearly allied to what are popularly known as vegetables.

Vegetables are usually classed as follows: tubers, represented by the potato; roots, such as turnips, carrots and beets; leaves, of which spinach and lettuce are the most important; flowers, which include such foods as cauliflower and Brussels sprouts; stalks, such as celery and rhubarb; shoots, of which asparagus is the most important.

**Composition.**—The composition of a majority of ripe fresh fruit reveals a large proportion of water, a fair percentage of carbohydrates, a small amount of protein, organic acids, essential oils, ethereal salts and mineral matter. On account of the high water content in many varieties it has been suggested that fruits containing eighty per cent. or more be classed as "flavor fruits." This class would include many of the common fruits, such as apples, pears, peaches, plums, oranges and most berries. Fruits with less than eighty per cent. would be known as "food fruits" and would include the banana, fresh figs and grapes. In most of the fruits and fruit products the carbohydrates are the food constituents most abundantly represented. Cellulose always appears giving stability to the structure. Pectose bodies are represented in a great number of fruits and vegetables, for example, green grapes, cranberries, currants and white turnips, the quantity growing smaller as the product reaches the period of ripeness. They give to fruit in the presence of acids the property of forming jelly. Other carbohydrates present are cane sugar, invert sugar, which includes glucose and fructose, and starch which occurs in varying proportions. The flavor of fruit is due partly to organic acids which include malic, tartaric and citric. These acids are found in various proportions and frequently occur as acid salts of potassium, sodium or calcium. In the ash of fruits can also be found small quantities of phosphates, carbonates, sulphates and chlorides. The importance of these acids and salts has already been mentioned.

In the composition of vegetables less water is found, carbohydrates are well represented by starch as in the potato, while sugar can be found in relatively large proportions in beets, par-

snips and onions. In the legumes the protein constituents are of special interest and a high mineral matter content makes spinach, lettuce and celery important articles in the diet.

**Cultivation.**—Marked improvements have been made in cultivation during recent years. Varieties can now be planted which will mature with different degrees of rapidity yielding products commonly known as early, medium and late varieties, thus extending the season in one locality over several weeks. Special attention along the lines of cultivation is also given to such fruits and vegetables as will stand handling, transportation and storage. In former times it was the invariable habit to pick these products in the green state and ship them to the market trusting that they would develop sufficiently to be salable. This idea is rapidly dying out except in tropical fruits similar to the banana. The extension of the cultivation of some types, such as asparagus, has resulted in placing that vegetable within the reach of nearly everybody where in the past it was used exclusively by the well-to-do.

Through the efforts of the modern horticulturist natural fruits that were full of seeds and pits thus making them objectionable have been so improved that in some cases seedless varieties are being successfully grown. Examples may be found in the banana, the seedless oranges and lemons and to some extent the seedless persimmons. Within our own areas can now be grown fruits which for a long period were considered tropical. California in recent years has supplied the market with fresh olives and figs. Undoubtedly these improvements are largely due to the work carried on by the United States Department of Agriculture and at the Experiment Stations of the various states.

**Handling on the Farm.**—Among the necessary steps for the preparation of fruits and vegetables for the market may be included harvesting, storage, cleaning and packing. Storage on the farm is usually for the purpose of holding these products for higher market prices. Methods differ with the various articles but conditions must always be such that decomposition will not start. Apples are generally picked before they are thoroughly

ripe and placed in piles in the orchard until they acquire a mellow flavor. When picked fully ripe they should be eaten within a short time as they cannot be stored. The care of apples is simple but exact. They must be kept dry and cool, the cooler the better, but must never be frozen. All decaying fruit must be removed at once from contact with the sound fruit or the trouble will spread with great rapidity. Almost all varieties of grapes can be kept if packed loosely in cork chips or similar material.

In general all vegetables should be stored in a dark, dry place of cool, even temperature. Celery can be held advantageously if it is well packed in salt hay and put into pits or underground cellars; or it may be held in a cool place without washing or trimming by placing with the heads up in a long, deep box and filled around the roots with sand which should occasionally be moistened. Cabbages and head lettuce can readily be wintered at a temperature near freezing if they are properly piled just as they are taken from the ground. When carrots are held in cold storage or in cellars they will keep best if placed on slat platforms and covered lightly with sand. Onions should be cured in the sun for several days if they are to be stored and a dry, airy place of storage is essential since they deteriorate rapidly in dampness. When being held to take advantage of market rises in prices the tops are frequently left on to protect them against bruising. In storing potatoes not only excessive moisture should be avoided but extreme dryness since the latter causes them to shrivel. To prevent shriveling of vegetables a covering of sand or soil, kept dampened, is frequently used. The root vegetables, such as turnips, beets and the like, should also be kept intact since the removal of the tops or leaves causes a loss of liquid content and a decided diminution in the flavor. Cabbages, lettuce and similar plants should never have the outer leaves removed until just before they reach the consumer. In shipping long distances the butts of asparagus stalks are occasionally dipped in paraffin to retain the sap of the plant.

Before being sent to the market a rough cleaning of vegetables is necessary. Roots are removed after which they are washed and roughly dried. Produce should always be carefully graded

before being packed. Usually fruits are divided into three grades, Firsts or Primes, Seconds and Culls. Firsts or Primes must be uniform in size, color and shape, of an even degree of ripeness and free from insect injuries, bruises and other defects. Seconds must be good, fairly uniform specimens, not noticeably marked by insects, fungus or other damage. Culls are those specimens which will not fill all the requirements of either of the other grades. Crates, boxes or ventilated barrels are now used for most products. In some localities growers find it profitable to wrap certain kinds of fruit in paper bearing an attractive label. The use of wrappers has a tendency to prolong the keeping qualities as well as to add to the attractiveness. The old practice of shipping vegetables, such as potatoes and turnips, in sacks should be abandoned as not sufficient protection is afforded for the material during handling. White potatoes contrary to the general belief are quite delicate. The skins are thin and if bruised they do not form the protection usually relied upon.

**Transportation and Storage.**—The storage of fruit and perishable products has become a great industry in this country. Through the application of cold storage in transportation it is possible to bring properly ripened fruits and vegetables from long distances. Modern methods are a great contrast to the old idea of carrying green products without special cooling conditions trusting to incipient decomposition to produce an effect similar to ripening. Through storage and the possibility of shipping long distances the season of most fruits and vegetables extends the year round, flooding of the market at certain periods is prevented and prices are more uniform.

Only the best fruits should be stored; those which are uniform in size and color and are free from blemish or mechanical injury. The essential factors in storage are good ventilation, sufficient moisture, good insulation and control of temperature. Ventilation is necessary in order that vapors given off by the fruit may be removed and that sufficient oxygen may be present for the respiration of the fruit. The change of air also helps to keep the surface of the fruits fairly dry and tends to hold rots in check. Moisture should be present in sufficient quantities to

prevent the shriveling of the fruit or the product might be unsalable. Maintaining desirable temperatures is largely dependent on good insulation. Storage house walls usually have dead air spaces or walls filled with sawdust or mineral wool in order to prevent the transfer of heat from without, thus warming the air within the storage chamber. After the material has been stored it should not be handled until it is ready to be repacked for shipment to market. A loss of ten to twenty-five per cent. always occurs due to evaporation and rotting.

**Marketing.**—Since it is a common practice to eat most fruits in the raw state they should be handled and marketed under sanitary conditions. Fruit which has fallen to the ground will be soiled with earth, water or other material which may contain typhoid or another type of pathogenic bacteria. Investigation has also shown that fruits exposed to street dusts and other unfavorable conditions, such as flies and various insects, become covered with bacteria and may be a possible source of contagion. Local rules are now in force to protect fruits and vegetables from the dust of crowded streets, overhandling and insects. A transparent medium like glass or celluloid is generally used as a covering. Notwithstanding these protections market fruit should always be washed before being eaten.

**Fruit Products.**—Various methods of preserving fruits and vegetables, for instance drying, preserving and canning are treated under the heading of Preservation of Foods.

*Candied Fruit.*—A wide variety of fruits are now being candied or crystallized and should belong properly to the class of confectionery. The process used in Portugal which is one of the most important producing countries, consists in repeatedly boiling the unripe fruit in strong syrup, draining after each operation and eventually drying the product on trays in the open air. Another method frequently employed is boiling the unripe fruit until tender, then suspending it in strong syrup, kept concentrated by occasional evaporation, until the fruit has become almost transparent. It is next placed in drying rooms until the syrup has crystallized.



*Jellies, Jams, Marmalades and Fruit Butters.*—The preservation of fruits, fruit juices and fruit pulp with sugar has grown to be an important industry in the United States. Jellies are sweetened products obtained by boiling fresh almost ripe fruit or berries in sugar syrup, straining while hot and allowing the clear liquid to cool and solidify. The solid fruit residue may be boiled for some time with additional sugar and water yielding an inferior type of jam. As a rule jam is prepared by reducing the entire fruit to a pulp and cooking in a sugar syrup. Fruit butters are less sweet than jams and usually have the addition of spice or cider. Marmalades are made by boiling the pulp or juice of thick-rind fruits, like the orange, grapefruit or komquat and portions of their rind with sugar. Apple pulp is frequently added to give the peculiar transparent, jelly-like consistency.

#### NUTS.

Nuts as they appear in the market ready for use are in reality the pits of a variety of pulpy inedible fruits yielded by a large number of deciduous trees. It is the custom to dry and remove the pulpy envelope before storage and marketing. The importation of nuts is still important commercially, although many of these varieties which were formerly grown exclusively in foreign countries are now being successfully cultivated in many parts of the United States. California especially raises big crops of walnuts and almonds while Louisiana and Texas are noted for pecans. Except for a few varieties, which include almonds, Italian chestnuts and the English walnut, imported nuts are largely products of forest trees. On account of the tough and fibrous nature of the shell nuts survive rough handling in transportation in excellent condition but it is a mistake to hold the opinion that they need not be protected from the attack of mold, insects and worms by suitable storage conditions. They can be safely carried through the winter if held in a cool, dry place but cold storage at a temperature just above freezing is desirable during the summer months.

**Composition.**—The composition of the edible portion of nuts is evidently not understood by the average consumer. Until com-

paratively recent years they have been considered in our country merely as a luxury or something to be eaten at odd times but fortunately a better appreciation of their food value appears to be gradually increasing. As a result of research work carried on at the California, Maine and Iowa Agricultural Experiment Stations a table has been published giving the average composition of nuts and nut products.\* The water content is usually low so nuts must be considered as concentrated food. With the exception of chestnuts which contain notable proportions of starch all nuts consist largely of peculiar fats or oils usually of the drying class, protein and cellulose. Rich in oil are the pecans, Brazil nuts, butternuts, filberts, hickory and walnuts, all containing from sixty to seventy per cent. fat. In general the nuts are also high in protein surpassing most ordinary animal and vegetable foods in this respect. Varieties which contain over twenty per cent. include peanuts, butternuts, almonds, beechnuts and pistachio. Starch as a rule occurs in small amounts with the exception of chestnuts, which contain seventy-three per cent. and beechnuts, pinenuts and peanuts which have about eighteen per cent. The agreeable flavor and odor of many nuts are due largely to harmless compounds of the glucoside class, for example amygdalin of the almond.

**Digestibility.**—On account of the high fat and protein content nuts are more desirable as the base of a meal rather than as the dessert. Excessive use of nuts at improper times has established for them a reputation of indigestibility which they do not deserve. When eaten in a reasonable manner they yield very satisfactory results but do not entirely replace animal protein. The roasting of chestnuts and other starch-containing forms tends to make them more digestible. The practice of salting almonds and various other nuts has no influence on their digestibility but modifies the taste making the large proportion of fat more acceptable to the palate.

**Nut Products.**—In foreign lands nut flours and meals are used in large quantities for preparing bread and cake but as yet they

\* Farmer's Bulletin No. 332.—Nuts and their Use as Food.

have found little favor in the United States. In general they are prepared from the ordinary edible nuts by blanching, thoroughly drying and grinding. Nut oils particularly that of the walnut, beechnut and peanut are highly prized as salad oils in some parts of Europe. South America uses Brazil nut oil for table purposes. Coconut oil is used largely in the tropics and in the United States not only for culinary purposes but on a large scale for technical applications. Recently nut pastes have come upon our market and on account of their agreeable taste and nutritive qualities are gaining rapidly in favor. Of these peanut butter is the best known. It is prepared by reducing the clean, roasted nuts to a paste by grinding. Salt and oil may or may not be added. On account of the high fat content they are apt to become rancid so are usually marketed in small jars.

## CHAPTER XII.

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### FATS.

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

**Extraction.**—In the technical preparation of fats and oils different methods known as rendering, pressing and extracting by solvent are employed according to the physical condition in which they exist, the source and use.

Crude processes of rendering which date back almost as far as the history of the human race itself are still employed in Central Africa, the Malay Archipelago and the South Sea Islands. These consist in allowing broken seeds or fruit to melt by the heat of the sun and collecting the oil which is exuded. The preparation of palm and coconut oil by boiling the fruit kernels with water is a later development of this method. The boiling-out method has long been practiced on the largest scale in rendering animal fats and oils from the tissue in the manufacture of tallow, lard, whale oil, cod-liver oil, etc., in packing houses and in the modern whale oil and fish rendering works. Since animal fats are contained in cells composed of protein tissue which putrifies soon after the animal is killed, it must be rendered immediately to prevent a foul odor from arising. The modern method of rendering consists essentially in cutting up the fatty tissue into small fragments, transferring them to open vessels containing water, where they are heated under ordinary pressure, or to digesters where increased pressure can be used. As the fat gradually exudes it collects on the top of the water while the membranous tissue known as "greaves" settles to the bottom. The fat is then drawn off and strained through sieves or filters. A further yield of fat is obtained by subjecting the "greaves" to hydraulic pressure. Low temperature and the greatest cleanliness must be observed where animal fats are intended for edible purposes in order to obtain a sweet and pure material.

The extraction of oil by the pressure method was practiced originally by crushing seed, such as linseed and rapeseed and grinding

between stones, a custom still found in India. An improvement of the method is used in the preparation of soya bean oil which consists in bruising the seeds, heating the meal in an open pan and pressing out the oil in a wedge-press. From these early customs and crude machinery the oil industry has developed until a most complete form of modern oil-pressing plant is used in countries which have gained supremacy in the oil crushing trade. The operations in treating oil seeds or oil nuts for the separation of the oil they contain are as follows: freeing the raw material from dust, sand and other impurities by sifting and from pieces of iron by passing over magnetic separators. When required the seeds and nuts are decorticated, the shells removed and the kernels

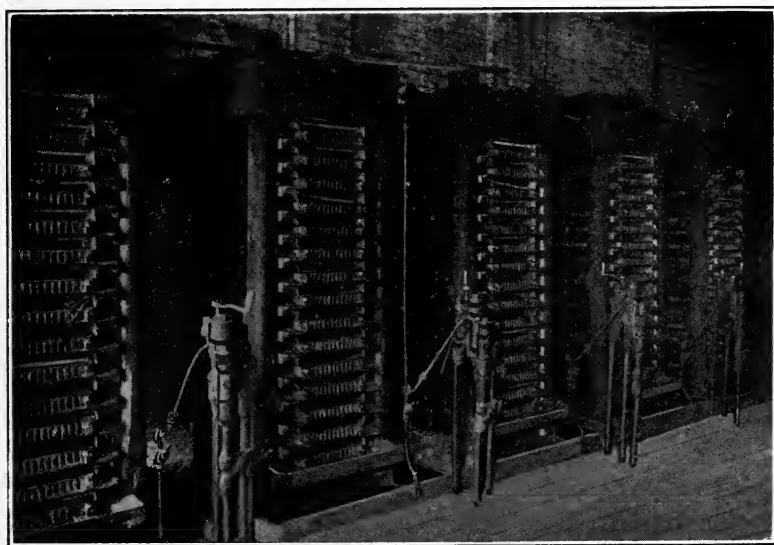


Fig. 43.—Hydraulic Presses for Oil. (Courtesy of Corn Products Refining Co.)

ground into a pulpy mass. For the preparation of edible oils the meal is pressed in the cold after having been packed in bags and placed in hydraulic presses. Fig. 43. A larger quantity may be obtained by pressing the meal at a higher temperature or by heating the residue after the cold-drawn oil has been removed. In the case of seeds of lower value (cottonseed) it is important

to express in one operation the largest possible quantity of oil. This is accomplished by warming the crushed seeds in a steam-jacketed kettle so arranged that some steam may be allowed to pass inside the kettle while it is being agitated, thus assisting in the bruising of the cells. The oil is then removed by pressure and the pressed cake containing from five to ten per cent. of oil is used as cattle food.

In cases where the full yield of oil is desired the seeds are extracted with volatile solvents, for example petroleum hydrocarbons and carbon disulphide. For this operation the seed is prepared in a similar manner as for pressing except that it is not reduced to as fine a meal. It is then placed in a series of closed vessels through which the solvent percolates by displacement, or in an apparatus, where by the application of heat the solvent may be passed repeatedly through the mass until the operation is complete. The solvent is then removed by distillation.

**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 technical purposes. Purifying can be carried out by filtration through various media, such as cotton fiber, bone-black, Fuller's earth, etc., with or without a treatment with caustic alkali, acid, or both.

#### BUTTER.

Butter being the most attractive form of fatty material has long been popular as a food product. In the United States and Canada it is the chief fatty form of food. Although not as largely used for cooking purposes as formerly it still retains its high favor as a cold edible fat. Until a very recent period butter was a household product the operation being under the control of the housewife. Necessarily made in small quantities with crude apparatus and under conditions difficult of regulation the quality of the product varied. With the advent of the creamery the operation became part of a considerable industry. Power and improved apparatus are employed resulting in an increased output of a more homogeneous composition. With better sanitary conditions a higher quality has resulted.

**Composition of Butter.—**

Water 12 — 16%	{ Soluble 10 % { Insoluble 90 %	{ Butyrin Caproin. Caprylin. Caprin. Myristin. Olein. Palmitin. Stearin.
Fat 82.5 + %		
Protein (Caseinogen)	{ Called curd. The amount is dependent on the method of separating the cream.	
Carbohydrate (Lactose)		
Mineral matter 0 — 4%	{ Salts of milk (trace). Added sodium chloride.	

The object in butter making is to extract from milk the fat which exists in an emulsified form. The United States Standard butter requirements call for at least eighty-two and one half per cent. fat and not more than sixteen per cent. water. The fat consists largely of palmitin, olein myristin, and a small amount of stearin in a loose state of chemical combination 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.—**

Separation of the cream	{ Gravity { Centrifugal force.	{ Shallow pan. { Deep setting system.
Ripening of the cream.		
Churning.		
Washing.		
Working.		

*Separation of the Cream.*—The gravity method of separating fat from milk has been used from the earliest times to comparatively recent years. This was called "gravity creaming." As

fat exists in the form of an emulsion by allowing milk to rest the globules being lighter will gather near the surface of the liquid. In so rising they carry with them certain of the milk constituents in minute particles as 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 twenty per cent. of the fat remains with the skim milk.



Fig. 44.—Early Experiment in Cream Separator.  
(Courtesy of the De Laval Cream Separator Co.)

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. 44). In separating cream by

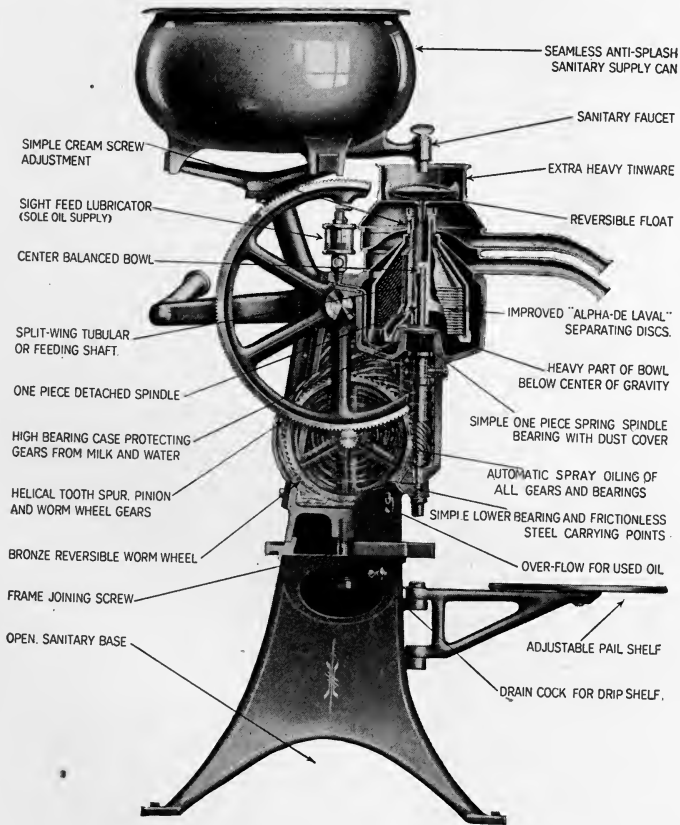


Fig. 45.—Improved De Laval Cream Separator.  
(Courtesy of the De Laval Cream Separator Co.)

