Faculty of Science
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Lectures in

Economic Botany

First year (Biology and Geology) students

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Contents

Economic Importance of Plants

Plants are extremely important in the lives of people throughout the world. People depend upon plants to satisfy such basic human needs as food, clothing, shelter, and health care. These needs are growing rapidly because of a growing world population, increasing incomes, and **urbanization** .

Plants provide food directly, of course, and also feed livestock that is then consumed itself. In addition, plants provide the raw materials for many types of pharmaceuticals, as well as tobacco, coffee, alcohol, and other drugs. The fiber industry depends heavily on the products of cotton, and the lumber products industry relies on wood from a wide variety of trees (wood fuel is used primarily in rural areas). Approximately 2.5 billion people in the world still rely on subsistence farming to satisfy their basic needs, while the rest are tied into increasingly complex production and distribution systems to provide food, fiber, fuel, and other plant-derived **commodities** .

The capability of plants to satisfy these growing needs is not a new concern. The Reverend Thomas Malthus (1766-1834) in his *Essay on the Principle of Population* in 1798 argued that population growth would exceed nature's ability to provide subsistence. According to the U.S. Census Bureau, the world population was about one billion in 1800, doubled to two billion in 1930, doubled again to four billion in 1975, and reached six billion people in 2000. World population is expected to be nine billion by the year 2050. The challenge to satisfy human needs and wants still exists.

Sugars

Green plants manufacture sugars so that they all contain some quantity of sugar. However, much of the manufactured product is used directly in plant metabolize that very little usually accumulates. Storage sugars are found in roots, as with beets, carrots, parsnips; in stems as in sugar cane, sorghum, maize and the sugar maple; in flowers, such as in palm trees; in bulbs like the onion; and in many fruits. There are several kinds of sugar, principal among which are sucrose or cane sugar, glucose or grape sugar and fructose or fruit sugar. They all seem to serve as a reserve food supply for the plant.

Humans require sugar in their diet. It constitutes a perfect food, as it is a form that can be readily assimilated in the body. Its main value is as an energy producer, and it is especially well adapted for use after heavy exercise. A large industry has developed in connection with the extraction of sugar from plant tissues, purification and refining. Additionally over 10 thousand different chemical derivatives have been made.

Sugar Cane

Most sugar is derived from Sugar Cane, *Saccharum officinarum.* It is a vigorous and rapid-growing perennial grass reaching a height in cultivation of 8-12 ft. The stem is solid with a tough rind and numerous fibrous strands, and contains about 80 percent juice, the sugar content of which varies considerably from area to area and season to season.

Sugar cane has been the principal export crop of the tropics and is unaffected by many of the conditions that influence the growing of other crops. It will grow well in any moist hot region where the average rainfall is 50 mm or more per year and where there is abundant sunshine and where temperatures do not drop below 70 deg. Fahrenheit. Sometimes small owners of a stand of sugar cane extracted their own sugar in a primitive mill.

- In the milling process the canes are first carried to crushers where they are torn into small pieces.
- They are then passed through three sets of rollers. In the first set 2/3rds of the juice is expressed. They are then sprayed with water to dilute what sugar remains, and are passed through the second set. These rollers exerts a very high pressure and remove nearly all of the moisture. After passing through the last set the residue is almost dry. This bagasse, as it has been named, can be used as a fuel for the mills, as a source of paper or wallboard because of its fibrous nature. It also contains a wax with some commercial value.
- The juice that flows from the mill is a dark-grayish sweet liquid full of impurities. It contains sucrose, and other sugars, together with proteins, gums, acids, coloring materials, soil and pieces of cane. The purification of the sugar involves the separation of the insoluble materials and the precipitation of the soluble nonsugars. The juice is first strained or filtered to remove the solid particles. It is then heated to coagulate the proteins, a process which is aided by the addition of sulfur. Lime is then added to neutralize the acids present, to prevent the conversion of sucrose into lower carbon sugars and

to precipitate some of the substances in solution. These are removed by a series of filter bags or a filter press.

- The juice is now clear and dark colored and ready for concentration. It is boiled down to a syrup of such density that the sugar crystallizes out. This operation is done in open kettles or vacuum pans.
- The resulting sticky mass is known as massecuite. It is placed in hogsheads with perforated bottoms. The juice slowly percolates through the holes leaving the crystals of sugar behind. The juice constitutes the familiar molasses of commerce.

Besides the bagasse, by-products of value are molasses, which is used in cooking and candy making. It is also used in the manufacture of rum and industrial alcohol.

Refining is the final stage of sugar preparation for markets. The process involves washing to remove the film of dirt from around the crystals of crude sugar, dissolving the sugar in hot water, the removal of any mechanical impurities by filtering through cloth, decoloring by passing through bone black, recrystallization by boiling, and the removal of the liquids from the granulated sugar by centrifuging or other means. The granulated sugar is washed, dried, screened, and packed.

Sugar Beets

Sugar beet, *Beta vulgaris*, is another important source of sugar. The leaves are edible as a substitute for spinach and the cooked beet serves as a delicious vegetable. The occurrence of sugar in the tubers was first noted in 1590. The industry formally began

around 1800 in both Germany and France. Sugar beet is a white-rooted biennial that grows best in regions where summer temperatures range around 70 deg. Fahrenheit.

Extraction of the juice is a simpler process than for sugar cane because the roots are soft and pulpy. The roots are cleaned, cut into thin strips and heated in running water in a series of tanks. About 97 percent of the sugar can be extracted in this manner. The waste beet pulp is removed and a process known as carbonation precipitates the insoluble impurities in the raw juice out. For this the raw juice is treated with lime, which coagulates some of the nonsugars, and carbon dioxide, which precipitates calcium carbonate. This settles out along with the impurities and the purified juice is separated out by filtration. The process is repeated several times during which sulfur dioxide is added to adjust the alkalinity. A clear liquid is left after filtration, which is concentrated, crystallized and centrifuged just as with cane sugar. The massecuite is reboiled several times. By-products of the industry include the green tops, which are used for cattle feed and fertilizers; the wet or dried pulp, which is a valuable cattle and sheep feed; the filter cake, which is used as a manure; and the molasses, which is used for stock feeding or for industrial alcohol.

Palm Sugar

Several species of palm provide a fourth source of commercial sugar all of which is only available in the tropics and subtropics. The species utilized are the Wild Date, *Phoenix sylvestris*, the Palmyra Palm, *Borassus flabellifer*, the Coconut, *Cocos nucifera*, the Toddy Palm, *Caryota urens*, and the Gomuti Palm, *Arenya pinnata*. Some of the oil palms also yield sugar.

Sorghum Syrup

The stem of the Sweet Sorghum, *Sorghum vulgare var. saccharatum*, contains a juice that is used in making syrup. To differentiate between a true syrup and a molasses it is necessary to realize that syrup is the product obtained by merely evaporating the original plant juice so that all the sugar is present. On the other hand, molasses is the residue left after a juice has been concentrated to a point where much of the sugar has crystallized out and been removed.