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 effi-

ciency of separation (Fig. 45). An entrance is made for the whole milk and suitable openings for the removal of the cream 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 perfection, the skim milk containing not more than one-tenth of one per cent. fat. 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, does not keep as well and involves greater labor in churning. 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, by the addition of sour cream of a previous operation or by those natural to milk, 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 Danes, who now employ this process largely. Professor Conn of Wesleyan University also highly recommended their use but they have never been as popular in America as they have been abroad although their use is constantly increasing. The majority of experts prefer the flavor of butter which has been ripened naturally under thorough sanitary conditions.

The amount of acid allowed to develop depends on the flavor desired. Experienced butter-makers usually judge by the appearance and flavor or tests can be made for acidity by the use

of Farrington's alkali tablets. 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 the fat in mass from the ripened cream so it can be readily removed from the milk serum. Originally butter was made from whole milk after it was sufficiently soured by placing it in the skins of animals and violently agitating it. While this process is still followed in some remote districts it is now customary to churn cream as the amount to be handled is lessened and the operation is far more economical. The old-fashioned dash churn worked by hand represents an early form of churn. 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 twelve to thirty 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 assists in the keeping quality and gives 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. In Continental Europe salt is rarely used and butter is purchased every day for immediate consumption.

*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.

*Preservation.*—It is a common practice in some sections of Europe to heat butter until the water is expelled. Protein matter can then be removed by filtration through cloth and the melted butter run into earthen-ware jars. With this process butter made during the summer can be preserved for use in the winter.

#### OLEOMARGARINE.

Oleomargarine the first substitute for normal dairy butter originated like many other food products in military necessity. The French Government in 1869 offered a prize for a butter substitute, cheaper and better than butter because less perishable, to be used for the army. The prize was won by Mège-Mouriés, a French chemist, who suggested the use of a cheaper fat obtained from beef suet. 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 some manufacturers and local dealers to sell it as butter and in spite of government inspection this fraud is still being practiced.

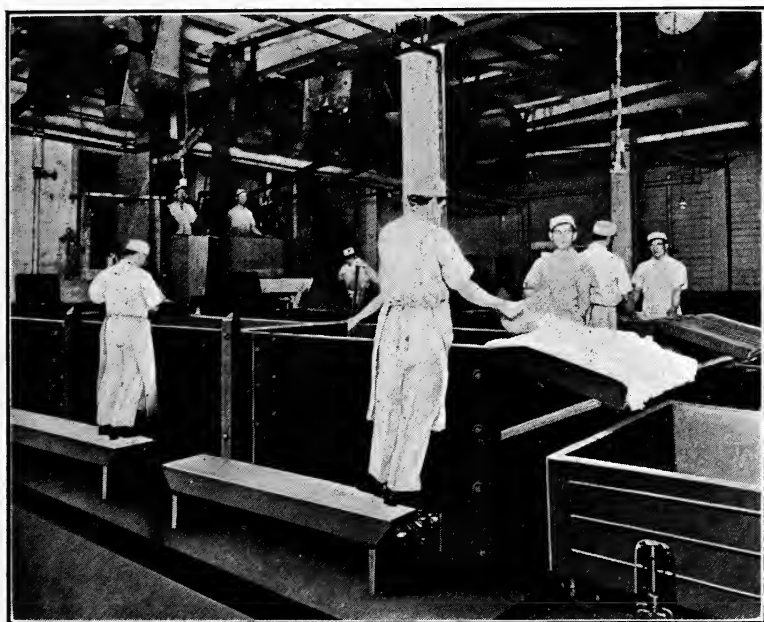


Fig. 46.—Chilling Butterine (Courtesy of Armour & Co., Chicago, Ill.)

**Materials Used.**—The fats utilized as a basis for butter substitutes are those which have been in the diet of civilized people for centuries. Originally oleo margarine was prepared from beef suet but owing to modern developments in the oil industries a variety of fatty substances is now being utilized. Among the animal fats may be found neutral lard and lard stearin; while the vegetable hard and soft fats are represented by copra, palm kernel, cottonseed, peanut, sesame and soja-bean oil. Many manufacturers prefer a mixture of animal and vegetable fats.

In recent years vegetable margarine sold under various trade names, such as nut butters has proved very popular in the European and American markets.

Ripened cream or butter 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. 46). 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 butterine is worked and finished for the market in a manner similar to the processes used in butter-making.

#### 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, strained to remove scum, and purified of the rancidity by washing. The oil is then aerated by "blowing" with air and afterwards emulsified with fresh milk inoculated with a bacterial culture. It is then churned and worked as for ordinary butter. 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.

#### 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 forty to sixty 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. For edible oil production the fruit is best gathered just previous to maturity, although the yield of oil is then less the quality is better. For all other purposes fully ripe or decayed and imperfect fruit is used.

The old methods of extraction still practiced on a small scale in Spain, Italy and other Mediterranean countries are very crude and yield an inferior product. The fruit is placed in a circular court of stone or other masonry, provided with a heavy mill stone, operated by a pole with mule power. After thorough pulping the mass is gathered in rush baskets and pressed in a screw press operated by hand. Inferior grades are obtained by repressing after the addition of water. The newer processes practiced on a large scale employ the most modern machinery and sanitary methods. For producing the finest grades selected, hand picked olives are cleaned, peeled and pitted, the meats are gently cold pressed, yielding the finest quality of oil known as "virgin," "sublime" or "first-expressed" oil. The press cake from this operation is subjected to hydraulic pressure and furnishes a high grade oil known as "huile surfine." A third variety of edible oil is obtained by pouring cold water on the press cake and re-

pressing; the product is sold as "salad oil." By mixing the pulp with hot water and again pressing the mass a fourth extract is made which yields a very inferior product used for soap making and lubricating purposes.

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. In recent years the more extended use of olive oil in the United States for salads and general cooking purposes has led to very strict regulations by Federal and State authorities so that it is hardly possible to sell an adulterated oil as genuine. In fact the label olive oil is generally a sufficient guarantee of genuineness. All mixtures of olive oil with other oils must be sold as salad oils and must disclose the ingredients on the label.

#### COTTONSEED OIL.

Although the cotton plant has long served the human race as a valuable source of fiber two-thirds of the crop was lost in the waste of the cottonseed. Those not needed to plant the next crop were usually thrown away or burned as fuel and it is only within the last fifty years that methods for using them have been developed. Cottonseed has been found to be particularly rich in oil and rapid developments, in methods of extraction and purification, have opened up a new industry and have placed on the market not only a comparatively cheap and nutritious edible oil, but an oil for technical purposes and a long list of valuable by-products. Among these are short fiber cotton for batting, paper-making and explosives, hull products for feed, fertilizer and fuel, meats yielding fatty matter for edible purposes, soap-making, glycerin, oil cloth and water-proofing compounds.

**Processes in Manufacture.**—The seeds when taken to the mill are screened, passed over magnetized 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 caustic soda, 10° Bé., the oil is heated to 80°-85° C. and the mass is constantly stirred with paddles until fatty acids are neutralized and impurities separate. 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 flavor modified 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.

#### COCONUT OIL.

Coconut oil is the fat obtained from the kernels of the coconut. At ordinary temperature in our climate it is a solid white fat possessing a bland taste and an agreeable odor. When not

pure, however, it turns rancid quite easily and then acquires a disagreeable odor and acrid taste.

The coconut is the fruit of a tree belonging to the palm family and growing on all coasts and islands of the tropics in both hemispheres. The tree is indigenous to the islands of the Malayan Archipelago from where the nuts are supposed to have been carried by sea currents, toward the east to the Pacific Islands and the coasts of Central America, and toward the west to Ceylon and the coast of Africa.

Since the earliest historical times the kernels have been used by the natives of India and the South Sea Islands as one of their chief articles of food. Primitive methods of obtaining the oil which are still being practiced consist in cutting the kernels into halves and exposing them to the sun. The sun-dried kernels are then boiled with water and the fat removed by skimming. The product is known as "cochin oil." For export trade the coconut meats are converted into copra by the removal of a large proportion of moisture. This is accomplished either by sun-drying or by kiln drying; the bulk is thus reduced and the danger of putrefactive changes taking place is lessened. "Copra oil" is prepared from the dried product in modern factories of Europe, United States and Australia which import the copra in large quantities for this purpose. The oil is obtained from the copra by the pressure method as is used with oils, such as cottonseed and maize.

Coconut oil has been used for a long period in soap and candle making. As the consistency is more nearly akin to butter than the other edible oils it has replaced butter to a considerable extent in many food industries. It is now used as a butter substitute by bakers and biscuit manufacturers, as an ingredient in oleomargarine and candy and for culinary purposes.

## CHAPTER XIII.

### 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.

As a rule these flesh foods furnish more concentrated nourishment than vegetable substances, more protein and water being present and a smaller quantity of carbohydrate. With the exception of milk and eggs the waste in most of these forms is greater than that of any other type of food material.

#### MEAT.

In the United States the term meat generally implies the edible portion of cattle, sheep or swine. Animals found in the wild state, such as the deer, moose, bear, squirrel and rabbit and known as game while highly prized 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 and 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. Muscle systems most frequently used are tougher than those which have little exercise hence the difference noticeable in the leg and breast of a fowl.

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, serum 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 mortis or the death-stiffening causes the meat to become very tough and it can 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 mortis 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 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 from three-tenths of one per cent. to one and nine-tenths per cent. of the total fresh material. The mineral matter present consists largely of phosphates, sulphates and chlorides of potassium, sodium, magnesium, calcium and iron.

**Meat Inspection.**—Among primitive races the habit of eating animals which had died of accident or disease was very common and undoubtedly resulted in diseased conditions of the partakers of such food. Experience has gradually taught man that it is not safe to use the flesh of animals dying from disease and it is even undesirable to consume the flesh of healthy animals killed by accident, although in the latter case the trouble would arise from contamination with bacterial organisms introduced at the time of the accident. Even in very recent times the slaughtering of animals was conducted under such filthy and unsanitary conditions that the flesh in many instances became contaminated with some of the many forms of micro-organisms present. As far as the diseased animals are concerned only certain types, for example foot-and-mouth disease and trichina are known to be positively injurious. In order to control these difficulties a more or less rigid government inspection is now carried on in most civilized countries. In the United States where the Federal Government exercises control over interstate and foreign commerce, officials are empowered to inspect all cattle and food products as well as packing houses, provided that the material is to be consumed in some other state or country. This cares for about sixty per cent. of the market meat. The remainder is inspected by state or local authorities. The evidence of federal inspection is usually observed by the ink stamp on the fatty material of beef, mutton or pork containing the words "U. S. Inspected and Passed," "U. S. Inspected and Suspected," "U. S. Inspected and Condemned." Cold storage establishments are also subject to periodical visits from the federal or local authorities in order to verify the conditions of stored food and to ascertain how long the articles have remained in storage. This latter precaution is now

considered necessary since such foods as eggs and poultry deteriorate quite rapidly even under the most carefully conducted storage conditions.

Chief among the diseases found in animals are foot-and-mouth disease which occurs principally in cattle, trichina most frequently found in swine and tuberculosis which attacks cattle and swine.

*Foot-and-Mouth-Disease.*—A malady of cattle and other domestic animals characterized by the appearance of an eruption on the mucous membrane of the mouth and upon the delicate skin between the hoofs. Foot-and-mouth disease has long been known in parts of Europe and from time to time has appeared in the United States, the last outbreak occurring in the fall of 1914. It is transmitted readily from animal to animal and on rare occasions has also been communicated to the human family. As a rule the latter infection occurs among the milkers and attendants in dairies and is transmitted by direct contact, although authorities now believe that it may be transmitted also by the consumption of milk and milk products from infected animals. It can be eradicated by the slaughter of diseased animals, disinfection and strict quarantine.

*Trichina.*—Swine are sometimes found to be infected with trichina, 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. Inspection in regard to this disease in the United States is not as rigid as abroad. Slaughter house statistics show the disease to be less prevalent on this side of the Atlantic probably due to the fact that a large proportion of swine lead an open air life, more or less removed from congested human habitation. Except by our foreign born population pork is eaten well cooked. This practice eliminates danger since trichina is killed at a temperature of 155°-160° F.

*Tuberculosis.*—Tuberculosis is 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 breeds. 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 condemning 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.

**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. The reason for cooking meat even in early ages was 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 moist 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—albumin, mineral salts, extractive and other organic bodies—dissolve especially on 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<sup>1</sup> 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 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.

<sup>1</sup> Jordan, *Principles of Human Nutrition*, p. 317.



When extracts are made according to this method they contain besides moisture chiefly mineral compounds from seventeen to twenty-five per cent., as potassium phosphate and sodium chloride, and meat bases from fifty to sixty per cent., as creatin and creatinin. On examination traces of albumin, proteoses and peptones 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 portion of the beef containing practically all of 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 this type 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 two dollars and sixty-eight cents to ten dollars and eighteen cents per pound. The amount far exceeds the cost of home made beef extracts which are as a rule 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. These 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 Leberwurst. In certain parts of the United States hogs' livers are used for edible purposes. They more frequently are utilized as one of the constituents of dog biscuit or as an ingredient of table sauces. In former years many were shipped to foreign countries where the custom of eating hogs' livers is more prevalent, but very 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 industry is one of great antiquity and has played an important part in the history of Western Europe and in the colonization of the New World. Tales of fabulous quantities of cod and herring brought back by European navigators to the Western shores of the Atlantic are supposed to have been the principal single inducement for further adventure and discovery. The settlement of Massachusetts and New Hampshire colonies was due directly to the fisheries and the commerce and navigation of that section were founded on fish.

With the extension of our country similar industries were established on costal and internal waters contributing materially to the early development and subsequent prosperity of the nation. Few if any countries can boast of a larger variety of highly valuable fish many of which support important industries. Those of the greatest economic importance are cod, haddock, hake, halibut, mackerel, bluefish and herring of the Atlantic and the salmon of the Pacific. To the latter belongs the distinction of being the most valuable fish not only of the United States but of the entire Western Hemisphere and with the single exception of the sea herring is commercially the leading fish of the world. Throughout the Great Lakes whitefish, trout and pike are taken in abundance while in the vast region drained by the Mississippi and its tributaries the catfish, buffalo-fish and carp contribute greatly to the income of the fishermen and the food supply of a score of states.

The catch throughout the country reaches approximately two billion two hundred million pounds annually, most of which is consumed in this country a small proportion only being prepared in various ways for export. The industry is divided into two

branches, inshore and offshore or deep water fisheries, the latter of which is more important. It is evident as the sea shore becomes more thickly populated and various waste materials are discharged into these waters that the varieties and quality of the fish for edible purposes will seriously suffer. In fact the formerly well known shad fisheries of the Delaware, Hudson and Connecticut Rivers have largely disappeared. Unless the authorities in control will exercise the power of keeping shores and streams in a sanitary condition the most desirable varieties of our edible fish will in time not be found in our markets. Troubles of this kind are not met with in deep water fisheries but on the other hand the cost of maintenance of the proper vessels, the duration of the voyage and the hardships endured by the fishermen make this form of fishing expensive.

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.

Outside of the fleshy portion of fish the custom of utilizing the eggs of certain varieties, known as the roe, prevails in the United States and some European countries. This is a particularly desirable product in the shad, sturgeon, haddock and similar species. In the countries of Europe bordering on the Baltic it has been the habit for a long period to preserve the roe of the sturgeon by salting. When thus prepared the product is known as caviar.

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 five per cent. High in fat are the herring, lake trout, mackerel and the salmon, ranging from seven and one-tenth to seventeen and eight-tenths per cent. Many of our common varieties, however, notably the bass, bluefish, cod, haddock, perch and the pickerel contain less than two 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 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 phosphates and sodium chloride.

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 seventy per cent. Taking fish of all kinds according to Dr. Wiley, some fifty-five to sixty per cent. of the total weight is edible.

To compensate for the vast quantities of food fish taken annually from the salt and fresh waters of our country the Federal Government in co-operation with various states, through the Bureau of Fisheries, is conducting very extensive work in artificial propagation. The output from the many hatcheries now in operation reaches the waters of practically every state in the union. The rescue of fish from the flooded lands in the valley of the Missis-

sippi and some of its tributaries assists in keeping up the fish supply as does also campaigns to induce our people to eat new varieties and other water products found to be wholesome and acceptable food.

#### 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 shellfish contain carbohydrate in the form of glycogen. Oysters are frequently compared to milk as to their food value 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 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.

**Oysters.**—The oyster has apparently occupied a place in the diet of the human race for over two thousand 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 Louisiana and Texas. Those of the greatest value come from Long Island Sound and adjacent waters while the largest crop in the world is taken from the Chesapeake Bay. The chief varieties are the Blue Point, Shrewsbury, Lynnhaven, Rockaway, Buzzards Bay, Norfolk, Stony Creek and Saddle Rock. These names formerly described the source of the oyster but now are applied to oysters from all sources and commonly indicate the size, the Blue Point being the smallest and the Saddle Rock the largest.

The prevalent opinion that oysters cannot be eaten during the summer has no basis. They are consumed throughout the year along the Atlantic Coast but it is advantageous to have a closed season which naturally falls during the summer months as this is the spawning period. During this time the hard shell clam largely replaces the oyster.

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 cooperated 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 oyster 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 fifteen to twenty per cent. and enhances their market value. The practice has proved to be unfortunate and in some states has been forbidden. 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 floating has deprived the oyster of ten to fifteen 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.

**Clams.**—There are two varieties of shell-fish commonly known as the clam, namely the genuine or soft-shell clam of the Long Island and New England coast which inhabits the sandy and muddy bottom of shallow bays, and the quahaug or hard-shell clam occurring in the sandy beaches of the same localities. Clams have as much nutritive value as oysters. Although not generally consumed in the raw condition, the soft-shell clam is considered a great delicacy when cooked. The quahaug is almost exclusively consumed in the raw state. It has less nutritive value and when cooked lacks the flavor of the soft variety.

**Scallops.**—In the cooler waters of the New York and New England coast there exist large quantities of a delicious shell-fish known as the scallop. This form consists of a delicate fluted shell operated by a powerful muscle which is the portion found on the market. The remainder of the scallop is exceedingly tender and although relished by natives will not bear transportation. It greatly resembles the soft clam.

**Mussels.**—One of the most abundant shell-fish of the Atlantic is the mussel which is only slightly inferior to the oyster in flavor and nutritive value. Large quantities are eaten annually in Western Europe but in the United States they have been little appreciated and practically the only use made of them until recently has been for fertilizer and bait. In 1914-15 when it became apparent that war conditions would necessitate the utilization of food that had been neglected in the past attention was called to the nutritive value of the mussel. This has resulted in the regular consumption of the shell-fish near the seaboard and is gradually extending over a wider area. It is hoped that an extensive mussel fishery may be developed on both the Atlantic and Pacific coast for the vast beds in which they occur are as yet untouched. They are in season at all times and are at their best in summer on the



New England and Middle Atlantic Coasts when the oyster supplies are most reduced.

**Lobsters and Crabs.**—The lobster and crab are shellfish which frequent the coast of the North Atlantic particularly New England, Nova Scotia and Newfoundland. The coast of Maine is the principal fishing ground of the lobster while the crab is found more abundantly further south. There is little difference in the nutritive value of the two, a slight advantage being in favor of the lobster. The main points are the more agreeable flavor of the lobster and the fact that the flesh is somewhat sweet due to the large proportion of glycogen. There is also less waste than in the crab. On account of its nutritive value the lobster should be a staple food but for years it has been a luxury for every season the price to the retail consumer becomes more prohibitive. In the past quarter of a century the catch has decreased over sixty per cent. due to disregard for the future, neglect of natural laws and indiscriminate fishing.

The principal crab fishery of the country is in the Chesapeake Bay. Over fifteen million crabs have been caught in that body of water in a single year. A curious custom exists of consuming crabs during the molting season in which case they are known as shedder or soft-shell crabs and are considered a great delicacy. If freshly caught no harm results from the indulgence in this practice. Lobsters, crabs and clams are extensively canned in the United States. If the material is in a perfectly fresh and sanitary condition previous to canning there is no danger in eating the prepared product otherwise they are likely to cause ptomaine poisoning. The crawfish of the fresh water system and the Pacific Coast sometimes replaces the true lobster of the Atlantic.

#### POULTRY.

Varieties of market poultry include chickens, such as broilers, spring chickens, pullets, fowls and capons; turkeys, known as chicken and full grown turkeys; ducks, usually sold by breed, and geese, known as geese and green geese. The habit of eating poultry was derived from the Eastern World. The Chinese who were one of the original consumers have long been the largest produ-

cers of chickens and ducks. Some of our best varieties still bear the Asiatic name showing the type; these include Brahma fowls, Shanghi roosters and Pekin ducks.

At the present time chickens are hatched largely with the use of incubators which give just as sturdy chicks and a more even yield with less loss than with the natural method. In preparing for the market chickens are sometimes fed for one or two weeks with a variety of grains mixed with buttermilk in order to produce more fat. The custom prevails of starving for twenty-four hours before death so that the intestinal tract may be as nearly empty as possible, then killing by cutting the large artery of the throat or by dislocation of the neck. Freshly killed chickens are those which are consumed from twenty-four to forty-eight hours after death. Fowls can be held for a week or ten days if the temperature is kept low. For purposes of transportation and where poultry is held a freezing temperature has been found to be essential. Unfortunately cold storage poultry is generally thawed before it is offered for sale. It is far safer for the housewife to buy such products in the frozen condition. When poultry is plucked it is very much easier to maintain constant temperature conditions, feathers are also apt to gather moisture and dirt. The reason why game is always offered for sale in the unplucked condition is due to the fact that the plumage is very attractive and adds considerably to the appearance of the carcass. In some communities local authorities require that poultry should be stored in the drawn condition but where this custom prevails special care must be taken that the cut surfaces are not contaminated. On the other hand undrawn poultry can be kept in storage for several months without danger of intestinal contamination. In fact the objection to undrawn poultry seems to be purely ethical but in any case the duration of the storage period should not be excessively extended.

The nutritive value of poultry bears a close resemblance to other flesh foods, ducks and geese being rather more fatty than chickens and turkeys. The composition of the white and dark meat shows a difference in the coloring matter in the dark which also contains a trifle more fat and considerable more extractives.

In plucked poultry the waste is less than in any other form of flesh foods except cuts of lean meat. The waste is largely diminished by the custom of utilizing the bony part and the adhering tissue for making extracts or soup.

#### 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 birds, for example ducks, geese, turkeys and guinea-hens, are frequently found on the market. The use of eggs is much more common in Europe and the Orient than in the United States although the custom has grown of late years in our country. As an industry egg production is on a very much firmer basis abroad, some countries furnishing enormous quantities of eggs for export to less favored localities. The custom here is to raise eggs on small farms near the section where they are to be consumed although the industry has reached large proportions in Ohio, Indiana, Illinois, Iowa, Kentucky, Tennessee, Texas, Missouri and Minnesota. The uncertain quality and condition of eggs, particularly the lack of uniformity, is due to a deficiency in co-operation and a want of satisfactory standards. The market is such at the present time that only a distinction is made between fresh eggs and those which have been held in cold storage. If the eggs have been properly tested before being placed in storage and have not been kept in this condition for too long a period they are more reliable than the so-called fresh eggs of the open market. The practice of stamping the shell is not necessarily a protection since there is no penalty for falsifying dates.

The active life of the hen is about a year during which time it is supposed to produce two hundred eggs. The chief difficulty is that the supply is largest during the warmer period of the year and may be entirely suspended or erratic during the cold season. Improper or insufficient feeding also influences egg production. Experiments have been carried on to ascertain the best conditions for increasing and averaging the yield. Hens lay best during March, April, May and June, a season when the ground has thawed and worms and insect life begin to appear. This gives

them naturally a supply of food. The great loss during transportation is largely due to poor packing and defective shells which have not sufficiently developed on account of lack of lime in the food.

**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. Examinations have 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 ninety-three and seven-tenths 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 four and two-tenths 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 two ounces of salt in one pint of water. A perfectly fresh egg will sink to the bottom of this solution. According to the experiments of Siebel, "An egg one day old will sink below the surface but not to the bottom, when over three days old it will float on the surface, the amount of shell exposed increasing with the 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 always marketed near the source of supply but modern conditions frequently require the transportation for long distances. On account of hens laying 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. It is necessary to keep the air in cold storage rooms moderately dry or the eggs will become musty or moldy. As a result of the dry air water evaporates from the egg and the air chamber becomes large, a condition which can be detected readily by candling. Further changes taking place are an increased tendency of the egg albumin to adhere to the shell membrane and a transference of part of the water of the white to the yolk caused by osmotic pressure. The latter causes the yolk to break easily when yolk and white are being separated. These changes are purely physical and do not at all indicate decomposition or unwholesomeness. They behave differently, however, in cooking operations, similar to poaching, so should not be sold as fresh eggs.

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 ten 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. Desiccation is accomplished by spreading the egg in a thin film on a dry surface and pulverizing the resulting mass or by carefully mixing the white and yolk and spraying the mixture in closed chambers through which cool dry air is constantly passing. Where fresh eggs have been used, and 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.

Most of the so-called egg powders on the market consist of cornmeal or starch colored yellow with harmless dye, in some cases containing small percentages of albumin not necessarily derived from eggs. It is obvious that such mixtures are substitutions.

**Composition of an Egg.**—As the contents of an egg are intended by nature to furnish the sole nutrition of the young chick during the process of development we may 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	48.5
Protein .....	12.3	15.7
Fat .....	0.2	33.3
Carbohydrate .....	—	—

## CHAPTER XIV.

### THE PACKING HOUSE.

The packing industry as it exists to-day was founded from forty to fifty years ago, although packing in a very primitive way has been practiced since the middle of the eighteenth 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. So naturally the important commercial and railroad cities nearest the large grazing areas of the west and southwest Chicago, Kansas City, St. Louis, Omaha, St. Joseph, Indianapolis, Fort Worth and others have become the largest packing house centers. Their proximity to the corn belt and their water or rail shipping facilities have also been large factors in the development of the packing industry.

The growth of this business has been very rapid. Although of comparatively recent origin it now ranks as one of the leading 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 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 neces-



sarily 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.

Under the old plan of every butcher doing his own slaughtering there was not only loss of by-products but there could be no division of labor, conditions under which meat was being dressed were not of the best and the meat was frequently of inferior quality. Under the modern plan as practiced by the large packers the cattle are bought in open competition and are dressed by the thousands instead of one or two at a time. Every modern mechanical contrivance known is used to reduce handling and every man performs a duty in which he is expert.

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 products, such 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 segre-

gated 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. 47).

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 as over excitement and fatigue. After slaughtering they are bled and the hide, head, feet and internal



Fig. 47.—Beef Viscera Inspection. (Courtesy of Armour & Co., Chicago, Ill.)

organs are removed. The carcasses are then scrubbed and washed thoroughly, 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 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 twenty-five to thirty days more or less shrinkage takes place after which the excess of 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 first cured and then painted with a depilatory solution which loosens the wool. This loose wool is put through a series of washing operations, dried and graded according to the length and sold to wearers for the manufacture of woollen cloth.

After the slaughter and scalding of swine the bristles are taken from the back and hams 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 cheap brushes. 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 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 oleo-margarine. For the manufacture of artificial butter see Chapter XII. 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 glycerin, oleic and stearic acids. Tallow may be utilized for lubricating pur-

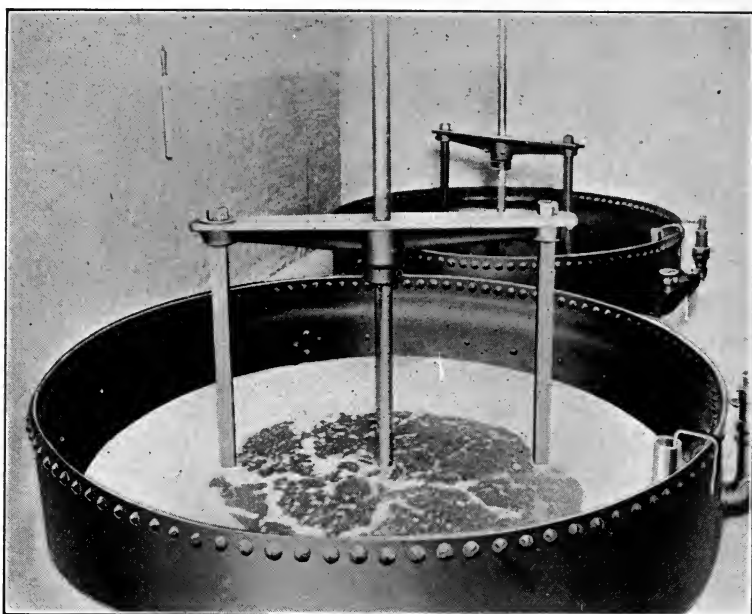


Fig. 48.—Lard Boiling. (Courtesy of Armour & Co., Chicago, Ill.)

poses 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 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. 48).

*The Feet.*—From the feet of slaughtered 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. 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 knife handles, buttons, combs, fans and many similar articles.

*Tankage.*—Tankage is the name given to the residue which remains in the tanks where meat scraps have been rendered to extract 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 from the lean 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 refuse, manure, water and other foreign matter. 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. In the textile industry uncoagulated albumin is used in setting the color permanently in such material as gingham. The fresh 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 sheeps' 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 and other 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 clarified, chilled and run into molds. 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, for example, 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 XVIII. 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. 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.

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 placed upon the market. Besides meat from differ-

ent parts of the beef and pork, such products may contain corn flour, cracker meal, boiled potatoes, starches and dextrans. 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, sugar, salt, white or red pepper, cinnamon, mace, allspice, cloves, coriander, carraway seeds, marjoram and onions or garlic. Salt-petre and coloring matter consisting of dyes of various kinds assist in giving a better appearance. The use of borax and boracic acid for purposes of preservation is still a common practice.

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 are 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 bullocks 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 XV.

### MILK.

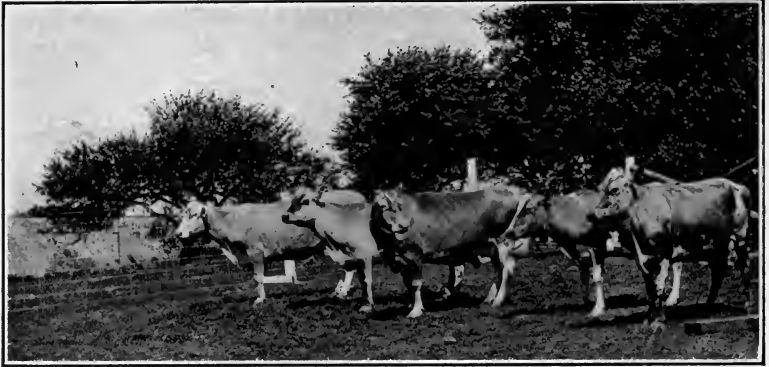


Fig. 49. —Burnside Farm, N. Y.

Milk is a white opaque fluid secreted by the lacteal glands of the female of all animals of 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 used 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 to supply milk to the human family and in the rough, hilly districts of Europe, especially in the Swiss Alps, goat's milk 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 tell 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 the sole source of supply. It is not more desirable for human food than the milk of other animals but in development the cow has shown herself to be able to give the best return for a given amount of care and feeding.

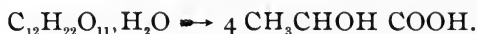
**Composition.**—Chemically milk is composed of all the essentials necessary to sustain life for a long period and is therefore frequently spoken of as a perfect food. It can only be regarded in this light, however, when utilized by the type of animal for which it is intended. The composition varies 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 considerable 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 three per cent. and except in very rich milk it will not exceed five 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 ninety per cent. of the total amount and consist of a number of fats of which palmitin, olein and myristin 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 ten 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 formulæ:



This change begins in the milk as a rule almost immediately after it is drawn from the cow and continues until nine-tenths of one 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 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 one-fifth to one-sixth 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, seven-tenths of one per cent. in cow's milk and is utilized mainly for building purposes. Small amounts of a variety of salts occur—phosphate of calcium and potassium, chlorides and sulphates of

sodium and potassium, with very small amounts of iron and magnesium. Human milk contains much less inorganic matter, approximately two-tenths of one per cent. being present. It is frequently necessary therefore in infant feeding to modify milk so it will more closely resemble mother's milk.

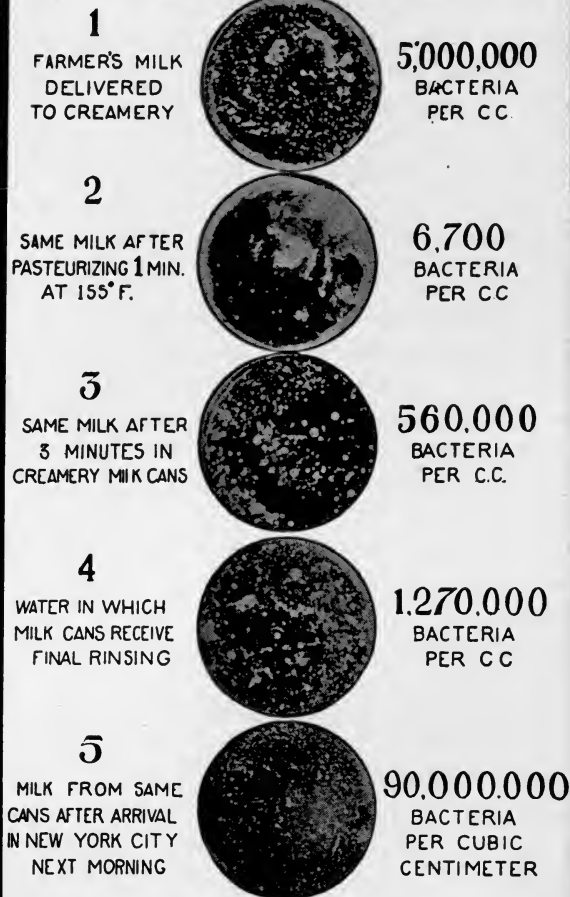
Milk contains several other constituents occurring in minute quantities. Calcium occurs in combination with citric acid in the form of a salt known as calcium citrate. It is also rich in various enzymes which assist in the digestion of the protein, fat and milk sugar. For a short period after it has 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, fluidity and composition of milk make it a most favorable medium for the growth of micro-organisms. These reproduce very rapidly and unless precautions are taken to inhibit their increase the number becomes enormously large in a comparatively short time (Figs. 50-51). 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.

# BACTERIAL TESTS OF CREAMERY MILK



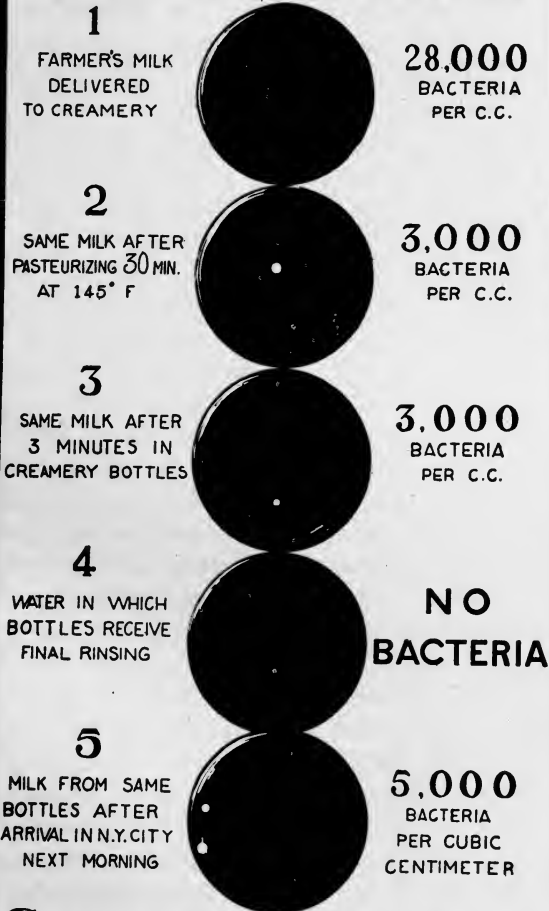
## CARELESS HANDLING

N Y MILK COMMITTEE

BACTERIA COUNTS TELL THE STORY OF UNSANITARY CONDITIONS

Fig. 50.

# BACTERIAL TESTS OF CREAMERY MILK



**CAREFUL HANDLING**  
N.Y. MILK COMMITTEE E.P.A.

BACTERIA COUNTS TELL THE STORY OF SANITARY CONDITIONS

Fig. 51.

**Diseases from Milk.**—The greater number of the germs in milk are harmless excepting the germs of specific diseases, such 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 years 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 to 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 clothing or unsanitary habits 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 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

\* Rosenau—The Milk Question, p. 100.



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.**—Milk becomes contaminated easily since it is a favorite medium for the development of bacteria and must frequently be carried long distances. Hence cleanliness is an absolute necessity in the production and handling of the 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 eighty-seven to eighty-eight per cent. water and should contain twelve to thirteen per cent. total solids of which three 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 rapid growth of microorganisms. The addition of borax, boracic acid, salicylic acid, formaldehyde or other preservative is forbidden. 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 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.

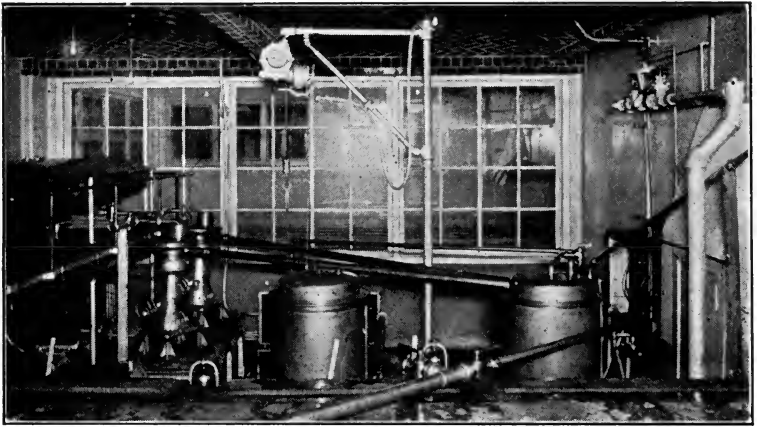
Although the state may control more or less the supply of milk from the producer to the consumer, once in the hands of the housekeeper, the law is powerless to control the handling of milk. Too frequently through ignorance or utter carelessness, milk which has been carefully handled by farmer and distributor 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 previously. The following hints to housekeepers have been contributed by some of the students of Teachers College: Buy only 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, such 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 it near strong smelling food; 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 either 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 then thoroughly sterilize them before returning; 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 unsanitary 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 fifteen minutes or to raise it to the boiling temperature on three successive days. This insures not only the destruction of bacteria 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.



A            B            C  
Fig. 52.—Pasteurization of Milk. The milk passes from the receiving tank (A) through the clarifiers (B) to the pasteurizer (C) where it is heated to  $145^{\circ}$  F. It is then conducted to the holding tanks (Fig. 53). (Courtesy of the Sheffield-Farms-Slawson-Decker Co.)



Fig. 53.—Holding Tanks. Milk heated to  $145^{\circ}$  F. is conducted successively to four holding tanks where it is held for fifteen minutes in each tank. At a temperature of about  $142^{\circ}$  F. it passes back through the pasteurizers and is rapidly cooled. (Courtesy of the Sheffield-Farms-Slawson-Decker Co.)