Misc. Sugars

Glucose Sugar

This sugar is also known as dextrose or grape sugar. It is present in small amounts in many of the organs of higher plants and is especially characteristic of fruits. However, commercial glucose is prepared from starch.

Fructose

Also known as levulose, this fruit sugar is present in many fruits together with glucose. It is somewhat sweeter than cane sugar and is valuable because diabetics can consume it. Commercial fructose is prepared from inulin, a polysaccharide that occurs in the tubers of the Dahlia, *Dahlia pinnata*.

Maltose

Maltose is rarely found in a free state in plants, but is easily produced from starch through the activity of the enzyme diastase. Maltose that

is obtained from rice starch has been used in Japan as a flavoring for over 2,000 years.

Honey

Flowers that are attractive, such as roses, hibiscus, etc., usually produce a sweet substance called nectar. This serves to attract various insects that are necessary for pollination of the plant. Nectar is composed mainly of sucrose with some fructose and glucose. It is used as food by bees, and some of it, after partial digestion, is converted into honey and stored for future use. During this process the sucrose is changed to an invert sugar, which is a mixture of fructose and glucose. Honey contains 70-75 percent invert sugar along with proteins, mineral salts and water. Honey was most likely the first sweetening substance used by humans. Beekeeping is one of the very oldest industries. The flavor and quality of honey vary depending on the source of the nectar. Flowers that contain essential oils impart a typical taste. The bees favor certain plants and these are often cultivated near the apiaries. Clover, Alfalfa, buckwheat, lindens and some of the mints and citrus are among the favorites. Honey is an excellent food for it is almost pure sugar. It is also used in medicine, in the tobacco industry and in the manufacture of a fermented beverage called mead.

Starches and Starch Products

One of the most important and widely available vegetable products, starch constitutes the principal type of reserve food for green plants. It is a complex carbohydrate. It is stored in thin-walled cells in the form of grains. There are several types of starch that differ in the size and shape of the grains and other physical and microscopic characteristics. Important sources of starch are the cereal grains and underground tubers, although nuts, legumes and other plant organs may contain substantial amounts.

Sources of Commercial Starch

Relatively few plants are used for the commercial production of starch. The main ones are potato, maize, wheat, rice, cassava, arrowroot and sago.

Cornstarch

Maize or Indian corn is the source of over 80 percent of the starch that is made in the United States. The grains are soaked in warm water with a small amount of sulfurous acid to loosen the intercellular tissue and prevent fermentation. Then the corn is ground so as not to injure the embryos. The ground material is placed in germ separators where the embryos are removed. The starch material is then ground very fine and is either passed through sieves of bolting cloth or is washed in perforated cylinders to remove the bran. The resulting milky liquid is run onto slightly inclined tables where the starch grains settle out and the remaining material flows off. The

starch is later collected and dried in kilns and is then ready for the market.

Potato Starch

Potatoes are utilized for making starch. These are washed and reduced to a pulp in graters or rasping machines. The resulting paste is passed through sieves to remove fibrous matter. After washing the solid starch is separated by sedimentation, the use of inclined tables, or centrifuging, and is then dried. Potato starch finds uses in the textile industry and as a source of glucose, dextrin and industrial alcohol. Europe is the principal producer.

Wheat Starch

The oldest commercial sources of starch were from wheat. It was known to the Greeks and was widely used in Europe in the 16th Century in connection with the linen industry. The gluten in wheat makes the removal of the starch a difficult process. It is accomplished by extraction with water or by the partial fermentation of the grain. Wheat starch is used mostly in the textile industry.

Rice Starch

Rice grains that are broken or imperfect are used for making rice starch. These are softened by treating with caustic soda and are then washed, ground and passed through fine sieves. More alkali is added and after a time the starch settles out as a sediment. This is removed, washed and dried. Occasionally dilute hydrochloric acid is used to free the grains. Rice starch has found use in laundry and for sizing.

Cellulose Products

The most complex of the carbohydrates, cellulose is present in the cell walls of all plants. Because of their strength, cells with thick walls have been used in various industries. Besides the natural product being used in the textile industry, artificial fibers are derived directly from cellulose as well as countless other products. Cellulose chemistry is an important phase of organic chemistry.

Cotton, a very pure form of cellulose, has been used for a very long time in the production of artificial fibers and other cellulose products. Wood is another very available source. When certain woods are treated with concentrated acids or alkalis, the bond between the wood fibers and the lignin, which cements them together, is broken, and the fibers, which are pure cellulose, can be removed. These fibers may then be reorganized as paper, or they may be treated further chemically. If the chemical treatment merely causes the dissolution of the fiber into its component molecules, these molecules may be synthesized into artificial fibers or converted into cellulose plastics. But if the molecules themselves are broken down, their component elements, carbon, hydrogen and oxygen, may be recombined to form wood sugar. Thereafter the wood sugar may be transformed into yeast or alcohol and thus become available for food or as the raw material for numerous industrial products.

Paper and Paper Industry

A very important use of cellulose is in the manufacture of paper, a very old industry. The word “paper” comes from the Latin “papyrus” the name of a sedge, the pith of which was used for paper in 2400 B.C. Egypt. However paper was first made in China.

Raw Materials

The papermaking value of the various fibers depends on the amount, nature, softness and pliability of the cellulose present in the cell walls. This cellulose may occur alone or in combination with lignin or pectin. Wood fibers, cotton and linen are the principal raw materials.

- **Wood Fibers**

Wood began being used in the paper industry from about 1850. Spruce is a very important source of wood pulp and has furnished about 30 percent of the total supply. It is ideal because it has all the requirements of a good pulpwood. The fibers are long and strong with a maximum content of cellulose. The wood is almost free from resins, gums and tannins; and it is light colored, sound and usually free from defects. Red spruce, *Picea rubens*, White spruce, is the main species. The Southern yellow pine, *Pinus australis*, is another important pulpwood.

- **Cotton and Linen**

Cotton fibers have a high felting power and a high cellulose content of about 91 percent. Rags and raw cotton in the form of fuzz or linters are utilized. Flax fibers, that comprise linen, contain 82 percent of pectocellulose and yield a paper of great strength, closeness of texture and durability. Textile waste may also be used.

Legumes

Legumes rank next in importance to cereals as human food sources. They contain more protein than any other vegetable and thus are akin to animal meat in food value. Fats and carbohydrates are also present. The proteins occur as small granules in the same cells with the starch grains. The high protein content is related to the presence on the roots of many legumes tubercles that hold nitrogen-fixing bacteria. These bacteria are able to convert atmospheric nitrogen into nitrates. This augments the nitrogenous material available for the plants.

The legumes belong to the family Leguminosae, which is noted for having a special kind of fruit, a legume, which is a pod that opens along two sutures when the seeds are ripe. Over 11,000 species of legumes are known, and many are of importance as industrial, medicinal or food plants. They have been cultivated and used for food for centuries worldwide. The seeds are of greatest importance. As is the case with other dry seeds, the low water content and impervious seed coats enhance their value for long-term storage and increase their longevity. Because all parts of the plant are rich in protein, legumes are valuable as field and forage crops. When plowed under they are an excellent fertilizer and greatly increase the nitrogenous content of soil.

Peas

Peas are annual, glaucous; tendril bearing, climbing or trailing plants, with white or colored flowers and pendulous pods. Although originating in warm regions they thrive where there is a cool summer

and abundant moisture. In Mediterranean climates they thrive during winter and spring months.

Field Peas

The gray pea of Greece and the Levant is thought to have given rise to Field Peas. They have colored flowers and angular colored seeds and are very hardy, withstanding frost and altitudes up to 8,000 ft. Field peas are grown for seed that is used for human consumption in the form of pea meal or split peas. They are also an excellent grain for livestock. The plants are sued for forage, silage and green manuring.

Garden Peas

Garden peas have white flowers and round smooth or wrinkled seeds that are yellow or white in color. They contain more sugar than field peas and the seeds are eaten green or are used for canning. For canning peas are usually harvested with a mowing machine. Pea-cannery refuse is a valuable livestock feed. In some varieties the pods are fleshy and crisp and are consumed as well as the seeds. Garden peas wee used by Gregor Mendel in his experiments in plant genetics.

Chickpeas الحمص

Chickpeas, *Cicer arietinum*, are native to southern Europe where they are still extensively grown. They are an important food in many parts of Africa, Asia and Central America. The plant is a branching, bushy annual, which mature in 90 days. Chickpeas are the best legumes for human consumption as the seeds are very nutritious. The sparse foliage is poisonous so the plant cannot be used for

forage. The green pods are infrequently consumed and the seeds are used as a substitute for and as an adulterant of coffee.

Cowpeas اللوبيا

Cowpeas, *Vigna sinensis*, are more closely related to beans than to peas. They are vigorous bushy or trailing summer annuals with curious, cylindrical pendant pods. The seeds are used as feed for poultry and cattle, and they may serve as a coffee substitute. The main value is as a forage crop, as a cover crop to prevent erosion and as a green manure.

Beans

Garden Beans الفاصوليا

Garden, Pinto or Kidney beans, *Phaseolus vulgaris*, are indigenous to America. In modern times the young pods (string or snap beans), the unripe seeds (shell beans) and the dried ripe seeds are all used for human consumption. The whole plant is used for forage. Beans are low, erect or twining annuals with small white or colored flowers, trifoliate leaves and slender pods. They are grown as either bush or pole beans and over 1,000 varieties are cultivated.

Soybeans فول الصويا

Soybeans, *Glycine max*, are small, bushy, erect or prostrate annual plants that resemble the cowpea. The seeds all mature at the same time. The soybean is one of the oldest cultivated crops. The seed

is the richest natural vegetable food known. The soybean has ever increasing other uses worldwide. It is an important aid to agriculture, a valuable commercial crop, a good livestock food and the source of numerous raw materials for use in industry. Soybean oil is an important drying oil. Soybean protein is extensively used to produce the foam liquid used for extinguishing oil fires and as the source of a synthetic fiber, similar to casein fibers.

Broad Beans

Broad Bean, *Vicia faba*, is also called the Windsor Bean, Horse Bean or Scotch Bean. It is grown as a forage crop as well as for the seeds that furnish food for both humans and livestock. The plant is a strong erect annual, 2-4 feet tall, with flat pods and large seeds. Over 100 varieties have been grown, mainly in the Old World.

Peanuts الفول السوداني

Peanuts, or Groundnuts, *Arachis hypogaea*, are true legumes rather than nuts because the shuck is merely a shell-like pod. The plant is a bushy or creeping annual with the strange habit of ripening the fruit underground. There are over 20 different kinds of peanuts grown that differ in habit and the size of the pod. The plants may be used for forage, livestock feed or as soil renovators. The nuts or seeds are used for roasting or salting. In candy and for the preparation of peanut butter. For the latter the seed coats and embryo are removed and the nuts are roasted either dry or in oil, and are then ground to a paste. Peanuts are very nutritious. One pound yields 2,700 calories whereas one pound of beef furnishes only 900 calories. Nevertheless, some are allergic to peanuts and must take precautions to avoid

ingesting peanuts or their derivatives. Peanut oil is important food oil. The protein contained in the nuts has been used in the manufacture of Ardil, a synthetic fiber.

Lentils العدس

Lentils, *Lens culinaris*, are some of the most ancient of foods and also one of the most nutritious. The seeds are used principally in soups and in East Indian cuisine mixed with rice and herbs. They are easy to digest, more so than meat. These are produced in colors that vary from gray to tan and red. The plants have been used for fodder. When prepared as split-pea soup, the addition of vinegar and sugar enhances the flavor.

Forage Crops

The need for forage crops arose with the domestication of animals. Initially wild grasses probably were used, but other sources were then sought.

Alfalfa البرسيم

Alfalfa, *Medicago sativa*, native to Southwestern Asia, may have been the first cultivated forage plant. Alfalfa is useful for pasture, hay and silage and for improving the soil. Dehydrated alfalfa or alfalfa mean is also used, and alfalfa sprouts are used for human food.

Nuts

The term “nut” is used loosely to describe a number of related or unrelated plant structures. Officially a nut is a one-celled, one-

seeded dry fruit with a hard pericarp or shell. Some of the so-called nuts of commerce correspond to this description. The following discussion will group nuts regardless of their morphological nature. They will be classified according to their fat, protein and carbohydrate contents.

Nuts with High Fat Content

Cashew Nut الكاجو

The Cashew nut tree, *Anacardium occidentale*, is a handsome native of Brazil that is now extensively cultivated in tropical countries from Mexico to Peru and Brazil, in the West Indies, southern Florida and the Mediterranean area, Mozambique, India, and the East Indies. It bears a thin-skinned, pear-shaped, yellow or reddish, juicy "fruit" known as the Cashew Apple. This is actually the swollen peduncle and disk. The true fruit, a small curved or kidney-shaped structure, is borne on the outside of the "apple" at the distal end. This is the cashew "nut." The rich kernel is delicately flavored and contains nutritious oil. The grayish-brown coat, or shell, contains oil that blisters the skin. The ripe fruit, which as a characteristic aroma, is consumed in many countries or used for preserves. The fermented juice makes a wine, Kaju that is sometimes bottled.

Coconut جوز الهند

This is one of the most important economic plants especially in the South Pacific and other tropical areas. Coconut is a palm, *Cocos nucifera*, probably native to the Malay archipelago, but possibly of Ecuadorian and Central American origin. It grows best near the seashore, but can occur at altitudes of 5,000 ft. It is undoubtedly

one of the most graceful and beautiful of all palms, often with a typical leaning habit. The fruit is a 3-sided dry drupe. It consists of a smooth rind, or exocarp; a reddish-brown fibrous mesocarp; and a hard stony endocarp, or shell that encloses the seed. The white meat and milk represent the endosperm of the seed; the embryo is embedded in the hard endosperm.