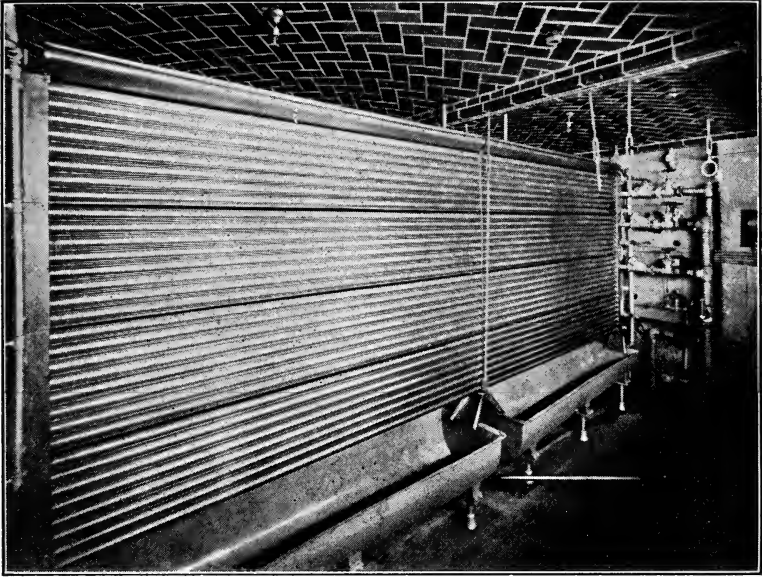


Fig. 54.—Milk Coolers. (Courtesy of the Sheffield-Farms-Slawson-Decker Co.)

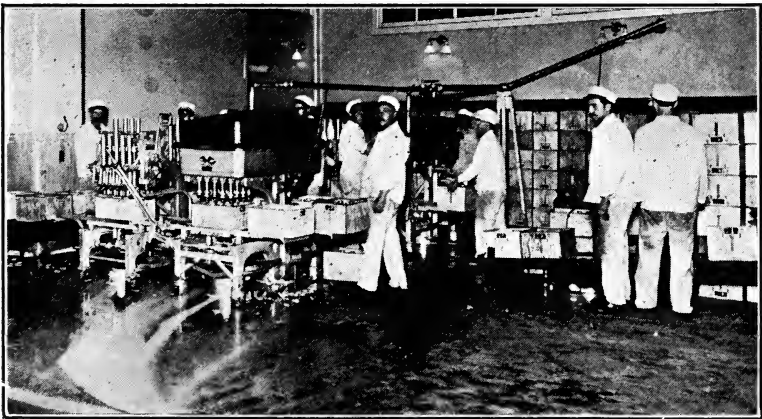


Fig. 55.—Milk Bottling Machine. (Courtesy of the Sheffield-Farms-Slawson-Decker Co.)

**Pasteurization.**—The terms pasteurization means the heating of milk below the boiling point, from 140° to 160° F., followed by rapid cooling (Figs. 52-53). 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 ninety-five to ninety-eight 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 unsanitary 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.

At present market milk is usually graded as

- A.—Best quality—for infant and invalids—may be pasteurized.
- B.—Medium quality—for general use—must be pasteurized.
- C.—Poorest quality—for cooking purposes—must be pasteurized.

**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 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 adapted 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.

**Homogenized Milk.**—When milk is subjected to a pressure of three to five thousand pounds per square inch and a temperature of approximately 75° C., the individual fat globules are broken up into exceedingly fine particles, which remain as a uniform and permanent emulsion. The resulting product is known as "homogenized milk." This process can be applied also to cream to increase its viscosity a fact frequently taken advantage of by ice cream makers. A cream of sixteen to seventeen per cent. butter fat can in this way be given the body and texture of cream from twenty to twenty-five per cent.

## CHAPTER XVI.

### MILK PRODUCTS.

**Condensed Milk.**—The importance of milk in the diet and the 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 nineteenth 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 taste. 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." The Borden 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 proportions, rapid strides having been made during the past fifteen years. This shows great 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 treated by the condensing process.

There are two classes of condensed milk, sweetened and unsweetened.



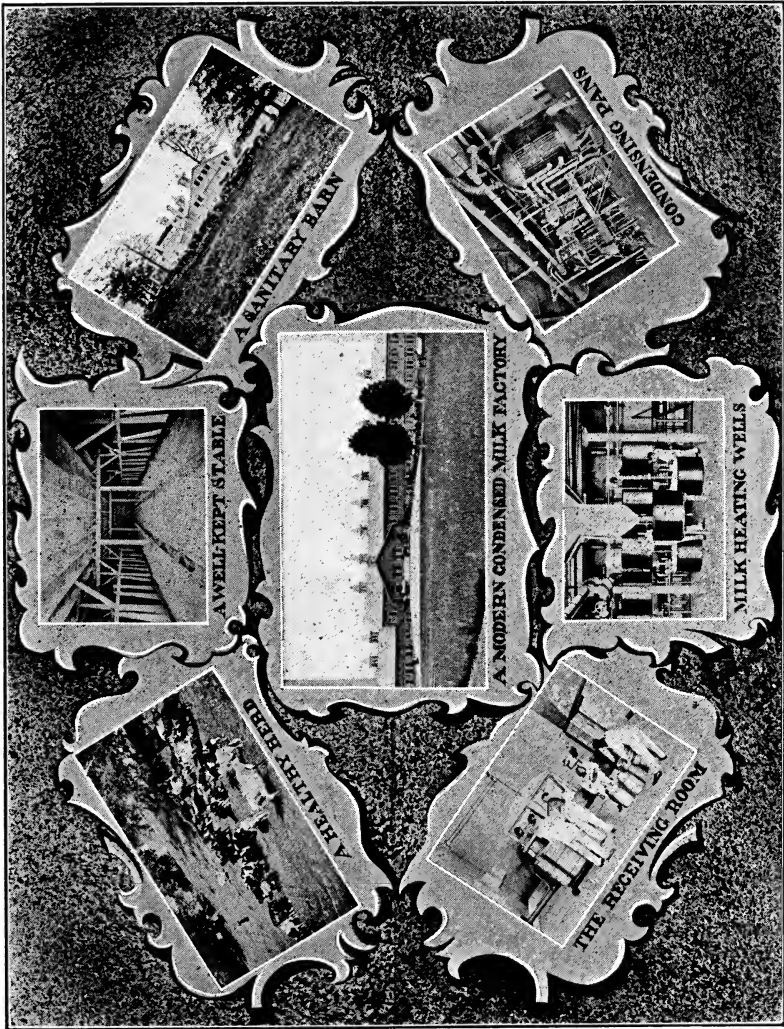


Fig. 56.—Condensed Milk Industry. (Courtesy of Borden's Condensed Milk Co.)

*Process.*—When milk is received at the factory it is tested, filtered to remove dirt, and quickly sterilized by raising the temperature of the milk to the boiling point. Sugar is added to the extent of about sixteen pounds to one hundred 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 forty 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.

**Milk Powders.**—The latest development in the art of preserving milk and the one which bids fair to outrival all other methods is that which places milk on the market in the powdered form. The

idea is by no means modern for the history of food preservation reveals that a Russian chemist, far back in the nineteenth century, slowly evaporated new milk over a fire until it was reduced to solid form, then powdered and placed the product in bottles, which were sealed with wax. Many years passed before this method was carried into industrial use and again a long period followed before the general public was aroused to the value of such a product. Like many foodstuffs it needed warfare to demonstrate its usefulness. During the World War pure, clean milk was required abroad in large quantities particularly for use in hospitals and orphanages. Transportation and refrigeration problems made fluid milk an impossible article to ship. Even the condensed and evaporated forms did not meet the need of the times. The high sugar content of the former prohibited its use for infants and invalids while the lack of sterility, poor keeping qualities when opened and bulk of both products were factors that finally led to their replacement by a more convenient form of preserved milk. Fortunately through experimentation and the invention of ingenious machinery, in the early years of the twentieth century, an excellent dried milk product had been placed on the market. Thousands of tons of powdered milk were ordered by war officers and its use in hospitals and charitable institutions of France has been widespread.

There has been much discussion regarding the respective merits of the methods of reducing milk to the powdered form. One process consists in subjecting the milk to a high temperature for a brief period of time and the other to a lower temperature for a longer period. In the latter process the water content is partially reduced by evaporation in vacuum pans, then passed over rollers heated by steam to a temperature of about 165° F., from which in two minutes it falls in sheets and is then bolted forming dry milk crystals. The quick drying process was a later invention and claimed by some to be a decided step in advance. Here fresh milk is dried upon a surface heated to 280° F., the whole operation being accomplished in one second and a half.

Still another, the Merrill Process, partially reduces milk in a vacuum pan from which it is discharged, as a fine spray, into a

current of warm dry air resulting in a fine snow-like powder, containing less than two per cent. of moisture and chemically unchanged.

The chief thing about any milk powder is that there should be little or no change in the chemical composition, and that the resulting product should keep well under ordinary conditions. The first of these conditions has been very generally met but all whole milk powders require special methods of preservation.

In our own country the first dried milk product was prepared from skim milk. This type is the most common in our market to-day and can be recommended for all cooking purposes. Through their manufacture thousands of gallons of skim milk which were formerly consigned to the sewer are being utilized. Clever machines are now in use in various sections of our country for reconstituting dry skim milk. The powder is mixed with water in correct proportion, pasteurized, a weighed amount of fresh butter added, emulsified by means of violent agitation and finally cooled by being passed over coils through which cold brine is made to circulate. In dairy sections such a machine could be used to advantage, provided a means of drying the surplus skim milk were likewise at hand. For practical use in the home an emulsor is of course an impossibility.

Dried milk powders for general use are also prepared from pure, fresh, whole milk which needs only the addition of water to reconstitute the whole milk. One quart of such milk can be obtained at less cost than market milk, needs no refrigeration, is a sterile product and provides a sure supply.

Still another type powder can be procured for infant feeding. The best grade of pure fresh cow's milk is modified by the removal of its fat and the addition of milk sugar. Undoubtedly the use of such powders has saved the lives of thousands of infants in the devastated countries of Europe at times when fresh milk was unavailable.

**Market Cream.**—Cream is the fatty constituent of milk. It may be separated by the same methods as are used in butter-making, namely gravity and centrifugal force. When obtained by the use

of the separator, which method is employed in practically all large dairy industries, less loss is involved, time and labor are saved and the product obtained is cleaner and richer. Separator cream will also keep longer since it does not contain so much of the entangled caseinogen. The composition which is based largely on the fat content is variable. The U. S. Standard cream must contain not less than eighteen per cent. of milk fat but State standards vary from fifteen to twenty per cent. Cream obtained by centrifugal force can be made to vary from "very light" as low as eight per cent. to "very heavy" as high as seventy per cent. A good quality for commercial purposes contains from eighteen to twenty-five per cent. and very rich cream from thirty-five to forty per cent. fat. The Commission on Milk Standards requires that no foreign matter be added; cream should contain only the ingredients of normal milk. In addition to preservatives, gelatin and calcium saccharate (viscogen) have been used to increase the consistency of a low-grade product. Cream should be kept under the same conditions as have been recommended for sanitary milk. As it is generally ten or twelve hours older than the corresponding grade of milk the bacterial count is apt to be considerably higher, about five times the amount is allowed.

**Ice Cream.**—The term ice cream as commonly used is applied to a variety of products prepared from frozen milk or cream. In the mountainous regions of the Far East sweetened fruit juices in a frozen condition known as sherbets were in common use in early ages. The custom of eating these frozen products was introduced into Europe by the Moors and the secret of their preparation became common property of the Spaniards and natives of adjacent countries. Ice cream as a frozen milk product was developed in the northern part of Italy, was carried from there to France and finally appeared in England during the reign of Charles II. In the latter part of the eighteenth century ice cream was publicly sold in New York City and one of the largest of the existing concerns began business in the same city in the early part of the last century. About sixty or seventy years ago frozen products made from cream with the addition of sugar and flavoring agents became known under the name of Phila-

delphia Ice Cream. In contrast to that product mixtures of milk and sugar with eggs, boiled starch, gelatin, casein or similar substances were called Neapolitan Cream. Within the last ten years a compound, intermediate between the sherbet and ice cream, known as Lacto or Sour Milk Ice Cream was introduced by Mortensen.

The manufacture and consumption of these products have increased in enormous bounds due largely to the practice of combining ice cream with soda water especially during the heated season. In some localities creameries now find it more profitable to convert their product into ice cream rather than into butter. Standards at present call for fourteen per cent. butter fat but if the product is to be mixed with nuts, eggs or other highly nutritious matter a lower per cent. of cream can be used. While it is advisable to maintain a high cream standard it is far more important to be certain of a low bacterial count. To ensure safety some manufacturers pasteurize cream. This practice does not, however, eliminate the danger should ptomaines be present in the product due to unsanitary conditions.

#### BY-PRODUCTS OF THE BUTTER INDUSTRY.

The chief industry using milk is the butter industry which has been described in Chapter XII. The most important by-products of this industry are mentioned below.

*Skim Milk.*—For butter-making the fat is separated from whole milk very largely 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 thrown away. This is a waste of valuable material for the protein and lactose can be recovered by the following 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

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, for the manufacture of imitation ivory articles and in several forms of concentrated food.

*Milk Sugar.*—After the removal of the caseinogen and neutralizing the acid, the water may be evaporated (over hot water) from the whey until the lactose crystallizes. 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 as a beverage, especially during the summer months. The chief points in which it differs from milk are poverty in fat and increase in acidity, due to the formation of lactic acid which rarely exceeds one-half of one per cent. Buttermilk 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, the mass is held at 100° F. for several hours, is then bottled and sold under a trade name.

#### CHEESE.

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, cheese 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, Ger-

many, 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 is used largely abroad for the manufacture of certain well known cheeses. As a rule milk is used in the 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 two hundred and fifty years ago. It has gradually grown in popularity until the manufacture has now spread over the civilized world.

#### PROCESS USED IN CHEDDAR CHEESE.

Straining milk.	}	Under the influence of the lactic acid fermentation.
Ripening—(82°-86° F.).		
Mixing rennet.		
Clotting.		
Cutting.		
Stirring.		
Cooking 98° F.		
Removing part of whey.		
Cheddaring or matting.		
Grinding.		
Salting.		
Pressing.		
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 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 milk-

ers, 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 either 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 clotting agent rennet is added, 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. The mass 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 cut 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 (cheddaring), 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 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 the curd 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 ex-

tension of the manufacture of certain varieties of cheese, and a saving of much money to the industry.

*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.

For information in regard to the manufacture of well known cheeses, such as Roquefort, Edam, Camembert and Brie, see a standard book on dairy products, *Milk and Its Products* by Wing or *The Practice and Art of Cheese-making* by Van Slyke and Publow.

**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 to emulsify the lard, after which regular processes of cheese-making can be carried out (filled cheese). This product is legitimate when sold under its own name.

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 XVII.

### 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 sulphites.
		Benzoic “ “ benzoates.
		Salicylic “ “ salicylates.
		Formaldehyde.
		Peroxide of hydrogen.

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, inclement weather, or for use at other seasons. 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 thirty per cent. and all stop developing when it is below twenty-five per cent.

Nature uses this method of preservation for when 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—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. The class of substances known as dried meat and fish is simply reduced to a more or less dry condition after which another method of preservation is added. This may consist in the addition of salt, sugar or other harmless preservative, or the product may be smoked. These cases will be referred to in detail under their special heading.

In early days sun-drying was used entirely and only surplus crops were preserved. The disadvantages of the old-fashioned method were loss of flavor and color due to oxidation or enzyme action, and contamination of the freshly exposed surfaces by the dust of the atmosphere and insect life. Certain fruits, such as grapes, which are commonly dried intact are still cured by this method owing to the protection of the tough skin and the presence of organic acids.

Modern methods in the production and drying of fruit have led to an enormous increase in the industry during the past fifteen years. Large orchards are now planted specifically for the production of fruit for drying and in many places the fruit is as carefully chosen and handled as that which is being placed on the market in the fresh state. In California and such sections as are free from rain and excessive moisture, open-air drying is still extensively employed in conjunction, however, with modern sanitary methods. Carefully selected, mature fruit is thoroughly

cleaned by brushing and washing if necessary. It is then surface dried, cut into desirable shapes by machinery, placed on trays, sometimes sulphured for bleaching and disinfecting purposes and dried in the sunlight. In countries with less dependable weather conditions in-door drying is largely employed. Several methods are now in use: 1st, hot air drying in which the fruit is placed in a cabinet, kiln or tower shaped evaporator through which hot air pipes are conducted, provision being made to carry off the evaporated moisture; 2nd, the vacuum drier operated by alternate exhaustion and renewal of warm air thus rapidly removing the moisture; 3rd, filtered air at ordinary temperature may be employed thus protecting the fruit from a loss of flavor which occurs in both of the former methods.

The increased output of the present day has resulted in not only a greater consumption of dried fruits at home but has placed these products in the European markets where they can frequently be bought for a lower price than fresh native fruit.

In time of stress as in the late war the drying of foodstuffs played an important part in the preservation of our over-abundant harvests. The processes being so simple resulted in a revival of the old housewife's custom of drying fruit and vegetables on the farm and even in villages, town and city life, a practice not used for a generation or more. Much food material was thus preserved which otherwise might have been wasted; transportation, cold storage and commission merchants charges and profits were saved. Moreover in the transportation of enormous supplies of food abroad for army, navy and civilian needs dried products were found to be easier to handle on account of the decrease in bulk. Thus milk, potatoes and similar material were carried entirely in this form. The great demand for dried products has given a new impetus to the industry resulting in the placing on our markets of many new varieties of foods.

#### COOLING.

With the exception of the Eskimo, nations and people of all times have sought for artificial cooling devices in order to preserve foodstuffs. Immersing in wells or running water, a custom

still common throughout our farming district, is as old as the human race itself. The bringing down of mountain snow to allay heat has been a custom among Orientals from days immemorial and the preservation of ice for domestic use was practiced in the days of Nero who had ice houses built at various points along the Tiber. Other early methods still employed took advantage of a marked drop in temperature at night in certain localities whereby water could be frozen in shallow, porous, earthen dishes resting on such a non-conducting material as grass or straw, by exposing to currents of night air. It is even believed by some people that the old time scientists had developed genuine artificial processes as freezing mixtures of different kinds and that such knowledge was lost with the fall of the Roman Empire. Although interest in artificial refrigeration revived some three centuries ago it did not pass beyond the experimental stage until the middle of the nineteenth century when the ammonia process was invented.

The principle of the cold storage method of preservation is surrounding food with temperature conditions unfavorable for bacterial development; this may mean low temperature or actually freezing according to the product. The thermal death point of micro-organisms ranges between wider limits than any other form of life. Boiling does not kill all types, neither does freezing. The best temperatures at which to hold food in cold storage, or to which it should be raised with sterilization, have been carefully studied. The physical properties of the food product must also be considered. With fruit which has a high water content and a fragile carbohydrate tissue the expanding force of the ice crystals is highly destructive; fruit should never be frozen. In the case of flesh foods less water and a tough highly elastic tissue, minimize the effect of the force, hence these products can be frozen if desirable.

*Advantages of Cold Storage.*—1st, The nutritive value is not affected; 2nd, foreign material is not added; 3rd, no new taste is imparted so the flavor is not greatly changed; 4th, the digestibility is not diminished; 5th, a large quantity of perishable goods can now be kept that were formerly thrown away.



*Disadvantages of Cold Storage.*—1st, 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; 2nd, 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; 3rd, 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. Many advantages are claimed for the latter: a lower temperature and at any desired degree can be maintained, refrigerators are dryer, the slop and dirt of handling ice are avoided, there is less waste and the plant is cheaper to operate.

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 the Ice Chest.*—1st, Do not wrap ice in newspaper for it is only in melting that a low temperature is maintained; 2nd, keep ice chest well filled with ice; 3rd, keep the chest as dry as possible as cold damp air harbors many low forms of plant and animal life; 4th, charcoal should not be utilized for lining as it soon becomes clogged and makes a fine incubator for

bacteria; 5th, wash frequently with warm water and a neutral soap.

The preservation of food in refrigerators depends on three conditions—low temperature, ventilation and dryness. Low temperature can only be secured by the melting of the ice. Ventilation in the past depended entirely on the opening and shutting of the door but in all well constructed refrigerators of the modern type provision is made for circulation of air. Dryness depends upon the rapid change of air in the ice-box and in a certain sense is connected with the question of ventilation.

#### **STERILIZATION AND EXCLUSION OF AIR.**

See Chapter XVIII—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 antiseptic action of sugar appears to be due to the ease with which bacteria give up to concentrated solutions a part of their constitutional elements thus weakening their reproductive power. 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. Melted paraffin poured over the top of the preserved product largely protects it against mold growth.

The great disadvantage of 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, such 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 fruit is 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 alone has never been used with protein material in America, it is still customary in Portugal to preserve fish, such as the salmon, by splitting, cleaning and sprinkling the interior with sugar. The claim is made 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 efficiency of salt as a preservative is probably due to the fact that in saturated solution the greater part of the tissue protein is insoluble. Further, salt being a highly crystalline compound, readily penetrates the tissue and in a short time the liquid portion reaches the point of saturation desired. The process of removing the salt before using is the reverse of the above and is termed freshening; this operation is more or less completely carried out just previous to cooking. There are three methods of salting as follows: 1st. Dry-salting or powdering where the sodium chloride in the powder form is freely rubbed on the surface of the object, the operation being repeated until the moisture appears to be absorbed. In many cases the material has been partially dried previous to salting. This method is now confined to certain types of fish. 2nd. Wet-salting—a slight modification of the above with less salt used. 3rd. Pickling—the commonest method of salting consists of immersing the product in a saturated solution of salt (pickle) and adding more dry salt

from time to time, in order to overcome any diluting tendency, due to the admixture of the pickle and tissue liquid. In case of red meats salt-petre is added to the pickle on the plea that it tends to retain the color.

The drying and salting of cod fish plays an important part in the fish industry of Gloucester, Massachusetts. As practiced in that locality the curing of fish consists in the following operations; the removal of the head, internal organs and back bone; placing in layers in butts, each layer being covered with dry salt; the addition of water; the fish remaining in the brine from four to six weeks; excess moisture is removed by pressure; fish are sun dried on racks provided with wooden shields for use when rainy, and with canvas covering which is used when the sunshine is sufficiently hot to cause burning; fish are taken indoors where fins, skin and small bones are removed; they are placed in containers and pressed by machinery after which they are wrapped in paraffin paper and packed in one, three and five pound boxes. For cod-fish cakes, the fish is shredded and sifted in coarse mesh sieves, the operation being repeated several times. The shredded cod-fish is then packed in glass jars or boxes, benzoate of soda being added just before boxing.

While salt is harmless and is needed in the diet this method on the whole has not been found satisfactory. The flavor is greatly altered, the physical nature of the product is so changed by the toughening of the fiber that it is more difficult to digest and the loss of nourishment due to osmosis is considerable. Other methods of preservation have to a great extent taken the place of salting.

#### 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 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.

The preservative action is now known to be due to certain products present in the smoke, for example 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



Fig. 57.—The Sausage Smoke House. (Courtesy of Armour & Co., Chicago, Ill.)

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 terpene compounds which would affect the flavor. Water plays an important part in the production of creosote so the wood is used generally in the green state (Fig. 57).

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 material only 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 composed 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 smoke. 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 creosote is more likely to penetrate.

#### USE OF FATS AND OILS.

Foods which do not contain a large amount of fat are excellent when 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 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 the United States. 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 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 XXI. Spices.

#### ALCOHOL.

Alcohol makes protein matter insoluble thus killing bacterial life. For this reason it is used largely in preserving biological specimens. To a slight extent it is also used for foods. Fruits of all seasons can be put up 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 using them 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. The claim is made that the housekeeper through careless handling frequently spoils food that the manufacturer has taken so much trouble to preserve. The prohibition of all preservatives would be as unsatisfactory to the consumer as to the producer. At the present time benzoate of soda is allowed by the Federal Government, it having been determined as not being poisonous or deleterious to health. When used each container must bear a label stating the amount. Although the government does not limit the quantity, one-tenth of one per cent. is employed by manufacturers. The use of salicylic acid or its salts is now forbidden. Rideal claims that the salts are irritating to the kidneys and distinctly antagonistic to most enzymes, especially starch digesting ferments. Neither can one part in a thousand always be relied upon as experiments have proved.

Arguments advanced in favor of their use are: 1st, these antiseptics are harmless when used in small amounts. One part benzoate of soda in one thousand is not injurious and may be beneficial in warding off intestinal diseases; 2nd, they are found occurring naturally in many of our fruits, such as currants, cranberries, raspberries and crab-apples; 3rd, these antiseptics are frequently developed during manufacturing processes, especially where sterilization by high temperatures is necessary.

Arguments against their use: 1st, they are not violent poisons, but some are believed to be undesirable as they are antifermentatives so interfere with the digestive ferments; 2nd, they are irritants so are apt to injure the mucous membrane of the stomach and intestinal canal; 3rd, the blood has for its chief function oxidation. These compounds interfere with the oxidizing function of the blood; 4th, 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 cocoa, 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. There seems to be reason for the belief that copper is a cumulative poison similar to lead and mercury, hence it is wise to abstain from these products. The use of copper is prohibited in Germany, Austria-Hungary and is limited in many other European nations. Since the report of the Referee Board of Consulting Scientific Experts the importation of coppered vegetables has been forbidden in the United States.

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 they are injurious to health. While such coloring matter may not be detrimental to the consumer, the use is undesirable for it enables the manufacturer to place

inferior goods for high grade material upon the market. Articles of food are preferable in their natural color, and it is unfortunate that the housewife so frequently chooses highly colored goods thus encouraging the use of artificial coloring matter.

## CHAPTER XVIII.

### THE CANNING INDUSTRY.

The discovery of processes by which food material can be preserved by canning was an outcome of a military measure enacted by the French government near the end of the eighteenth century. It provided for a sum of twelve thousand francs to be awarded to the inventor of an improved method of preserving food. The object was to secure better quality and to control the loss in waste and spoilage in foods utilized in military and naval stores; also to reduce the liability from scurvy which caused serious injury to the military forces. The prize was eventually won by Nicholas Appert of Paris in 1810 who, after fifteen years of persistent work, succeeded in preserving food by heating the product and hermetically sealing the container. Although conceived primarily as a military measure the method described by Appert was so simple and the product so wholesome and palatable that it soon attracted the attention of the housewife. Shortly afterwards it was put into commercial practice on a small scale in France, Great Britain and the United States.

The history of the canning industry on this side of the Atlantic dates back to 1819 when a few salmon, lobsters and oysters were packed in New York. For a long period attention was given principally to marine products which were abundant in all coastal states but could not be transplanted inland with safety in the fresh condition. Cranberries, currants, quinces and damsons were said to have been packed in Boston as early as 1820 but in those days there was little demand for preserved fruits and vegetables, for those products could be obtained in local markets and the demand did not exist for something out of season or from other lands.

The discovery of gold in the West gave the first impetus to this industry for canned goods were used largely by the "forty-niners" who found them a convenient form in which to carry food material across the country. The superiority of canned foods over those which were dried, salted or pickled was even more fully appreciated during the days of the Civil War and information of their palatability was carried home by returning

soldiers to all sections of the country. Domestic and commercial canning at once began to increase. The growth of the industry since that time has been very rapid and at the present time canneries are scattered throughout the United States. Rapid growth resulted in the formation of Associations of Cannerymen, the development of which led to new and better methods of making cans, great improvement in machinery, skilled workers and much experimentation in regard to the best methods of sterilization. In the last work manufacturers have been greatly assisted by scientific investigation.

**Principles in Canning.**—Canning has been described as the art of preserving a food through sterilization by heat and maintaining it in that condition in an hermetically sealed container. Apert did not know why foods kept when treated according to his method but ascribed it to the exclusion of outside air after applying sufficient heat to the food. This idea was even shared by Guy Lussac, the foremost chemist of the time, who was appointed by the French government to investigate the cause for keeping. He reported that spoilage was a series of oxidation changes and that by the exclusion of outside air these changes were prevented in bottled or canned goods. This explanation was accepted until the advent of the new science of bacteriology the first application of which to the canning industry was made in this country in 1895.

Experience has shown that there are two principal points to be borne in mind in the preservation of foods by canning: 1st, the destruction of all micro-organisms and their spores by means of heat; 2nd, by hermetically sealing to exclude those from without. It has been discovered that not all micro-organisms are killed at the same temperature, that some spores possess great resistance and that some products bear types of organisms which are more resistant than others. These facts make it clear why some products need a very high temperature while others require a relatively low temperature for only a few minutes. Many bacteria which cause spoilage in peas, cornmeal and the like will not develop readily in fruits on account of their acidity. All fruits may be sterilized in a short time at or near the boiling

point of water and as the temperature descends below the boiling point the period must be increased. As a rule vegetables are not so easily sterilized as fruits; for the most part they require a temperature above 212° F.

When low temperature is employed the sterilizing process simply consists in heating the product over a water bath. Increased temperatures may be secured by either adding to the water bath some substance like calcium chloride which will raise the boiling point or by heating in an autoclave or retort and subjecting to steam or hot water under pressure. In the latter method any degree of temperature may be attained. The general practice is to process all vegetables, meat, fish and milk in this manner varying the degree and the time to suit the particular product. A recent improvement has been the development of an agitating cooker, which causes the cans to roll or to turn in such a manner that the contents will come to the outside, or that the liquid present will be carried through the mass. This method reduces the time considerably without injuring the product.

Until quite recently increased temperature could not be secured in home canning. It was customary in preserving products like corn to heat the containers for a short period on three or four successive days. The same result can now be accomplished by the use of small pressure cookers which can be obtained in the market at comparatively small cost.

**Methods in Commercial Canning.**—In order to secure a high quality product it is imperative that the raw material be a good grade, uniform and in the proper stage of development. As standing causes spoilage and makes a difference in toughness and flavor, factories are built near the growing beds and every appliance is used to preserve the product as quickly as possible.

*Preliminary Preparations.*—The first operation in the factory is that of grading according to quality and to size. The former is accomplished as a rule by the eye and the latter by machinery. Revolving cylinders or vibrating screens having holes of standard dimensions are frequently employed. In the case of fruit many ingenious machines have been invented. Tapering rollers may be used so that as the fruit reaches a certain size it will fall through

or the rollers may mechanically open and permit the dropping of certain sizes in the proper bins. The same result may be accomplished by wire belt which is made to open and close or by an apple sizer which works on the principle that with uniform force a light body can be thrown farther than a heavy one. While careful grading is carried on as far as possible at an early stage it is followed at nearly every step until the material is placed in the can.

In the grading of peas the separation is frequently carried on by not only screening but by immersing the peas in a weak brine then in a stronger one. Those which float in the first brine are young and tender since old peas are heavier than the young, those which float in the second brine are somewhat harder and those which go to the bottom are very hard.

Other preliminary processes vary widely with different products. Some fruits need little preparation other than picking out foreign matter and defective material whereas others require peeling, pitting, coring and sizing. Weak alkali is frequently used in peeling peaches and such fruit. Plums and cherries are stemmed, apples and pears are peeled and cored, peaches are pitted and peeled, corn is husked, peas shelled, beans snapped, etc. Some processes are still dependent upon hand labor but much ingenious machinery has been invented to assist in this work. The pea viner threshes the peas from the pods and makes the separation as clean as wheat from straw. It can shell as many peas in a day as two hundred or more persons and with less bruising and no touching by hand. A corn-husking machine eliminates the drudgery of husking by hand; a silking machine removes adherent silk and bits of husk and the cutter removes the kernels from all sides.

*Washing.*—A thorough washing of the product is absolutely essential in canning. This process is carried on by machines which are most ingenious in the way and care with which they handle particular products. They may be soaked and sprayed, soaked and agitated to loosen dirt, sprayed with a large volume of water or sprayed with small but strong pressure. One type of washer resembles a squirrel cage which in revolving causes

peas, beans and other products to roll over while they are subjected to sprays of water as light or heavy as desired. Another type of machine passes the product on conveyers under or between sprays of water.

Mechanical washers have also been devised for washing containers since they collect dust and dirt during manufacture, in shipment and in storage. This process even extends to machines, buckets and pans which are cleaned after each operation no matter how many times they may be used during the day.

*Blanching.*—The operation of blanching is in reality parboiling. Most vegetables require such treatment and it is sometimes advantageous with fruit. The object is not to whiten as the name might seem to indicate, although it does have the effect of producing a much clearer liquor than would otherwise be present. In the case of peaches, cherries, and other fruit, it is for the purpose of securing a degree of flexibility so as to enable better packing in the can and to produce a greater uniformity of color. The main object with asparagus, beans and peas is the removal of a sticky or gummy substance from the surface, and also to cause a certain amount of softening that is not only necessary for the handling in the case of asparagus but considered desirable as influencing edible quality. The work is accomplished by automatic machinery and consists in dropping the product into boiling water where it remains from one to fifteen minutes.

*Filling the Cans.*—The filling may be done by hand or by automatic machinery. The majority of high grade fruits require hand filling owing to the fact that they must be layered more or less to get a uniform filling and weight. This is difficult to accomplish with machinery without injuring the product. As most vegetables are filled by volume the work can be accomplished by machines. In some cases the product is partially filled by machinery and the weight corrected by supplemental hand filling. The practice is to fill the cans as full of the product as possible without injuring in any manner and then to add the liquid to fill the interspaces. All high grade fruit requires a sirup; water alone is used with only the lowest grade. Vegetables require a salt or a sweet brine, the latter being made with a mixture of

salt and sugar. Some products like tomatoes and squash do not need the addition of any liquid.

*Exhausting and Closing.*—In order to produce a can with the ends properly collapsed a process known as exhausting is used before capping with some products. This operation consists in heating the cans gradually to partially drive out the air or they may be sealed in a chamber under partial vacuum. This has little if anything to do with sterilization but if the air is not driven out the can will not collapse properly and it may be difficult to detect spoilage. It also lessens the attack of the contents upon the container. Some products which were found to have a rather high content of dissolved salts of tin before exhausting were shown to have a lower amount after the treatment and practically all products are benefitted.

The method of closing the cans depends on the type used, see page 259. The open tops are sealed by a machine known as a double seamer. It places the cover in position and steel rollers crimp it on without acid or solder. The solder top cans are also sealed by machinery. The top is wiped, the cap placed on, acid applied, the hot soldering irons drop into place and the vent is closed without the introduction of hand labor. As the cans pass from the capping machine they are sometimes submerged into a hot bath for inspection of leaks which can be detected by the rise of bubbles.

*Processing and Cooling.*—The cans are next processed or sterilized according to the nature of the contents. The simplest method is to place the cans in baskets and immerse them in a tank containing boiling water or if pasteurization is desired in water kept at the proper degree of heat. Processing above the boiling point is done in iron boxes or steel cylinders known as retorts. Steam may be introduced with water or steam under pressure may be used. By means of the latter any suitable temperature can be maintained. Fig. 58.

As soon as the processing is complete the cans should be cooled as quickly as possible as retention of heat for a longer time than is necessary for sterilization only tends to injure the product—fruits are softened, peas break and the liquid becomes muddy,



tomatoes turn brown and have a bitter taste and the majority of cans show an unnatural darkening. The cooling may be done by turning cold water into the retort, by immersing the cans in

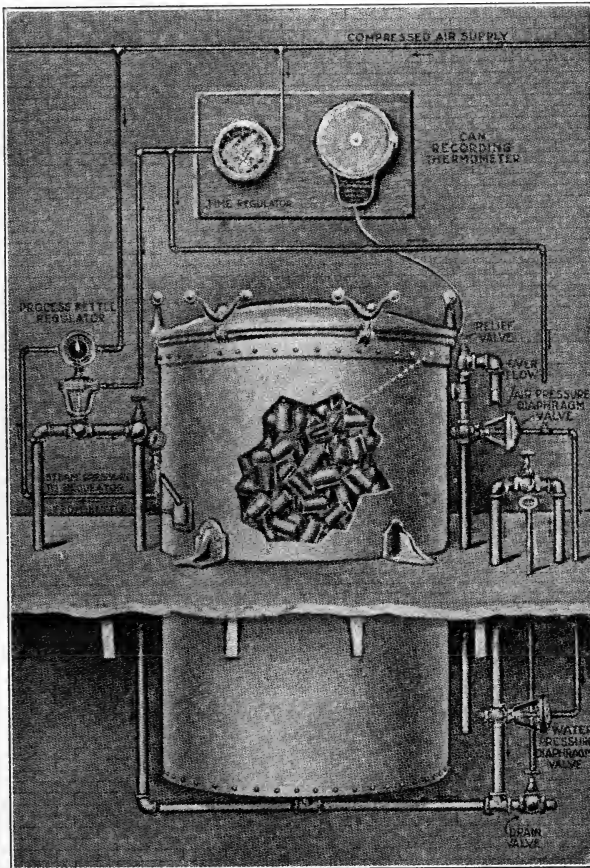


Fig. 58.—A typical retort or cooker with regulators for automatically controlling the temperature, fixing the time, and cooling the product when finished.

cooling tanks, by spraying the tanks in the air or stacking the cans in an open shed so air may circulate freely for a day or two.

**Containers.**—The tin can is preeminently the container of commercial canning. Its use was first suggested by Peter Durand of England who experimented on material of all kinds shortly after Appert made public his new process of preserving foods. The first container was the ordinary glass bottle with a comparatively small mouth and closed with a cork but it soon gave way to the wide mouth bottle and later to the jar with a metal cap and wax top to take the place of the cork. The metal screw

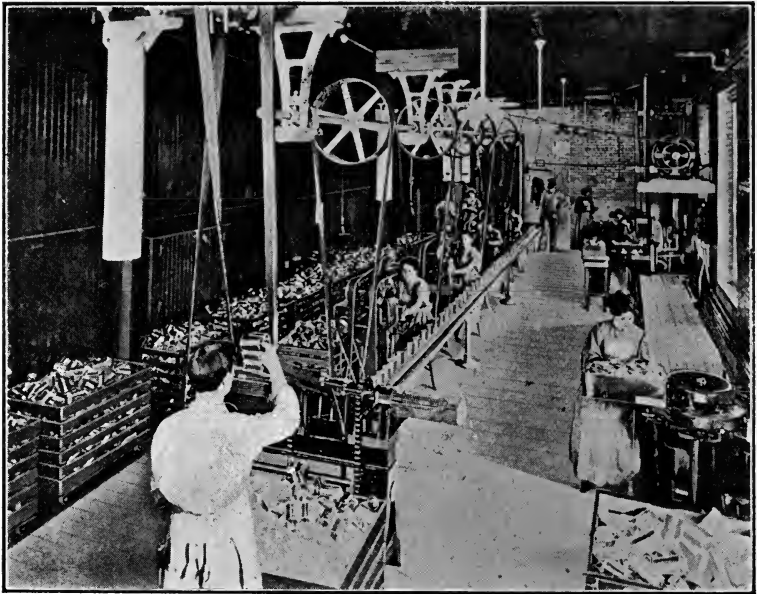


Fig. 59.—Can Closing Machines. (Courtesy of the Franco-American Food Co.)

cap with the rubber ring and various other devices were in time introduced. The glass container has always been utilized more largely in domestic canning than commercially as it is more expensive, breaks easily, increases labor requirements in factory operations and raises freight rates. Through recent improvements, however, it is growing as a commercial package especially in those products which cannot be preserved to the best advantage in tin.

While the tin can lacks much as an ideal container it is the most practical that has as yet been evolved. There are two styles in use known as the hole-and-cap can and the open-top or sanitary can. The former which is older and is sealed by means of solder has been superseded in many cases by the open top because of the ease with which they can be cleaned, filled and closed. In this case the sealing is done by double seaming on the top, no solder being used on the can except in making the side seam. This removes the objections to acid and solder on the ground that they contaminate the foodstuff.

A recent improvement in the tin can is the inside coating or lacquering. This is a decided advantage in preserving fruits that have considerable color like berries and beets. It prevents the bleaching effect induced by their action on plain tin. While such coatings are not perfect they are a step in advance and further improvements will undoubtedly be made in the near future.

**Animal Products.—Meats.**—The canning of meats for interstate commerce is more carefully safeguarded than any other line as all animals are given an ante and post mortem inspection and canning operations are carried on under government inspection. See Chapter XIII. The meat used for canning is principally the forequarter of beeves and other parts that cut with waste upon the butcher's block. Excess fat, bone and cartilage are trimmed off and the meat is placed in a jacketed kettle to heat for a period at a low temperature. Without this preliminary cooking meat would shrink within the can and float in an unattractive looking liquor. The cooked meat is cut into the proper size pieces, packed into the cans and meat jelly is added to prevent the meat adhering to the tin in spots and to give a better appearance. The further processes of sterilization and exclusion of air are quite similar to those used in other canning industries.