The coconut plants have many uses. The leaves are highly incendiary that when burned produce a bed of coals, which imparts a delicious flavor to grilled meats. The fibrous husk yields Coir, a textile fiber. The hard shell, or endocarp, is used for fuel, vessels and other containers, and a fine grade of charcoal. The water of the green coconut makes an agreeable and refreshing drink. The meat may be eaten raw or shredded and dried to form desiccated coconut. However, the main use of the meat is for copra, the source of coconut oil and oil cake. The leaves are also used for thatching, baskets, hats, mats and curtains. The petioles and midribs are used for fence posts, canes, brooms, needles and pins. The trunk furnishes a strong, durable wood for houses and bridges. Some of the porcupine wood of commerce, much used for cabinetwork, is from the coconut. The heart of bud at the apex of the stem is used in salads or is cooked. The bark contains a resin and the roots a drug.

Hazelnut **البندق**

Hazelnuts, Corylus spp., are found in cool temperate regions of both hemispheres. European species, *C. avellana* and *C. maxima*, are the source of Filberts, Cob Nuts and Barcelona Nuts. Filberts are cultivated in Southern Europe and Oregon. Wild filberts have been grown successfully in West-Central Wisconsin, but were eliminated by

Power Companies when considered a threat to the lines, even though the plants never reached more than one meter in height due to freezing temperatures in winter.

Nuts with High Protein Content

Almonds اللوز

Almonds are probably the most popular of the high protein nuts. They are obtained from a medium-sized tree, *Prunus amygdalus* that is related to the peach and closely resembles it in blossoms and young fruit. Almond trees are also cultivated as ornamentals. The almond fruit is an edible drupe, with a tough fibrous rind surrounding the stone or "shell" and the seed or "nut." There are two major types of almonds; Sweet Almonds, *Prunus amygdalus var. dulcis* and Bitter Almonds, *Prunus amygdalus var. amara*

Pistachio Nuts الفستق

Pistachio, *Pistacia vera*, also known as Green Almond, is a small tree indigenous to Western Asia. The fruit is a drupe. The seed contain two large green cotyledons with a reddish covering. These high protein "nuts" are salted in brine while still in the shell. They are highly prized for their color and resinous flavor and are combined with other nuts as mixed nuts and as a flavoring material for ice cream and candy.

Nuts with High Carbohydrate Content

Acorns ثمرة شجرة البلوط

Acorns are the fruits of oak trees, *Quercus spp*. They are true nuts. Acorns have been used in America for fattening livestock,

especially hogs. They are an excellent human food, but are rarely used except by indigenous people.

Chestnuts الكستناء

Chestnuts, *Castanea spp*., are found in the eastern United States, Japan and Europe. It was a handsome tree and furnished valuable timber as well as excellent quality nuts. These served as food, either raw or roasted, for over 200 years.

Essential oils

Essential oils, or volatile oils, are found in many different plants. These oils are different from fatty oils because they evaporate or volatilize on contact with the air and they possess a pleasant taste and strong aromatic odor. They are readily removed from plant tissues without any change in composition. Essential oils are very complex in their chemical nature. The two main groups are the hydrocarbon terpenes and the oxygenated and sulphured oils.

These oils do not have any obvious physiological significance for the plant. They may represent byproducts or metabolism rather than foods. The characteristic flavor and aroma that they impart are probably to some advantage in attracting insects and other animals, which play a role in pollination or in the dispersal of the fruits and seeds. When in high concentration, these same odors may serve to repel enemies of the plants. The oils may also have some antiseptic and bactericidal value.

All the distinctly aromatic plants contain essential oils. They occur in over 60 families and are especially typical of the Lauraceae, Myrtaceae, Umbelliferae, Labiatae and Compositae. The oils are secreted by internal glands or in hair like structures. Almost any organ of a plant may be the source of the oil. Examples are flowers (rose), leaves (mint), fruits (lemon), bark (cinnamon), wood (cedar), root (ginger) or seeds (cardamom).

These oils are extracted from the plant tissues in different ways depending on the quantity and stability of the compound. Three principal methods are: expression, distillation and extraction by solvents.

Perfumes

The most valuable perfumes are combinations of several essential oils. Frangipani, for example, contains sandalwood, sage, neroli, orris root, and musk, while one of the formulas for *Eau de Cologne*, which dates from 1709, calls for neroli, rosemary, lemon and bergamot dissolved in pure alcohol and aged.

Perfumes also contain fixatives, which are substances that are less volatile than the oils and which delay and so equalize evaporation. These may be of plant or animal origin. Musk, ambergris, and civet are frequently used for this purpose. Balsams and oleoresins, such as benzoin, styrax, and oak moss; essential oils with a low rate of evaporation like orris, patchouli, elary sage, and sandalwood; and various synthetic materials are also used.

Perfume Oils

Some of the more important essential oils used in the manufacture of perfumes are as follows:

Otto of Roses

This is valuable oil that is also called Attar of Roses. It has been one of the most favorite perfumes either in combination with other oils or alone.

Geranium

Pelargonium spp. leaves yield an essential oil after distillation. Geranium oil is widely used as an adulterant of or a substitute for Otto of Roses in making perfumes and soap.

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Cassie or Acacia

Flowers of the Sweet acacia, *Acacia farnesiana*, yield an essential oil that is almost as valuable as Otto of Roses. It is a thorny small tree of the West Indies. The oil is removed from the petals by maceration with cocoa butter or coconut oil, or by extraction. It is similar to the odor of violets and is widely used for sachets, powders and pomades.

Neroli زهر البرتقال

This oil, obtained from orange blossoms, is extensively used in blends and for mixing with synthetic perfumes. True oil of Neroli, or Neroli Bigarade, is distilled from flowers of the Bitter orange, *Citrus aurantium*. Neroli Portugal is from the Sweet orange, *Citrus sinensis*.

Bergamot

This is greenish oil that is expressed from the rind of the Bergamot (*Citrus aurantium subsp. bergamia*). It has a soft sweet odor and has been widely used in the United States for adding scent to toilet soaps and in mixed perfumes. Italy and Sicily have been the chief exporters.

Lavender

Lavender perfumes are very old and were used by the Romans in their baths. It is still one of the most important scents. Lavender has a clean odor and the dried flowers are used in sachets and for scenting chests and drawers.

Violet

One of the most popular perfumes is made from violets. Blue and purple double varieties of *Viola odorata*, native to Europe, are grown mainly in the vicinity of Nice. Solvents or maceration with hot fats extracts the oil.

Jasmine

A highly esteemed perfume, Jasmine is cultivated in southern France and surrounding areas. The main source is *Jasminum officinarum* var. *grandiflorum*, which is usually grafted on a less desirable variety. The flowers are picked as soon as they are open and the oil is extracted by enfleurage.

Rosemary

Rosemary, *Rosmarinus officinalis*, is a native of the Mediterranean region. It has long been a favored sweet-scented plant and has been important in the folklore of many countries. It is one of the least expensive and most refreshing odors. The plant is a small evergreen shrub that is cultivated in Europe and the United States. The oil is extracted by distillation of the leaves and fresh flowering tops or by extraction. It is used in Eau de Cologne, toilet soap and medicine. The leaves are valuable as a spice.

Sandalwood

The oil is obtained by distillation from the wood of *Santalum album* and related species. The tree grows wild in India and other parts of Southeastern Asia and is cultivated in many other areas. The oil is used throughout the Orient as a perfume and also in medicine. It is an

excellent fixative and is used in blends. The sweet-scented wood is made into chests and boxes. Demand for sandalwood has been very great, resulting in the eradication of the species in many areas. Several substitutes have been used.

Essential Oils Used in Other Industries

Camphor

Camphor is an important essential that is used in industry. Commercial camphor, called camphor gum, consists of tough, white translucent masses or granules with a penetrating odor and pungent aromatic taste. The oil is obtained by distillation of the wood of the camphor tree, *Cinnamomum camphora*, and native to China, Taiwan and Japan. Only trees 50 years of age or older were used and every stages in the process was carefully regulated. The wood is reduced to chips or ground to a fine powder and the leaves are also ground up. This is then distilled with steam for several hours and the crude camphor crystallizes on the walls of the still. This is removed and must be purified before it is ready for market. Synthetic camphor from pinene, a turpentine derivative, gradually dominated the market.

The principal use of camphor has been in the manufacture of celluloid and various nitrocellulose compounds. It also has a wide range of medicinal uses, both internally and externally. It is also used in perfumery.

Cedarwood Oil

This inexpensive oil is obtained by steam distillation from the heartwood of the Eastern red cedar, *Juniperus virginiana*, and related

species. Wood chips, sawdust, waste from the lead pencil and other industries, old stumps, roots and even fence rails have been utilized. Cedarwood oil is also used in perfumery, soaps, deodorants, liniments, cleaning and polishing preparations and as an adulterant of expensive sandalwood and geranium oils. It has insecticidal properties and is used as a moth repellent and in fly sprays.

Fatty Oils

Fatty oils are fixed oils because they do not evaporate or become volatile. They cannot be distilled without being decomposed. Chemically fatty oils are close to animal fats. They contain glycerin in combination with a fatty acid. They are liquid at room temperature and usually contain oleic acid. However, fats are solid at room temperature and contain palmitic or stearic acid. Fatty oils are insoluble in water but soluble in several organic solvents. Breakdown products of fats are fatty acids and glycerin accompanied by a rancid odor and taste.

Fatty oils occur in many plant families, both tropical and temperate. They are stored, frequently in large amounts, in seeds and somewhat in fruits, tubers, stems and other plant organs. They may also contain proteins. This kind of reserve food material is available as a source of energy for the processes involved in seed germination. Fatty oils are bland and lack the strong taste, odor and antiseptic qualities of essential oils. Thus they are suitable for human food. These edible oils contain both solid and liquid fats and form an important part of the human diet.

Extraction of fatty oils varies. Usually the seed coats have to be removed and then the remainder is reduced to a fine meal. The oils are removed by solvents or by subjecting the meal to hydraulic pressure. The residue is rich in proteins and is valuable as an animal food and fertilizer. Pressure causes the cell walls to break and the fats are released. The extracted oils are filtered and may be further purified. Higher grades are edible and lower grades are used in various industries. Fatty oils may also have medicinal value.

Four classes of plant fatty oils are (1) drying oils, (2) semidrying oils, (3) nondrying oils, and (4) fats or tallows. The drying oils can absorb oxygen and on exposure dry into thin elastic films. These oils are importance in the paint and varnish industries. Semidrying oils absorb oxygen slowly and only in small amounts. They form a soft film only after long exposure to air. Some are edible; others are used as illuminants or in making soap and candles. The nondrying oils remain liquid at room temperature and do not form a film. Such oils are edible and may be used for soap and lubricants. The fats are solid or semisolid at room temperature. They are edible and also useful in the manufacture of soap and candles. Drying and semidrying oils are more common in plants of temperate climates, while nondrying oils and fats predominate in plants of tropical areas.

Drying Oils

Linseed Oil زيت بذرة الكتان

Flax seed, *Linum usitatissimum*, has been the source of one of the most important of the drying oils. The oil content is 32-43 percent. The seeds are collected and stored for several months. Then impurities are removed and the seeds are ground to a fine meal. The oil is usually extracted by pressure with heat or by the use of solvents. Linseed oil varies from yellow to brownish in color and has an acrid taste and smell. It forms a tough elastic film when oxidized. Linseed oil has been used mainly in making paints, varnishes, linoleum, soft soap and printer's ink.

Soybean Oil

Soybean, *Glycine max*, is native to China and has been a most important food plant in Eastern Asia. The oil is extracted from the seeds by expression with hydraulic or expeller presses or by the use of solvents. The oil content of improved varieties now exceeds 22 percent. After refining, soybean oil has been widely used in salads or as cooking oil and for other food purposes. It is also used in the manufacture of soap, candles, varnishes, lacquers, paints, linoleum, greases, rubber substitutes, cleaning compounds disinfectants and insecticides.

Safflower Oil القرطم

Safflower, *Carthamus tinctorius*, is the source as a dye as well as oil from its seeds. It is extensively cultivated in Egypt, India and the Orient and somewhat in North America. It is widely used in Mexico. Uses include manufacture of paints, soap, varnishes, illuminant and edible oil.

Semidrying Oils

Cottonseed Oil

The most important of the semidrying oils, cottonseed oil is used as the standard of comparison. The pure refined oil is of value as a salad and cooking oil and for making margarine and lard substitutes. The residue is the source of various products that have a wide range of industrial uses. Among these are soap, oilcloth, washing powders, artificial leather, roofing tar, insulating materials, putty,

glycerin and nitroglycerin. Cottonseed meal is important as a food for animals and as a fertilizer.

Corn Oil

There is about 50 percent oil located in the embryo of maize kernels. It is used for a wide variety of purposes. Refined oil is for human consumption either directly or in margarines, while the crude oil has industrial uses such as the manufacture of rubber substitutes, paints, soaps. Corn oil has little lubricating value.

Sesame Oil

Also known as gingelly oil, sesame oil is the product of seeds of an annual herb, *Sesamum indicum*. The seeds contain about 50 percent oil that is easily extracted by cold pressure. The finer grades are tasteless and nearly colorless and are used as a substitute for olive oil in cooking and in medicine. Enormous quantities of sesame oil are used in Europe in the manufacture of margarine and other foods. Poorer grades of oil are used for soap, perfumery and rubber substitutes and sometimes as a lubricant. In India the oil is used for anointing the body, as fuel for lamps and as food. Oil cake is a good cattle feed, and sesame seeds are also used in confectionery and baking industries.

Sunflower Oil

Common sunflower seeds, *Helianthus annuus*, contain 32-45 percent of light golden-yellow oil equal to olive oil in its medicinal and food value. It is an excellent salad oil and is used in margarines and lard substitutes. The seeds are a nutritious bird and poultry food, while

the oil cake is excellent for livestock and the whole plant is often grown for silage. The oil has semidrying properties rendering it useful in the varnish, paint and soap industries. Its origins probably lie in South America but it is cultivated worldwide.