A large variety of meat products is found on the market, some of which have been partially cured, for example corn beef; others contain mixtures of meat, cereal and spices. The latter when finely ground and highly spiced are known as potted or

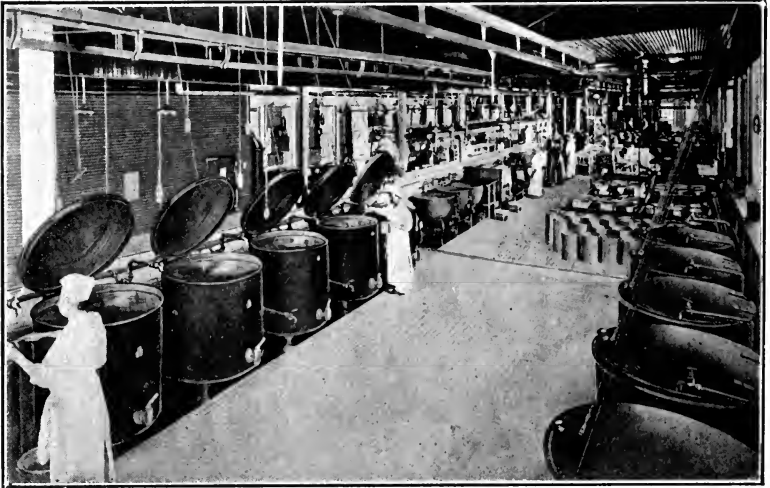


Fig 60.—Stock Boilers. (Courtesy of the Franco-American Food Co.)

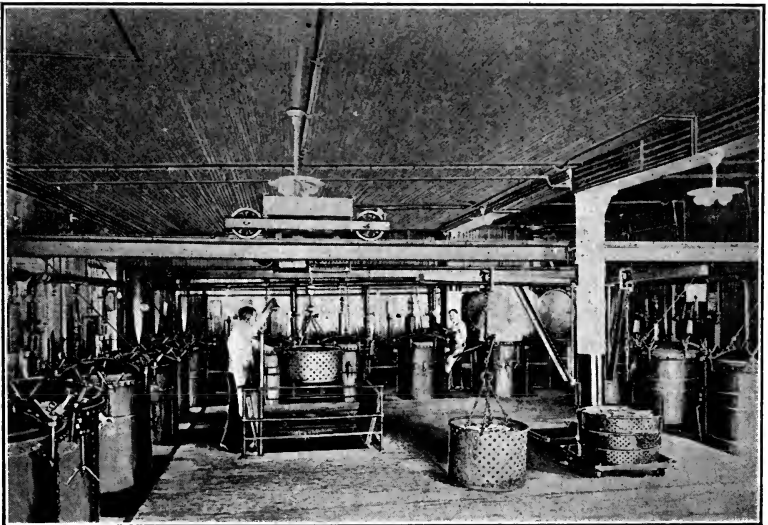


Fig. 61.—Sterilizing Process. (Courtesy of the Franco-American Food Co.)

deviled meat. Ground meat may also be found in the form of sausages.

*Soups.*—Soups of almost every description made according to the formula of the particular packer may be obtained in cans. They are classed as meat or vegetable although the latter variety is usually prepared from some kind of soup stock. Those cuts of meat are selected which have the flavor best developed and as far as possible fresh vegetables are used.

Soups are also known as light and condensed. The former are ready to serve without the addition of a liquid; the condensed soups require an equal volume or more of water or in some cases milk. As the making of soups is peculiarly a chef's work and as so many varieties are prepared it is impossible to give a general formula.

**Marine Products.**—Fish have long been recognized as one of the sources of cheap protein, the cost being much less than with meat from domestic animals. With the development of modern methods of catching and machinery for handling, it is possible for a large variety of fresh and salt water products to be preserved by canning. The fish packers employ their own fleets as a rule in order to have prompt delivery and since nearly all the products are in a most perishable state when used careful supervision of factory conditions is essential.

The general classes of canned marine products are: (1) plain boiled, steamed or otherwise cooked as used with salmon, mackerel, oysters, lobsters, crabs and a large variety of fish and shellfish; (2) preserved in oil, represented by sardines; (3) prepared with vinegar, sauces, spices, jellies, etc.; includes various forms of herring, mackerel, sturgeon, lobsters and crabs; (4) cooked with vegetables, a method used with chowders, codfish balls, terrapin stew and deviled crabs; (5) preserved by some other process but placed in cans for convenience in marketing, for example many smoked varieties of fish and brine salted mackerel, cod and caviar.

**Milk.**—See Chapter XVI. Milk Products.

**Specialties and Ready-Made Entrees.**—Under these headings may be placed a large variety of foods, sauces, condiments, etc. They include baked beans, sauerkraut, tamale, chili con carne, chow chow, mince meat, salad dressings, sauces for meats, vegetables and puddings, beef a la mode, goulash and many similar products.

#### IMPORTANCE OF THE INDUSTRY.

The United States to-day is the largest producer and consumer of canned food in the world. In some sections of the country it constitutes the principal industry. This is particularly true of states bordering on the Pacific. California is noted for its high grade fruit, tuna fish and sardines; Alaska and the State of Washington produce enormous packs of salmon. Along the Atlantic coast large quantities of vegetables, fruit, fish and shell-fish are canned while Chicago and other packing house centers supply most of the preserved meats.

Thousands of tons of vegetables and fruits are being used even in summer, chiefly because they can be obtained in a convenient form for cooking. To these may be added soup, entrees and the many specialties mentioned above. Millions of tons of milk are being canned not only on account of the convenience in usage but because of the difficulty of preserving the product in the fresh state. There was such an enormous demand for foodstuff of this type during the late war not only for domestic use but for the army and navy that there was little left for export. That which was sent found a ready market. American canned goods have been introduced in many foreign markets where they were known only in a small way before the war and there is every reason to believe that they have now established as permanent a foothold abroad as they have in the home markets.

## CHAPTER XIX.

### TEA, COFFEE AND COCOA.

#### TEA.

According to the writings of an ancient Chinese author the virtues of tea were known in the Orient some twenty-seven hundred years before the Christian era. Many legends exist as to the 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 latter part of the sixteenth century that the ships of the Dutch East India Co., in their voyages 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 passed 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 eighteenth 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 ever-green 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 which yield the tender new leaves so desirable in tea-making. 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 placed on a southern exposure so the sunshine will protect it from cold



Fig. 62.—The Tea Plant. (Courtesy of McCormick & Co., Baltimore, Md.)

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 shrubs may be picked at regular intervals. It is customary to occasionally allow the plants 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: black tea, which has a dark, dull appearance; 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 traveled in China on behalf of the Horticultural Society of Great Britain.

Tea is also classified according to the size of the leaf (Fig. 63). (1) Pekoe, which consists of the three young shoots at the tip which 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. (2) Souchong is prepared from the leaves immediately below the pekoe variety and makes a tea of popular price. Pekoe and souchong are sometimes mixed when the product is known as pekoe-souchong. (3) 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 and souchong for China green teas. (4) Bohea is a name frequently applied to any larger leaf used for tea-making than the congou variety. This tea is no longer found on our market.



*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 - Suchong.*

Fig. 63.

**Process of Manufacture.**—The processes used in the preparation of black tea for the market are as follows: The leaves are picked, withered in the sun, rolled until soft, fermented, fired and sorted. The manufacture of green tea is somewhat different. It consists in the following operations: Leaves are picked, withered

in pans, rolled until soft, withered again, sweated in bags and slowly roasted.

*Picking.*—The tea leaves are plucked entirely by hand the operation generally being carried on by women and children. In 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 around.

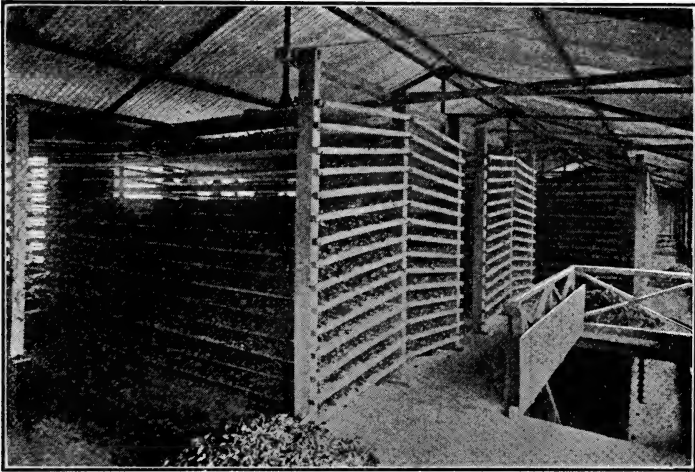


Fig. 64.—Withering Tea Leaves. (Courtesy of The Spice Mill Publishing Co.)

*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. 64). In good weather this operation takes about eighteen to twenty-four hours but when cloudy or rainy artificial heat must be used and a longer time is required. 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.

*Rolling.*—In China rolling is still done very largely by hand (Fig. 65). 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



Fig. 65.—Rolling Tea Leaves. (Courtesy of *The Tea and Coffee Trade Journal*.)

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 they turn 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 dis-

agreeable 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, 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: 1st, 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; 2nd, 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.

**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. 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 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.

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 the introduction of coffee into Arabia, one of which places the original home in the province of Caffa, Abyssinia, 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 the origin may have been Europeans discovered its use in Arabia during the fifteenth century. Undoubtedly the knowledge of it spread very largely through the Arabian merchants 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. Coffee reached Constantinople in the sixteenth century and spread from there to the countries bordering on the Mediterranean, fin-

ally being introduced into London, Paris and other European cities during the seventeenth 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 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 tree attaining a native growth of some eighteen to twenty feet, but under cultivation it is rarely allowed to exceed from four to six feet in height. This dwarfing the plant increases the crop and facilitates picking. The leaves are a fresh green color expand-



Fig. 66.—Coffee Bean.

ing 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 usually 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. 66). 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. Occasionally a single bean occurs, common to all varieties of coffee, in which case it is called "pea-berry" and is supposedly of finer quality than the split beans.

**Cultivation.**—The coffee trees thrive best in rich, well-irrigated soil and in tropical climate where the rainfall exceeds seventy-five inches per annum. They are propagated from seeds, which are planted directly in the fields or grown in wicker baskets in nurseries until eighteen 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 trees. The first crop of any importance is born when the plant is from four to five years old, and with care harvesting may be continued at regular seasons for twenty 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 the modern plantations of



Brazil, many planters claiming that it has advantages over the modern wet process.

*Wet Method.*—When 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.

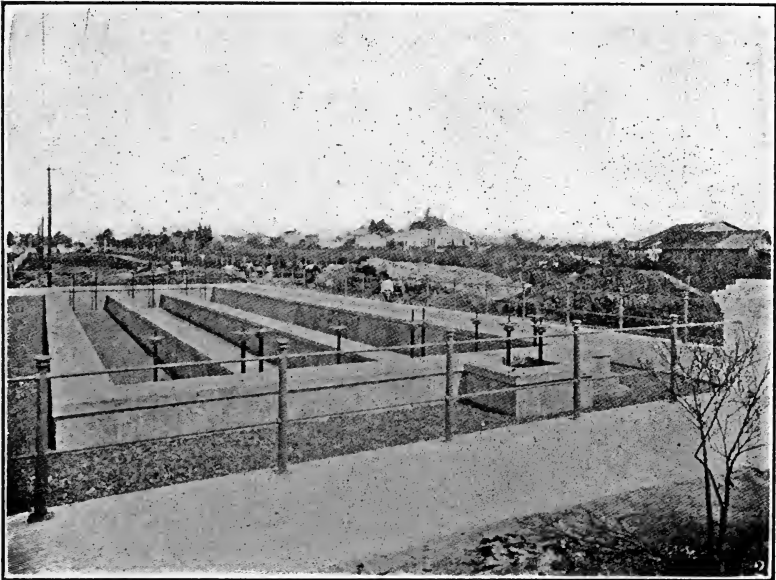


Fig. 67.—Views of Coffee Cultivation and Industry of Brazil. Washing Tanks.  
(Courtesy of The Spice Mill Publishing Co.)

*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.

*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 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 said—“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. 68).

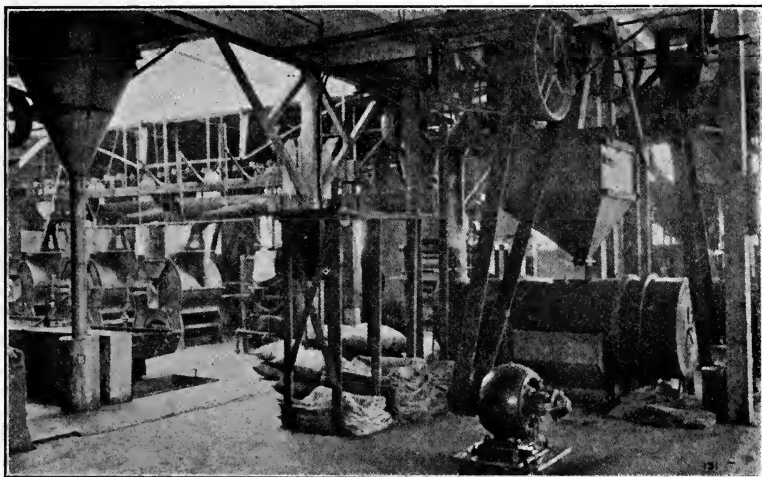


Fig. 68.—General View of Coffee Roasting Room. (Courtesy of the Spice Mill Publishing Co.)

The effect of roasting is both physical and chemical. The physical state of the bean is changed to a brittle form in which 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 possible after roasting and should never be pulverized until the time of the preparation of the beverage.

During the roasting operation there is also an appreciable amount of the alkaloid caffeine which volatilizes, consequently, in some of the most improved coffee roasting establishments, the vapor developed during the operation is thoroughly cooled for the purpose of recovering the caffeine. By subjecting coffee to a long continued roasting at low temperatures practically all of the caffeine present in the bean volatilizes and is recoverable. Coffee roasted by this method has been sold in the bean under the name of caffeine-free coffee. When treated in this manner, however, it lacks some of the flavor of the ordinary product.

**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 caffeine. It is the same substance as is found in tea but occurs in a rather smaller proportion, approximately one to two per cent. being found in the unroasted bean. Tannic acid is also found with a larger amount of other substances such 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.**—A number of forms of dry extract of coffee can now be obtained. They consist essentially of a solution of finely ground coffee in hot water made under conditions which cannot be repeated on a small scale. These solutions are afterwards boiled down in vacuo to such a consistency that they harden on cooling. When cold the solid mass is finely pulverized. Usually a level teaspoonful of this material represents a cup of coffee.

#### COFFEE SUBSTITUTES.

For several years past cereal products have 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, peahulls and molasses. Some of the first products contained also 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 any 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. 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 extravagant 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.

**Physiological Effect of Tea, Coffee and Cocoa.**—The stimulating effect of tea and coffee is due to the presence of caffein, a powerful drug which acts on the nervous system. The excessive use of these beverages frequently results in nervousness, insomnia, headache and indigestion; disturbances of other organs may follow. A limited use appears, however, to be harmless or may even be beneficial to some people but they should never be given to young children. Cocoa and chocolate contain a substance similar to the caffein of tea and coffee but is milder in its effects.

As chocolate is a concentrated food it frequently causes biliousness when indulged in too freely.

#### COCOA.

Cocoa 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 cocoa 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 the use of cocoa 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. Cocoa was first introduced into the States by the fishermen of Gloucester; 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.**—Cocoa is the fruit of a tropical tree commonly known as the cocoa 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, Venezuela, Ecuador and Brazil being the largest exporting countries. Mexico still produces the greatest amount of cocoa but uses most of it for her own consumption.

The cocoa tree is grown from seeds either planted directly in the fields or in nurseries. It attains an average height of about twenty to thirty feet and bears small, red, wax-like flowers which appear either singly or in clusters, along the trunk and main branches of the tree. The fruit is a pod some eight to ten inches long, three to four inches thick (Fig. 69). 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 cocoa beans which



Fig. 69.—Pods and Leaves.

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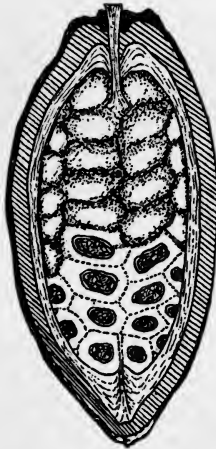


Fig. 70.—Section Cocoa Fruit.

are covered with a thin shell greatly resembling an almond (Fig. 70). 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 condition 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 to 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 are cut open with a sharp cutlass. The pulp and cocoa 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 pulpy matter that may be clinging to them. Whether they are washed or not the cocoa beans 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 a practice is made of polishing the bean after drying. The cocoa is now ready to be bagged and shipped to the markets of the world.

When received by the manufacturer cocoa 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;

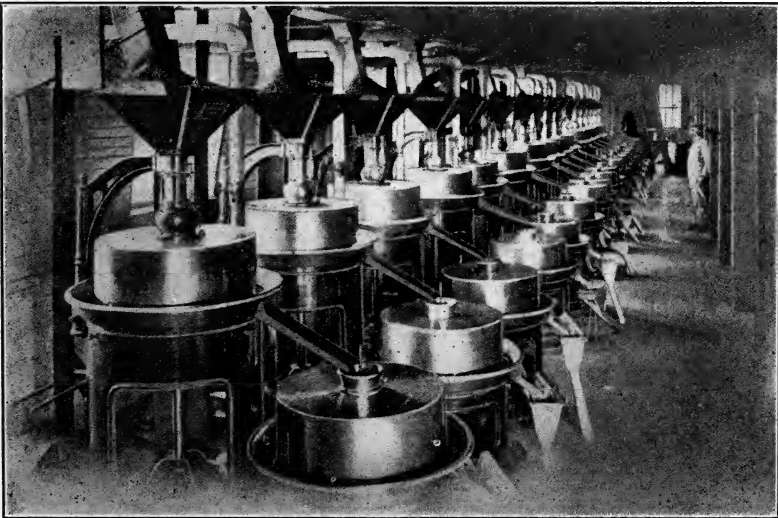


Fig. 71.—Grinding Room.

(Copyrighted by Walter Baker & Co. and used with their permission.)

too much heat means bitterness and too little leaves the cocoa with a crude undeveloped taste. The process is usually carried out in large iron drums heated to  $125^{\circ}$ - $145^{\circ}$  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 cocoa 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 cocoa 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 cocoa nibs are used for the preparation of the commercial chocolate and cocoa.

**Preparation of Chocolate.**—The cocoa nibs are ground into a paste by a series of revolving stones arranged in pairs and slightly heated to assist in liquefying the cocoa. 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, the product is placed on the market as sweet chocolate or as milk chocolate if condensed or powdered milk has also been added.

**Preparation of Cocoa.**—As the cocoa 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 cocoa. 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 sixty to seventy per cent. of the fat. The mass is then allowed to cool after which it is reduced to a powder and boxed. Foreign manufacturers remove further amounts of fat from cocoa by treatment with an alkali after which it is thoroughly washed and neutralized. The use of alkali is generally defended on the plea that it makes cocoa soluble but this statement is not borne out by the facts. No market cocoa or chocolate is completely soluble but owing to the fine state of division of the particles it does not readily settle in the hot, thick liquid. American manufacturers do not generally favor this process. The extracted fat is clarified and made into cocoa-butter. As cocoa-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.

**As a Beverage.**—Cocoa 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 cocoa bean as given by Payen.

Fat .....	50
Starch .....	10
Protein.....	20
Water.....	12
Cellulose .....	2
Mineral matter.....	4
Theobromine .....	2

Theobromine which is responsible for the stimulating effect of cocoa is closely related chemically to the alkaloid caffeine 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 cocoa 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.

## CHAPTER XX.

### NON-ALCOHOLIC BEVERAGES.

Non-alcoholic beverages may be classified as mineral waters and the so-called soft drinks. For many years natural water of sparkling or effervescent quality and containing a large amount of mineral matter or unusual mineral constituents have been used for medicinal purposes. Later the custom of preparing these beverages artificially and charging them heavily with gas has almost entirely eliminated the use of the natural products. So general has become the use of these beverages that their preparation constitutes an important unit of industry. A little later pure soft waters or distilled water heavily charged with carbon dioxide and flavored with pleasant tasting syrups gained universal popularity as soda waters. These were the primitive soft drinks.

The industry has expanded so greatly of late years that a simple classification is requisite in order to avoid confusion. The following seems to fit every known example.

### NON-ALCOHOLIC BEVERAGES.

#### MINERAL WATERS.

Natural  
Artificial

#### SOFT DRINKS.

Sodas  
Acid drinks (fruit or phosphate)  
Fruit juices.  
Sugary liquid flavor with spices  
(ginger ale)  
Cereal beverages

Where every precaution is employed to prevent the slightest contamination distilled water is used in the manufacture of these beverages. This practice insures absolute freedom from mineral and organic impurities. To obtain the best and most economic results in water distillation the process is briefly as follows: 1st, the local water supply is filtered through sand with or without the coagulant alum; 2nd, filtered water is preboiled in an open still to permit the escape of volatile matter; 3rd, water is distilled in a closed still (Fig. 73), cooled, aerated and stored.

**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.

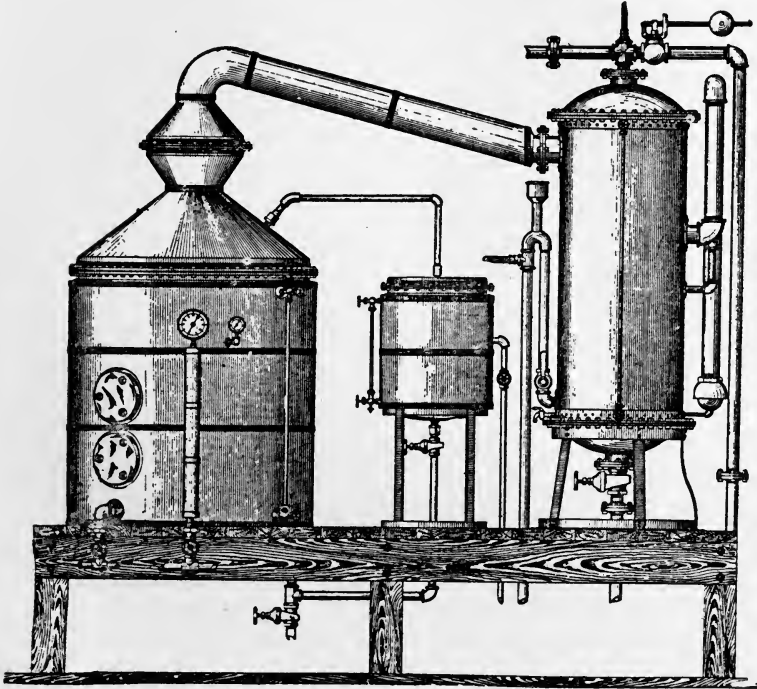


Fig. 73—Distillation Apparatus. (Courtesy of Carl H. Schultz Co.)

According to their most characteristic ingredients they are classified as follows:

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 pres-

sure by losing their gases with great rapidity. This causes them to be thrown upward to a height of twenty to forty 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.*—Hot mineral springs have been found to occur most frequently in volcanic districts where there is likely to be much sulphur and a considerable variety of mineral matter. Carbonated springs are usually found in localities containing a deposit of limestone. They occur in many 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 Value.*—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 worshipped and their

sick healed of whatsoever disease they incurred. In the works of Latin writers we often meet 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 little changed has come down from these early times to the present day. How much they really do affect disease is a question of great interest to the modern physician. Considerable difficulty is experienced by investigators of the subject for it is hard to eliminate other circumstances which may 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 retiring and arising, new and possibly cheerful society, relief from the harassing cares of business or demands of social life are experienced. 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 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 using these waters it should be carefully determined that the water is effective for the specific disease and that the sanitary conditions surrounding the springs have been properly 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 it was suggested by scientists 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.



### CARBONIC ACID GAS GENERATOR.

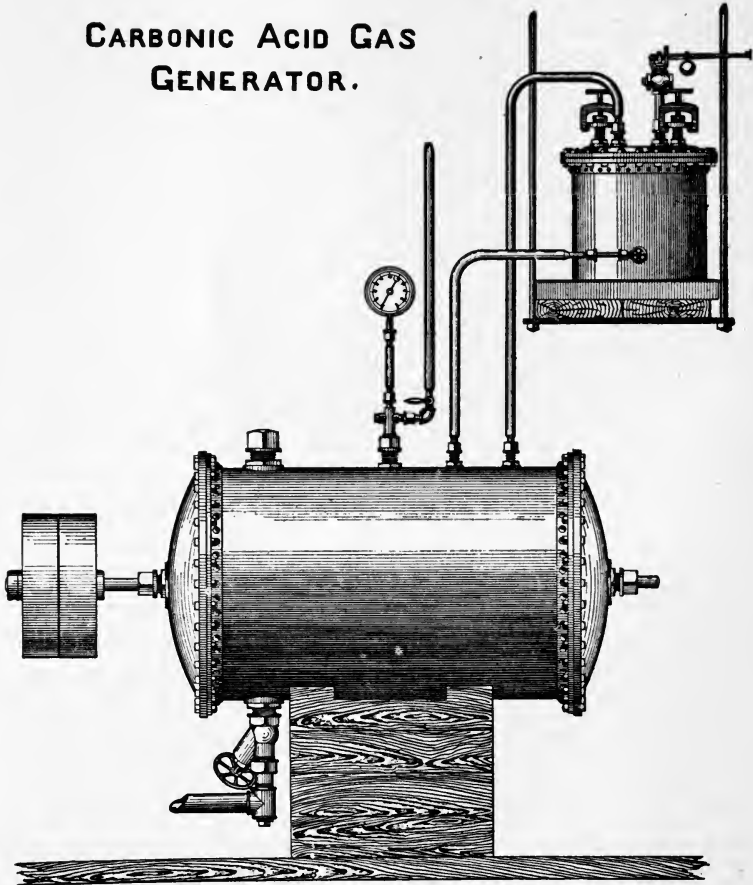
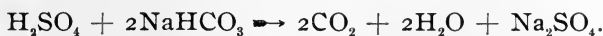


Fig. 74.—Carbon Dioxide Generator. By allowing sulphuric acid to flow drop by drop from the upper container into the lower tank which is filled with a solution of bicarbonate of soda, carbon dioxide gas is obtained. (Courtesy of Carl H. Schultz Co.)

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. 74).



From this simple suggestion 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. The trouble with the natural waters is that they cannot be expected to be constant in composition; the artificial, if carefully compounded, are invariable. Care should be given, however, in the use of these waters that the firm placing them on the market is thoroughly reliable.

#### SOFT DRINKS.

The bottled sodas usually referred to as soft drinks occupy an important economic position in our industrial life. Few realize that over three billion bottles are produced annually requiring approximately one hundred thousand tons of sugar in their manufacture and representing in money value about one-tenth that of milk used for beverage purposes.

The term soft drink was originally intended to distinguish non-alcoholic from alcoholic beverages since the true soft drink has not undergone fermentation to any appreciable extent and little or no alcohol is present. The use of the word soda has been questioned by some since soda does not enter into the composition of the product but through custom and long usage the term has become generic. Soda or soda water is now applied to all artificially prepared carbonated beverages composed of water, sugar, fruit juice or other flavors.

There are few articles of the diet to-day which are being produced under such extremes of sanitary conditions of plants and raw materials as are the carbonated beverages of this type. Large establishments under the supervision of chemists produce the highest type of delicious healthful beverages. Every precaution is taken that sanitary conditions prevail, the water is known to

be pure, the extracts free from harmful adulterants, the syrup room and bottling plant are screened and free from insects and the floor, walls and machinery are kept scrupulously clean. In marked contrast to these factories are bottling plants operated by people of unclean habits who are using filthy bottles and foul receptacles for syrups, who give little or no attention to the water supply, accompanied by a lack of everything else which is necessary in the production of a satisfactory sanitary food product. Uncleanliness while undesirable in the production of any food means more in the manufacture of these beverages since there is no safety afforded the consumer by partial or complete sterilization, such as would be found in canned goods, baking products and confectionery or where cooking is employed in the final preparation for use. Fortunately for the industry people of large means are now being attracted to it by the total abstinence movement which is about to succeed in inhibiting the production and sale of intoxicating beverages. Progressive bottlers are more and more realizing the importance of plant sanitation as it affects the quality of the product and integrity of the industry and the better class of manufacturers are generally anxious to put out as good an article as it is possible for them to produce.

The kinds of extracts used by bottlers generally fall into two classes. One includes the juice, oil or flavoring principle obtained from fruit, leaves, bark and roots of plants. They are obtained by pressure or by extraction with various solvents, water, alcohol, acetone or the like. The second class of flavors are known as synthetic products made to imitate fruit extracts by combining certain esters of which ethyl acetate, ethyl butyrate, ethyl benzoate, amyl acetate and amyl butyrate are the most important. In the past imitation flavors have largely predominated perhaps for the reason that sodas produced with synthetic flavors are not so easily affected by dirty or improper methods of bottling as are fruit juices. There has been, however, in late years an apparent increasing demand for beverages produced with true fruit flavors and extracts.

The kind of sweetening material which it is advisable to use is also an important consideration as regards quality. Saccharin which was used freely at one time was prohibited by the Food and Drugs Act and also by the laws of most of the States. Sugar was generally supposed to be the sweetening agent but the sugar shortage due to war conditions caused serious trouble in the industry and led the Bureau of Chemistry to experiment with a number of other materials which could be used as substitutes. These are principally glucose, maltose, honey and refiners' syrup. Some of the formulas recommended proved very satisfactory and are now being used but such substitution must be stated on the label.

The food value of the beverage is largely due to the sugar content which varies from one-half to one and a half ounces to the eight ounce bottle. The dry ginger ales contain the least, sasaparilla from three-quarters to one and a quarter ounces, while the acid drinks of the phosphate type contain the most sugar. The food value of some of these drinks is further enhanced by their fruit juice or fruit extract content.

*Sasaparilla* is prepared by making a thin syrup of sugar or glucose which is then flavored with extracts of sasaparilla, charged with carbon dioxide and bottled. In similar manner *ginger ale* is prepared using extract of ginger root and sometimes red pepper. *Lemon soda* so-called is a sweetened solution of citric acid flavored with lemon oil. These beverages are frequently colored with harmless coloring matter to attract the eye. Soap bark has also been used to increase the foaming quality.

#### FRUIT JUICES.

The first of the non-alcoholic beverages derived from fruit were lime juice and lemon juice. All British ships making long voyages through the tropics were required by an Act of Parliament to carry among their stores a supply of lime juice which was to be used as an antiscorbutic. In consequence of this practice English seamen to the present day are known the world wide as "lime juicers". Lime juice has also been extensively used in the West India Islands in all cooling beverages in much

the same way as lemon juice has been used among our own people as lemonade. Another early fruit juice which was served as a basis for summer beverages was prepared from the raspberry. In time the list of such products was greatly enlarged including apple, grape, pineapple, blackberry, cherry, peach, orange and loganberry. When carefully prepared they are not only agreeable to the taste but furnish a wholesome drink since they contain mineral salts, organic acids and sugars of the various fruits.

Fruit vinegars are similar products but are more acid due to the fact that vinegar is used in their manufacture. They are usually prepared from raspberries, strawberries and blackberries by heating the fruit, sugar and vinegar, straining, pasteurizing and preserving in sterilized bottles.

*Grape Juice.*—The idea of preparing unfermented wine or grape juice as it was called later was conceived in Vineland, New Jersey in 1869. The object at that time was to serve a non-alcoholic communion wine in the church of the locality. Having demonstrated that such a product was a practical thing the attention of ministers and physicians was called to the value of unfermented grape juice and some of its advantages over the fermented beverages.

Like many other industries the inventor met with many discouragements during the early years for only a few fanatics in the church and a handful of cranks in medicine wished to have anything to do with wine that wasn't wine. Many years followed before modern methods of pasteurization were understood, the public was aroused and a market created for grape juice either natural or carbonated for making a cooling, wholesome beverage.

In the process of manufacture sound grapes of a good quality, preferably the Concord variety, are picked when fully ripe, weighed and inspected. A series of rollers receive them from the wagons and conveys them through jets of cleansing water to the stemming machine (Fig. 75) where the berries are separated from the stems. They next pass to the stirring kettles which heat the grapes sufficiently to loosen the color pigment and free

the sugar before they are passed to immense hydraulic presses which slowly remove the juice without crushing the seeds. The juice flows out in pipes to the pasteurizing kettles while the residue known as "pomace" is utilized to fertilize the vines for another year or for fuel purposes. A temperature of not lower than 175° F. nor above 200° F. is used for pasteurizing. The "must" as it is then called is run from the pasteurizer into sterilized five gallon carboys, securely corked and stored for some months to allow the argols (cream of tartar) to settle.

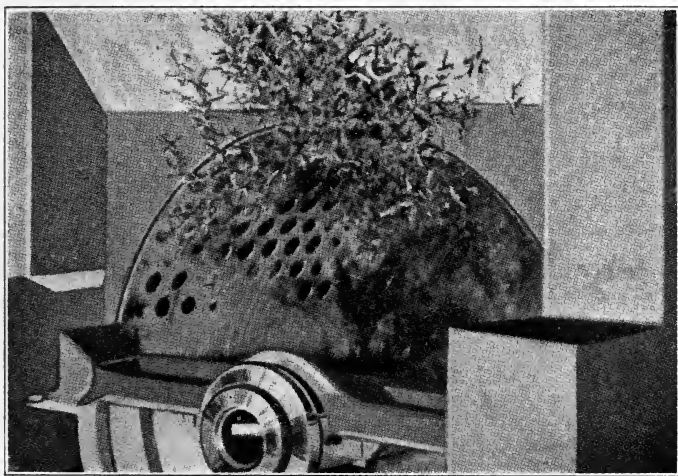


Fig. 75.—The Stemming Machine. (Courtesy of the Welch Grape Juice Co.)

The clear juice is afterwards siphoned off by machinery, filtered, bottled, capped, pasteurized again, labeled and packed for shipment. Grape juice prepared in this way will keep almost indefinitely if stored in a cool, dark place.

#### CEREAL BEVERAGES.

Beverages prepared from cereals are usually sold under a trade name. The grains used by many are barley and rice, a mixture of barley, corn and rice or corn grits and rice. The rice used is known in the trade as brewers screenings and is not the whole kernel but parts broken when the rice is polished. The

product is perfectly pure and wholesome but is not adaptable to the grocery trade for table uses.

As many of the cereal products are comparatively new the method of their preparation is still a secret. This precaution is being taken by the manufacturers of beverages which have attained country-wide popularity in order to prevent as far as possible imitations and substitutions. There are, however, two general processes in which the cereal beverages on the market now go through which are known and recognized by the government. One process is that wherein beer is manufactured through usual methods and the alcohol content is extracted by a process of evaporation until less than one-half of one per cent. by volume remains. The other process of manufacture as known by many is where the soft drink at no stage of the process is permitted to ferment or if fermentation does develop it is arrested before reaching one-half of one per cent. by volume.

The first method mentioned wherein fermentation is employed consists of the following general operations—malting, preparation of the wort, boiling, cooling, fermentation, removal of the alcohol, preservation. In the classification of the carbohydrates maltose occurs in the disaccharid group  $C_{12}H_{22}O_{11}$ . This substance is never found in nature in large quantities so must be prepared for commercial use by allowing the enzyme diastase to act upon starch. As there is a large demand for malt sugar its preparation is usually carried on by a separate industry. Barley is generally acknowledged to be the best source of starch not only on account of its composition but the fact that greater amount of enzymes are developed than with most cereals. Among the enzymes released during germination cytase, diastase and peptase are the most important. The two former bring about the hydrolysis of the starch granule while the latter influences the protein.

The process of changing barley into malt consists in steeping, sprouting and drying. When barley is received at the malting house broken grains and foreign matter of all kinds are removed by revolving sieves and strong currents of air. The grain is softened by being steeped in water for several days and is then

placed in a metal cylinder or drum which is rotated slowly to keep the germinating barley moving while moist air is blown through the mass. Temperature and humidity can be carefully controlled by this means. Drying is accomplished by either trans-

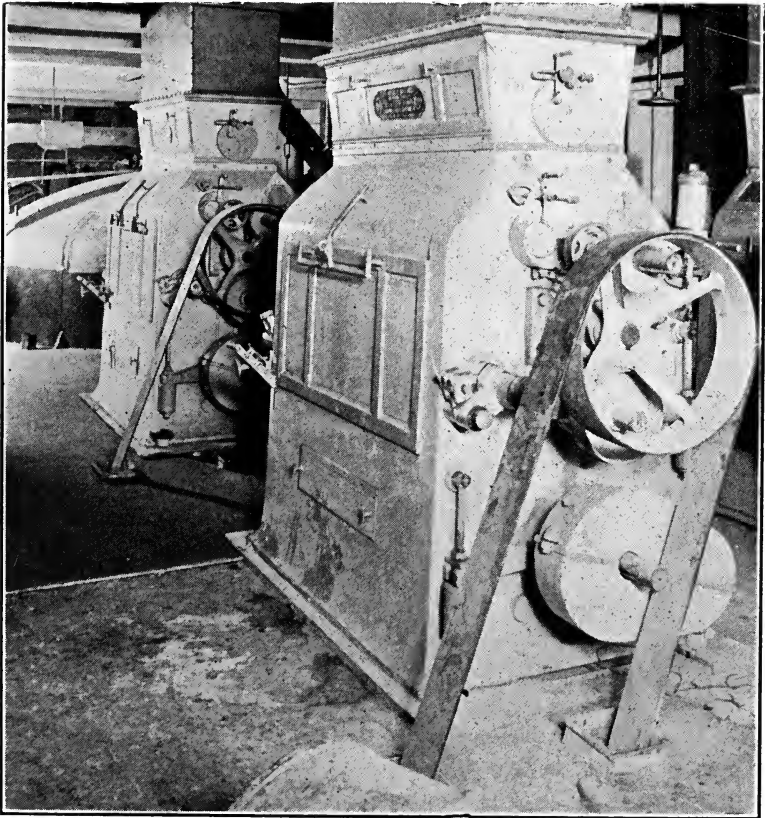


Fig. 76.—Roller Mill for Grinding Barley Malt. (Courtesy of the United States Brewers' Association.)

ferring the grain to a kiln or by simply passing hot air through the drum.

The preparation of the wort is the second stage in the preparation of the beverage. The malt is cleaned and coarsely ground in

a roller mill (Fig. 76) and the grits are mixed with water. To this may be added corn or rice which has been previously cooked. This process is intended not only to dissolve all water soluble material but to allow the enzymes to convert any starch present to dextrin and maltose. After the conversion is complete the watery extract is drawn off, filter pressed (Fig. 77) and boiled down (Fig. 78) in order to concentrate and sterilize the wort

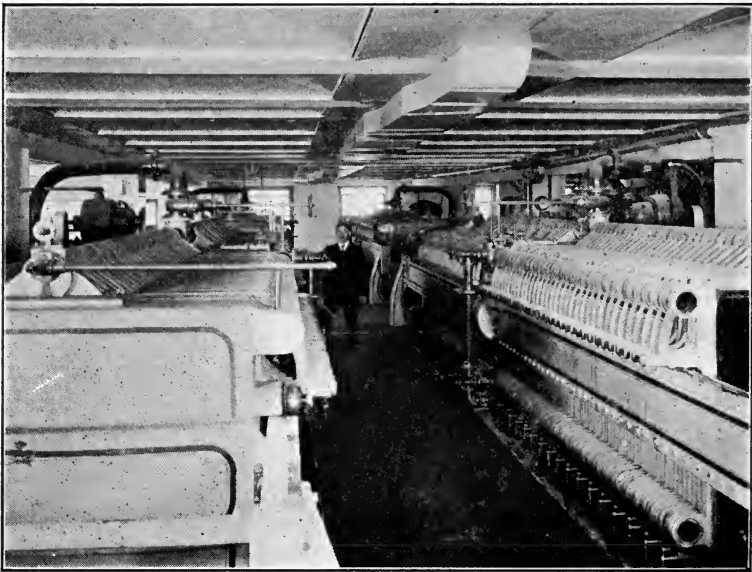


Fig. 77.—Filter Presses for Clarifying the Wort. (Courtesy of the United States Brewers' Association.)

and to coagulate unchanged protein. Hops are added during the boiling process, the active principles of which are taken up by the wort giving taste and aroma. After straining off the hops the wort is immediately cooled by being passed over pipes through which brine is circulating. When cooled to the desired temperature yeast is added and fermentation takes place in closed iron vats lined with porcelain. The alcohol formed during fermentation is later removed by distillation until one-half of one per cent. by volume remains. After bottling pasteurization is



usually employed as a means of preserving the beverage. The alcohol which has been evaporated is recovered, accounted for to the Government and sold for industrial and commercial purposes.