Nondrying Oils

Olive Oil

The fruits of the olive, *Olea europaea*, provide olive oil, and it is the most important of the nondrying oils. The tree is a small evergreen cultivated principally in Mediterranean countries. These oils are golden yellow, clear and limpid. They are used chiefly as salad and cooking oils, in canning sardines and in medicine. Inferior grades have a greenish tinge and are used for soap making and as lubricants.

Peanut Oil

Seeds of the common peanut, *Arachis hypogaea*, originally from South America, provide peanut oil. The seeds are shelled, cleaned and crushed, and both hydraulic presses and expellers express the oil. The filtered and refined oil is edible and used as a salad oil, for cooking, for packing sardines, in making margarine and shortenings, and as an adulterant for olive oil. Inferior grades are for soap making, lubricants, and illuminants.

Castor Oil

Seeds of *Ricinus communis* furnish versatile oil. The plant is a coarse erect annual herb that is cultivated in both temperate and

tropical regions. In North America it is a favored ornamental plant but has been grown for its oil. Caution is required in handling the plant which has poisonous qualities. The chief use of castor oil used to be in medicine, where it acts as a purgative. Presently most of the production is utilized in industry in the manufacture of over 25 different products. It is water resistant and thus may be used for coating fabrics and for protective coverings for airplanes, insulation, food containers, firearms, etc. It is an excellent lubricant especially for airplane engines. Castor oil may also be used in making soap, inks and plastics, for preserving leather and as an illuminant.

Vegetable Fats

Coconut Oil

Widely used fatty oil, coconut oil is obtained from the dried white interior of the seed of *Cocos nucifera*. This oil is pail yellow or colorless and is solid below 74 deg. Fahrenheit. It is used in candy industry and for making the highest quality soaps, cosmetics, salves shaving creams, shampoos, suntan lotions, etc. It is used for marine soaps and also as an illuminant.

Palm Oil

This is a white vegetable fat that is solid at room temperature and which is obtained from the seeds of the African oil palm, *Elaeis guineensi*, a tree of Western Africa. Palm oil is used in making soap and in the manufacture of tin plate, terne plate and cold reduced sheet steel. The refined oil is used in margarine and

vegetable shortenings. It has also been used as a fuel for diesel motors in Africa.

Waxes

Waxes usually occur on the epidermis of leaves and fruits where they serve to prevent water loss through transpiration. The impervious waxes are harder than fats and have a higher melting point. They do not become rancid and are less easily hydrolyzed. Chemically waxes are similar to fats, but they are esters of monohydric alcohols rather than glycerides. Very few are of commercial importance.

Jojoba Wax

Jojoba is an evergreen bush, *Simmondsia chinensis*, of semiarid regions on the southwestern United States and northwestern Mexico. it is unique in having seeds with a 50 percent liquid wax content. This wax is suitable for polishes, candles and as a substitute for whale oil. It is also useful as an illuminant and, after processing, for several types of foods.

Fibers & Fiber Plants

Plants yielding fibers have been second only to food plants in their usefulness to humans and their influence on the furthering of civilization. Primitive humans in their attempts to obtain the three most important necessities for life: food, shelter & clothing, focused on plants. Even though animal products were available, some form of clothing was needed that was lighter and cooler than skins and hides. It was easier to obtain from plants such items as bowstrings, nets, snares, etc. Also plant products were available from the leaves, stems and roots of many plants to construct shelter.

Economic Classification (Fibers)

Plastic materials are often used instead of natural products because they cost less and sometimes tend to be more durable. However, natural plant products continue to have some superior attributes and are used when materials are readily available. There are six principal groups of fibers distinguished according to the way in which they are used.

Textile Fibers are the most important in that they are used for fabrics, cordage and netting. To make fabrics and netting flexible fibers are twisted together into thread or yarn and then either spun, knitted, woven or in some other way utilized. Fabrics include cloth for wearing apparel, domestic use, awnings, sails, etc., and also coarser materials such as gunny and burlap. Fabric fibers are all of some commercial value

Brush Fibers are stiff tough fibers including small stems and twigs that are utilized for making brooms and brushes.

Rough Weaving & Plaitling Fibers. Plaits are fibrous, flat and pliable strands that are interlaced to make straw hats, baskets, sandals, chair seats, etc. The most elastic strands are woven together for mattings and the thatched roofs of houses. The supple twigs or woody fibers are for making chairs, baskets and other wickerwork.

Filling Fibers are used for stuffing mattresses, cushions and in upholstery; for caulking seams in boats and in casks and barrels; as stiffening in plaster and as packing material.

Natural Fabrics are usually obtained from tree basts that are extracted from bark in layers or sheets and pounded into rough substitutes for lace or cloth.

Fibers for Paper Manufacture includes textile fibers and wood fibers that are used in either the raw or manufactured state.

A plant cannot be restricted absolutely to any single group because the same fiber may be used for different purposes. Also, a plant may yield more than one kind of fiber. Thus the following discussion includes species that are considered in the group in which they are of the greatest importance.

Structure & Occurrence (Fibers)

All fibers are similar in that they are sclerenchyma cells that serve as part of the plant skeleton. They are predominantly long cells with thick walls and small cavities and usually pointed ends. The walls

often contain lignin as well as cellulose. Fibers occur singly or in small groups, but they are more apt to form sheets of tissue with the individual cells overlapping and interlocking.

Fibers may occur in almost any part of a plant: stems, leaves, fruits, seeds, etc. The four main types grouped according to their origin include bast fibers, wood fibers, sclerenchyma cells associated with the vascular bundle strands in leaves, and surface fibers that are hair like outgrowths on the seeds of the plants.

Fibers of economic importance occur in many different plant families, especially those from the tropics. Some of the more important families are the Palmaceae, Gramineae, Liliaceae, Musaceae, Amaryllidaceae, Malvaceae, Urticaceae, Linaceae, Moraceae, Tiliaceae, Bromeliaceae, Bombacaceae, and Luguminosae.

Textile Fibers

These fibers must be long and possess a high tensile strength and cohesiveness with pliability. They must have a fine, uniform, lustrous staple and must be durable and abundantly available. Only a small number of the different kinds of fibers possess these traits and are thus of commercial importance. The principal textile fibers are grouped into three classes: surface fibers, soft fibers and hard fibers, with the last two often referred to as long fibers.

Surface or short fibers include the so-called cottons. The soft fibers are the bast fibers that are found mainly in the pericycle or secondary phloem of dicotyledon stems. Bast fibers are capable of subdivision into very fine flexible strands and are used for the best grades of cordage and fabrics. Included are hemp, jute, flax and ramie.

Hard or mixed fibers are structural elements found mainly in the leaves of many tropical monocots, although they may be found in fruits and stems. They are used for the more coarse textiles. Sisal, abacá, henequén, agaves, coconut and pineapple are examples of plants with hard fibers.

Surface Fibers

Cotton

Cotton (*Gossypium spp.*) is one of the greatest of all industrial crops. It is the principal fiber plant as well as one of the oldest and most economical. It was known since ancient times and well before written records.