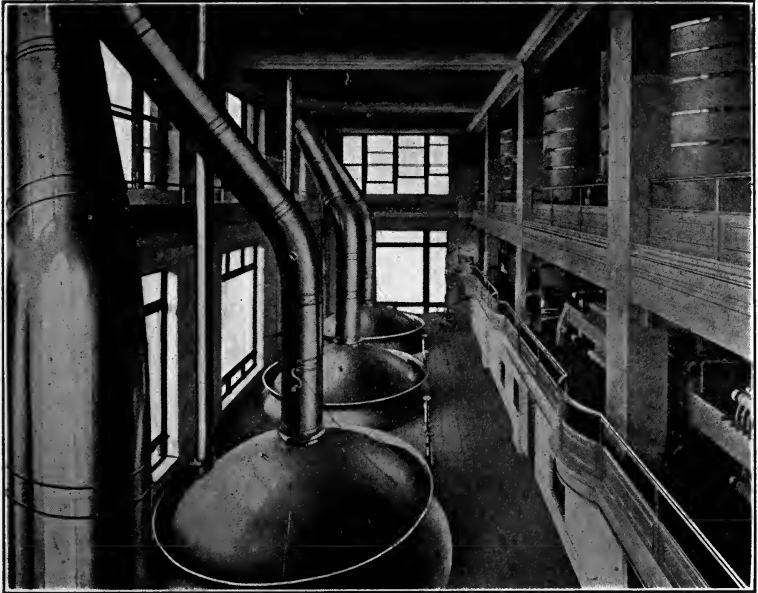


Fig. 78.—Copper Boilers. (Courtesy of the United States Brewers' Association.)

The second method of making the cereal beverages is practically the same up to the point of fermentation. At this period the wort is sterilized and bottled.

## CHAPTER XXI.

### SPICES AND CONDIMENTS.

The terms condiments and spices are 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. The words are confusing for the reason that many of the bodies included under the headings are similar in chemical composition but all do not belong to the same series of chemical compounds. Actually the terms as employed describe conditions of usage rather than composition. The word condiment describes material which is used commonly in the daily diet and covers all varieties of food while spices are not so commonly employed being restricted largely to pastry, puddings, cakes and the like. Condiments are represented by salt, pepper, mustard and vinegar; spices, by cinnamon, nutmeg, ginger, etc.

#### CONDIMENTS.

**Sodium Chloride.**—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.

The process of preparing salt for the market necessarily differs according to its source. Where natural deposits occur salt is mined by sinking a shaft and working similar to a coal mine. The salt can be sent to the market just as it is mined under the name of rock-salt or it can be ground and screened. When salt has been obtained by evaporation from the ocean or other body of salt water it is usually quite impure so must be washed and recrystallized. The method used to the greatest extent to-day consists in evaporating brine obtained from salt beds. The brine is generally purified by concentrating until the less soluble constituents, such as calcium sulphate, crystallize when they can readily be removed. The brine is then concentrated in pans either by the sun's rays, direct heat or exhaust steam and sometimes in vacuo. However obtained the crystals are drained, dried, sifted into grades and packed.

*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.

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



Fig. 79.—Pepper Plantation near Singapore. (Courtesy of The Spice Mill Publishing Co.)

pepper is generally supposed to be produced from a different spice but is in reality the same fruit prepared by a different method. This variety is obtained by decorticating or removing the dark skin from the fully ripened black peppercorn, leaving a light colored kernel which is pulverized, and forms the white pepper of commerce. White pepper is more expensive but has a more delicate flavor than the whole pepper ground.

There are several varieties of red peppers, the cayennes which have a sharp, acrid taste and the paprikas which are sweet and mild. Paprika is used in cooking for its color as well as flavor. It is rapidly finding favor among American housewives.

*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 markets.

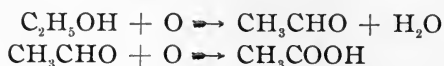
The two most common varieties of seeds used at the present are brown and yellow in color, the brown yielding the highest grade product. Mustard is prepared by passing the interior of the seed through a winnowing machine for the removal of foreign material and crushing the grain between rollers, after 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, cayenne pepper, etc.

*Curry Powder.*—Curry or curre powder is a very highly seasoned condiment which has been used for many generations in East India but has come into favor in the Western World only in recent years. It consists chiefly of ground turmeric roots highly flavored with cayenne pepper, ginger, and similar pungent spices. Curry is usually applied to cooked dishes just before serving.

*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.

Vinegar is obtained by the fermentating 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 :



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 bung being left open. This process was so tedious, 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 ageing before being placed on the market. Cider vinegar has four and a half to five and a half 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 two per cent. of the entire weight.

In wine producing sections of the world vinegar is prepared from cheaper grades of wine and from wines which have spoiled by the action of the acetic ferment. 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 matter of the grape such as acid potassium tartrate.

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 extract matter in which dextrin, maltose, protein, mineral matter and extractives can be found. The per cent. of acetic acid is not as high as in wine and cider vinegar therefore a small quantity of sulphuric acid is frequently added one-tenth of one 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.

#### 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 colonization 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, cayenne pepper being the most important. 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  $25^{\circ}$  N. and  $25^{\circ}$  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 science 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 be kept for a length of time on account of the high content of spices. Fruit cake furnishes another example, as 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

\* The Use of Spices as Preservatives, by Conrad Hoffman & Alice Evans. Published in *Journal of Industrial & Engineering Chemistry*.



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.

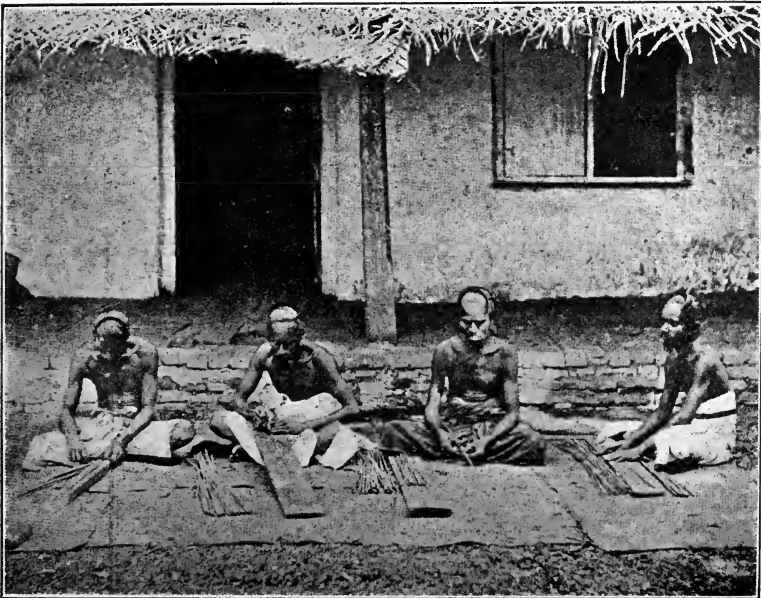


Fig. 80.—Rolling Cinnamon Bark into Quills. (Courtesy of the Spice Mill Publishing Co.)

**Commonly Used Spices.**—*Cinnamon and Cassia.*—Cinnamon is the inner bark of young shoots of 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 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." When put up in bundles they are ready for exportation (Fig. 80). Cinnamon contains an essential oil which consists largely of cinnamic aldehyde. A synthetic cinnamic aldehyde prepared from coal tar is frequently used in flavoring extracts to replace the genuine oil.

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 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 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 sixteen per cent. of a volatile oil, which can easily be removed and is of considerable value. It consists largely of a substance known as eugenol. The oil is used largely in perfumery and in soaps (Fig. 81).

*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 appear to be a combination of those obtained from cinnamon, cloves and nutmeg. The fruit is picked before it is ripe, 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



Fig. 81.—Clove Tree of Zanzibar. (Courtesy of The Spice Mill Publishing Co.)

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. When the thin outer seed coat is broken, the kernel or nutmeg is removed, cleaned and packed. Nutmegs are exported in the unground state in order to retain the flavor, and usually lime coated for preservation. The inner envelope which surrounds the nut is also dried and exported under the name of mace.

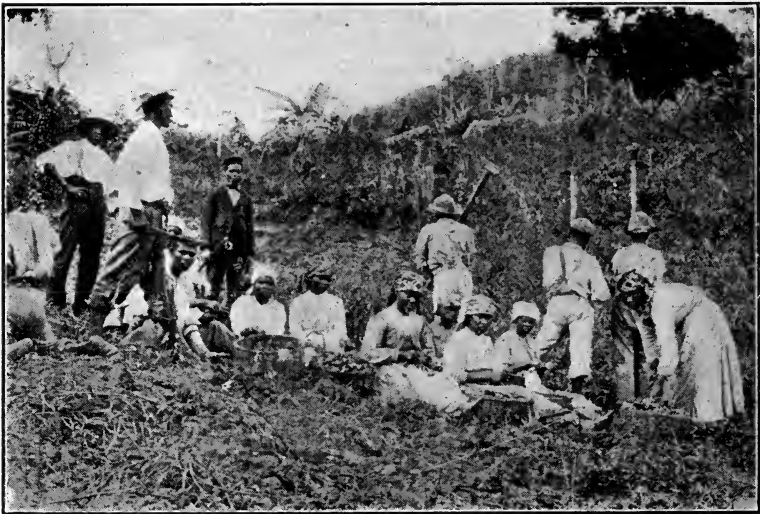


Fig. 82.—Digging and Peeling Ginger in the Fields—Ginger Plantation, Jamaica.  
(Courtesy of The Spice Mill Publishing Co.)

*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. 82).

**Vanilla and Lemon Extracts.**—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 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.

Modern science has furnished a commercial rival to vanilla extract in the production of a synthetic product. Vanillin has been largely prepared from eugenol, a substance to which oil of cloves owes its characteristic odor, and in recent years much has also been obtained electrolytically from sugar.

In the preparation of vanilla extract the flavor is obtained from the bean by a mixture of alcohol and water as the resins in the bean will not impart their flavor to either alcohol or water alone. (From forty to sixty per cent. alcohol is the strength used according to the character of the bean.) The method of extraction is preferably that of percolation. At least thirteen and thirty-five one hundredths ounces of extracted matter in one gallon of the finished product is required by the United States Department of Agriculture. The best vanilla extracts are kept from six months to two years in white oak casks or vats in order to have them acquire a fine dainty bouquet which cannot be obtained by any other known process. Storage, however, raises the cost of the product twelve to fifteen per cent. owing to losses from evaporation and interest on the money invested and to insur-

ance rates. The partly extracted beans are dried, ground and used in the powdered state by ice cream manufacturers.

Lemon extract contains at least five per cent. by volume of lemon oil in alcohol of proper strength. The lemon oil industry has been carried on largely in Sicily. A very small quantity is prepared in the West Indies and experimental quantities in California, but the Sicilian lemons have so much finer bouquet and flavor that ninety-nine per cent. used in this country comes from that section. In the best extracts eight per cent. of the oil is used, the maximum amount that can be held in solution by ninety-five per cent. alcohol. A higher percentage would become cloudy if subjected to changes in temperature especially cold, and would appear unsightly although the product would be in no way injured. Alcohol is necessary in the manufacture of lemon extract not only to hold the oil in permanent solution, but to protect it from the action of oxygen, since that element combines chemically with certain constituents of the oil known as terpenes, resulting in a turpentine-like odor and a bitter, disagreeable taste. Fresh lemons are frequently added to give a fine aroma and zest to the oil.

Much adulteration, substitution and misbranding have been practiced with vanilla and lemon extracts. In the former an extract made from the tonka bean, the active principle of which is coumarin, is frequently used in inferior extracts to replace the more expensive vanilla. Imitation products from oil of cloves have also been largely employed. Such extracts have a strong pungent odor which will not volatilize in cooking as quickly as the genuine vanilla. They are often used for flavoring ice cream and cakes on the market. Coloring matter and a low alcoholic strength are frequently found in both vanilla and lemon extracts. In the later imitation lemon, prepared from lemon grass oil and citric acid, has been much used.

The flavoring extract business to a large extent passed into the hands of unscrupulous men, mail-order and premium-giving houses who put most inferior goods upon the market. As a result the Flavoring Extract Manufacturers Association of the

United States was organized, the object of which is to do away with all evil practices, to place the industry on a firmer basis and to secure uniform Pure Food Laws in the various states, which will be in accordance with those adopted by the National Government.

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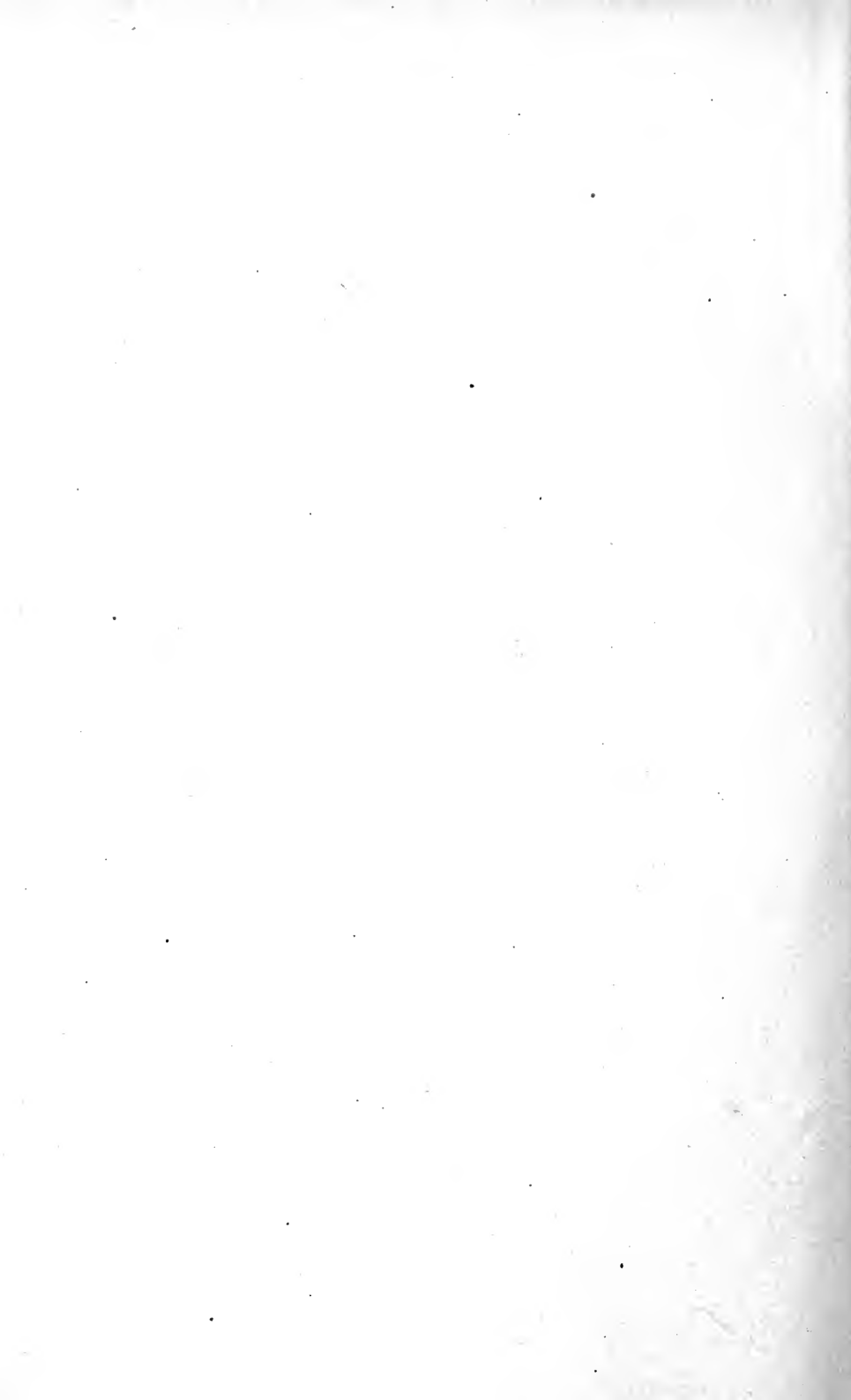
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# Household Chemistry

for the use of

## Students in Household Arts

BY

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Teachers College, Columbia University

CONTENTS.—Introduction; Chapter I.—Outline of Organic Chemistry; Chapter II.—Atmosphere and Ventilation; Chapter III.—Water; Chapter IV.—Metals; Chapter V.—Glass, Pottery and Porcelain; Chapter VI.—Fuels; Chapter VII.—Carbohydrates; Chapter VIII.—Fruit and Fruit Juices; Chapter IX.—Fats; Chapter X.—Proteins; Chapter XI.—Baking Powders; Chapter XII.—Tea, Coffee, Chocolate and Cocoa; Chapter XIII.—Ferments and Preservatives; Chapter XIV.—Disinfectants and Disinfection; Chapter XV.—Cleansing Agents; Chapter XVI.—Volumetric and Gravimetric Analysis; Chapter XVII.—Reagents. Appendix. Useful Tables.

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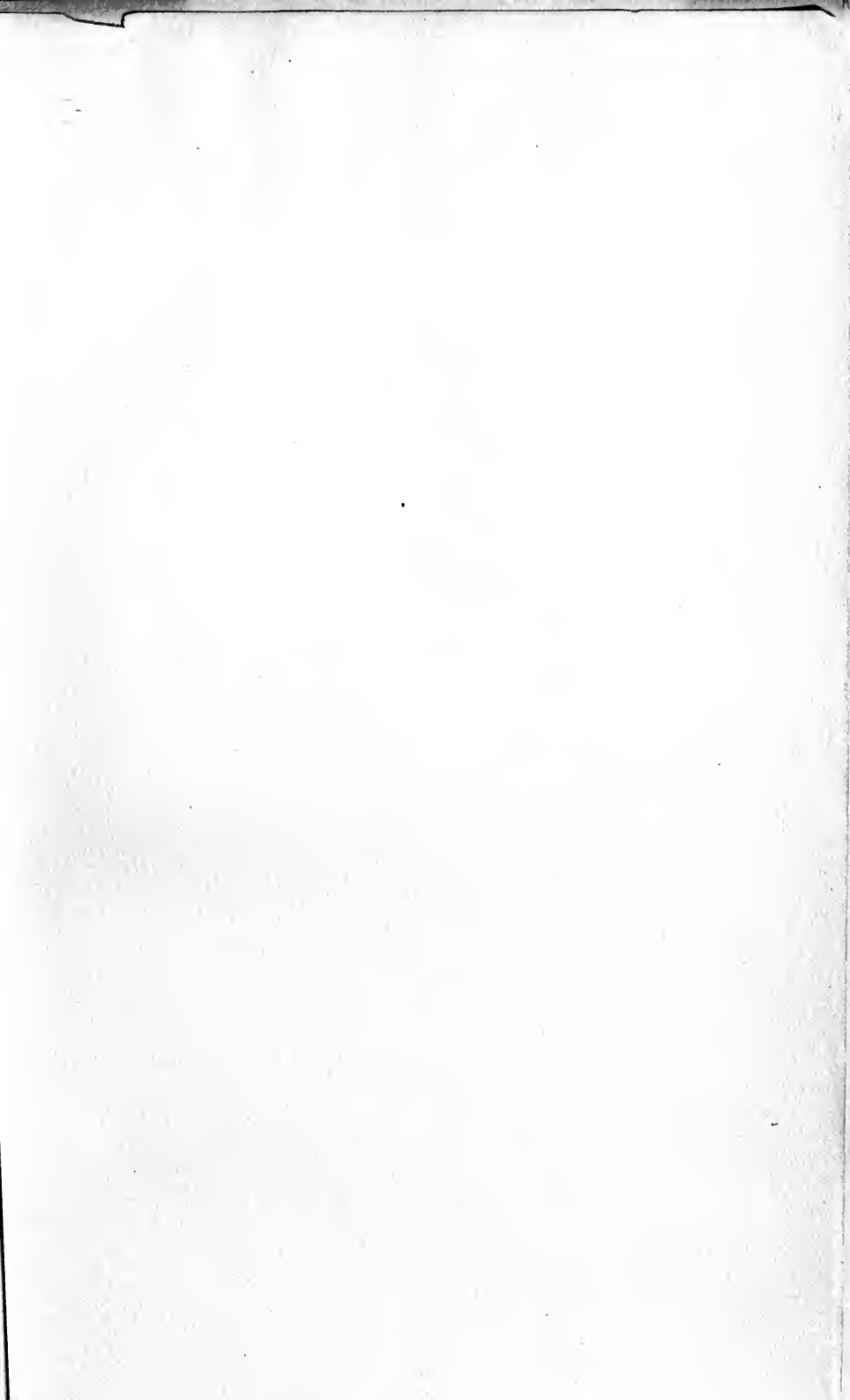
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