Kinds of Cotton

Hundreds of varieties have been developed from wild ancestors or produced by breeding during the long period of cultivation. Varieties differ in fiber character as well as other morphological features.

Gossypium barbadense probably originated in tropical South America. The flowers are bright yellow with purple spots. The fruit, or boll, has three valves, and the seeds are fuzzy only at the ends.

Egyptian Cotton This cotton is grown in the Nile basin of Egypt where it was introduced from Central America. The plant is similar in appearance to sea-island cotton and is believed to be a hybrid. However, the staple is brown in color and shorter. Its length, strength, and firmness make this cotton suitable for thread, undergarments, hosiery, and fine dress goods.

Cotton Uses

Cotton is used either by itself or in combination with other fibers in the manufacture of all types of textiles. Unspun cotton is extensively used for stuffing purposes. Treating the fibers with caustic soda, which imparts a high luster and silky appearance, makes Mercerized Cotton. Absorbent Cotton consists of fibers that have been cleaned and from which the oily covering layer has been removed. It is almost pure cellulose and makes up one of the basic raw materials of various cellulose industries.

Soft or Bast Fibers

Flax الكتان

Once the most valuable and useful of fibers, flax gradually became less important as synthetics and cotton assumed more prominent roles. Flax is more durable than cotton and can yield a very fine fabric. Flax is in the genus *Linum* that contains several wild species of no economic importance as well as *Linum usitatissimum*, the source of the commercial fiber. The plant is an annual herb with blue or white flowers and small leaves. It grows to a height of from 1-4 ft. The fibers are formed in the pericycle and are made up of very tough, stringy strands from 1-3 ft. long that are aggregates of many long pointed cells with very thick cellulose walls. Preparation of the fibers is a more expensive procedure than for cotton. The crop is harvested and a process known as rippling breaks the stems. The fibers may then be rotted out by submerging the stems in water or by

exposing them to dew. During this process called retting and enzyme dissolves the calcium pectate of the middle lamella, which holds the cells together, and frees the fibers. After retting the straw is dried and cleaned and the fibers are completely separated from the other tissues of the stem by an operation known as scutching. Finally the shorter fibers that constitute the tow are separated from the longer fibers. The long fibers are the only ones suited for spinning.

The fibers of flax have great tensile strength, staple length, durability and fineness. They are used in the manufacture of linen cloth and thread, canvas, duck, strong twine, carpets, fish and seine lines, cigarette paper, writing paper and insulating materials. Fibers from the stalks of flax grown for seed are too harsh and brittle for spinning but may be used for other purposes.

Hemp

The term “hemp” is applied loosely to include a number of very different plants and fibers. The true hemp is *Cannabis sativa*, a plant native to Central and Western Asia but has spread worldwide where it often occurs as a troublesome weed. Hemp has been used to make ropes, carpets, twine, and sailcloth, yacht cordage, binder twine, sacks, bags and webbing. The waste and woody fibers of the stem were sometimes used to make paper.

Jute

Jute has been used almost extensively as cotton even though it is much less valuable than either cotton of flax. It is a bast fiber obtained from the secondary phloem of two species of *Corchorus* of

Asia. The best quality is from *C. capsularis*, a species with round pods that is grown in lowland areas subject to flooding. The plant is a tall, slender, somewhat shrubby annual with yellow flowers that grows to a height of 8-10 ft. It requires a warm climate and a rich, loamy alluvial soil. Fiber from *C. olitorius*, and upland species with long pods, is somewhat inferior but the two are not separated in commerce.

Jute has been used mainly for rough weaving into burlap bags, gunnysacks and covers for cotton bales. The fiber is also used for twine, carpets, curtains and coarse cloth. Short fibers and pieces from the lower ends of the stalks make up jute butts that have been used in paper manufacture. India has the largest acreage of jute.

Agave Fibers

By the middle of the 20th Century agave fibers were next to cotton in importance in America. These plants are stemless perennials with basal rosettes of erect fleshy leaves. The leaves contain fibers that are removed either by hand or machine. There are numerous species of local occurrence. They are very drought tolerant and flourish in dry sterile soils.

Wickerwork اعمال الخوص

This includes chair seats, chairs, infant carriages, hampers and other light articles of furniture. Willows, rattan and bamboo are the main plants used.

Rattan is obtained from several species of climbing palms, *Calamus spp*., that grow in the humid forests of the East Indies and other parts of tropical Asia. The stems of these plants are long, strong, flexible and uniform. They are used either entirely or as splits in Asia for furniture, canes, baskets and other items. A considerable quantity of rattan is exported for making furniture.

Bamboos occur in most tropical areas, but they are especially abundant in the monsoon regions of Eastern Asia. They are the largest of the grasses with woody stems that sometimes reach one foot in diameter and a height of over 10 feet. The stems are used for all kinds of construction in areas where these plants grow. Exported bamboo is used in the manufacture of furniture, fishing rods and implements of various kinds. Bamboo splits are made into baskets and brushes.

Wood & Cork

Forest products have been of service to humans from the very beginnings of our history (Hill 1952). The most familiar, and the most important, of these products is wood. Wood is used in all types of construction, as a fuel and as a raw material of the paper and rayon industries. Other products include rubber, cork, many of our tanning materials and dyes, resins gums, oils, drugs and even sugar, starch and some chemicals. Additionally, the seeds and fruits of many trees may serve as food for humans or their livestock.

In addition to being of value to humans, forests themselves have many utilitarian features. They help to regulate climate and temperature. They aid in the conservation of the water supply and in flood control by preventing water runoff. Their roots hold the soil firmly in place and control erosion. They may also act as shelter area against drying winds. They afford a range for livestock, a shelter for wild life and offer many recreational aspects for humans, the importance of which cannot be underestimated.

This section is limited in discussion to wood and cork following the format of Hill (1952). Other useful materials from trees are considered in other sections together with similar economic products from other sources.

WOOD STRUCTURE

Wood is a plant secondary tissue that is formed mainly in the stems of gymnosperms and dicotyledons through the activity of a growing layer, the Cambium. The cambium is responsible for the growth of stems in thickness through the formation annually of new layers of both wood and bark.

Composition of Wood

Wood is a heterogeneous tissue made up of several different kinds of cells, some that have the function of mechanical support and others that of conduction. In softwoods, or gymnosperms, both these functions usually occur in cells called Tracheids. In hardwoods, or angiosperms, a division of labor usually exists. Mechanical support is provided by the several types of wood fibers that make up a greater part of the woody tissue, while the conduction of water is by tubular cell fusions called Vessels. Tracheids are also occasionally present. Wood also functions in the distribution and storage of carbohydrate that is accomplished in the Parenchyma Cells. These are the only parts of the wood that is truly living and which contains protoplasm. Parenchyma cells occur in two forms, (1) wood parenchyma and (2) ray parenchyma. The former are arranged vertically in the stem while the latter are horizontal.

Early & Late Wood

In temperate climates new wood is formed annually during a limited growing season and definite growth layers result. These usually have two distinct areas within each layer. In springtime when growth resumes, the first wood to be formed contains many large and thin-walled cells as a response to the greater need for conducting nutrients. This is the early wood or spring wood. As the season progresses a more dense kind of wood is laid down that has smaller, thicker walled cells, the late wood or summer wood. This produces a sharp transition between the cells formed at the end of a growing season and those formed at the beginning of the succeeding one. In

cross section this appears as concentric rings called Growth Rings. The growth ring of one year is called an annual ring and the number of these indicated the tree's age. In the tropics where growth may continue throughout the year growth zones may occur also, but they are due to changes in weather or other causes rather than to definite growth periods.

Sapwood & Heartwood

When young all wood cells are physiologically active. But in time many of them lose their activity and become skeletons that serve only to provide strength to the tree. Eventually two distinct areas develop: (1) a light colored outer region of varying width, the sapwood, and (2) a darker inner region the heartwood. Only parenchyma cells in the sapwood remain physiologically active. The older cells of the heartwood that have died often attain a color and are very resistant to decay because of the deposition in them of gums, resins or other waste substances. This heartwood can be polished to a high luster and is valuable in making furniture, cabinets and other woodworking aspects. Although heartwood is generally distinct from sapwood in durability, appearance, etc., it may not always be very clearly differentiated.

FOREST PRODUCTS AS FUEL

Fuel is an indispensable necessity of life both in home and industry. Any material that burns readily in air can be utilized, but this includes a great variety of plant products. The most important of these are wood, peat and coal, which represent different stages in the carbonization of the original plant tissue.

Wood

Farms and rural communities have accounted for about 90 percent of the total amount of wood used for fuel. Wood makes an excellent fuel because it is about 99 percent combustible when dry and so leaves only a small amount of ash. It is also flaming fuel and well adapted for heating large surfaces. The value of different kinds of wood for heating purposes depends on the amount of moisture present.

Coal

Coal comprises the fossilized remains of plants that lived in former geological periods (Hill 1952). The original plant tissue has been more fully decomposed and converted into carbon. Coal is much harder and more compact than peat or lignite, and has a greater heating power. It also yields a larger amount of smoke and ash. Coal is a comparatively inexpensive source of power and heat and also of many useful chemical products.

Petroleum

It has been generally believed that petroleum had an organic origin and was formed under pressure from the minute floating plant and animal life of former shallow seas. Crude petroleum has many uses, but the substances derived from it by fractional distillation are of much greater importance. Among these products are gasoline, kerosene, plastics, petroleum jelly, medicines and paraffin.

CORK

Cork or corkwood consists of the outer bark of the tree, which can be harvested without injury to the tree. It is renewed annually. The rich dark-red color of the exposed areas is one of the typical sights in a cork forest that is being used for commercial purposes. It is obtained commercially mainly from the Cork oak, *Quercus suber*, a tree native to the Mediterranean region.

Uses of Cork

A great variety of products are manufactured from cork. Articles that have been made from natural cork include bottle stoppers, hats and helmets for use in tropical areas, tips for cigarettes, carburetor floats, handles for golf clubs, penholders, fishing rods, mooring buoys, floats, life preservers, life jackets, surf balls, baseball centers, decoys, mats, tiles, etc.

Tannins

Tannins are complex chemical substances derived from phenolic acids (sometimes called tannic acid). They are classified as phenolic compounds, which are found in many species of plants, from all climates and all parts of the globe. They are large molecules that bind readily with proteins, cellulose, starches, and minerals. These resulting substances are insoluble and resistant to decomposition.

Tannins occur in many species of coniferous trees as well as a number of flowering plant families. These tannins can leach out of the plants. The water in the soil becomes rich with tannins and seeps into the ground water or drains into lakes and streams. These waters become brown in color and look like tea.

The word tannin comes from the old German word *tanna* meaning oak. It refers to the use of wood tannins derived from oak trees that were used to convert animal hides into leather. Other cultures from antiquity obtained tannins from willows (*Salix* spp.), quebracho (*Scinopsis balansae*), sumac *(Rhus* spp.), maples (*Acer* spp.), wattle (*Acacia* spp.), eucalyptus (*Eucalyptus* spp.), and red mangrove (*Rhizophora* spp.).

Different colors, textures, and durability of leathers were achieved by using different formulations of plant tannins referred to as “tanning liqueurs”.

In addition to tanning leather, tannins are used in photography, as mordants in dyeing, clarifying wine and beer by precipitating proteins out of them, and as astringents in medicine.

Tannins are found commonly in the bark of trees, wood, leaves, buds, stems, fruits, seeds, roots, and plant galls. In all of these plant structures, tannins help to protect the individual plant species. Tannins that become stored in the bark of trees protect the tree from being infected by bacteria or fungi. In this case, the tannins precipitate out the enzymes and other protein exudates from bacteria and fungi thus not allowing these organisms to infect the tree. Many bud scales on woody plants contain tannins to protect the inner leaf tissue from being consumed and in many seed plants the initial set of leaves from a germinating seed are also high in tannins.

Unripened fruits are high in tannin content. The high tannin content discourages fruit eating animals from consuming the fruit until the seeds are mature and ready for dispersal. As the fruit ripens the tannin content lessens.

Beside fruits, tannins are also contained in coffee, tea, red wine and beer. The initial astringent taste when you sip a red wine actually comes from tannins in the wood of the oak barrels in which the wine was aged.

Tannins are also responsible for many of the enchanting colors seen in flowers and the final beauty of autumn leaves.

Medicinal Plants

Plants have been used from ancient times to attempt cures for diseases and to relive physical suffering. Ancient peoples all had acquired some knowledge of medicinal plants. Drug plants were always of especial interest. As early as 5,000 B.C. many drugs were in use in China.

Drug Plants

That branch of medical science dealing with the drug plants themselves is known as Pharmacognosy. It is concerned with the history, commerce, collection, selection, identification and preservation of crude drugs and raw materials. The action of drugs is Pharmacology. Worldwide there are several thousand plants that have been and are still being used for medical purposes.

A plant's medicinal value is due to the presence in its tissues of some chemical substance or substances that produce a physiological action on the body. Most important are the alkaloids, compounds of carbon, hydrogen, oxygen and nitrogen. Glucosides, essential oils, fatty oils, resins, mucilages, tannins and gums are all utilized.

Drug Classification

Many methods have been proposed to classify drugs and drug plants. Classifications can be based on the chemical nature or the therapeutic value of the plant product, the natural affinities of the various species or the morphology of the plant organ from which the drug is obtained.

Drugs from Plant Roots

Aconite

This is obtained from the tuberous roots of the monkshood, *Aconitum napellus*. Although poisonous, its use in medicine is comparatively recent. It is used externally for neuralgia and arthritis, and internally to relieve fever and pain.

Colchicum

Dried corms of the meadow saffron, *Colchicum autumnale*, are the source of colchicum. It is a perennial tulip like herb of Europe and Northern Africa. It possesses an alkaloid, colchicine, which is used in the treatment of arthritis and gout. Colchicine has the ability to double the chromosomes in genetics studies.

Gentian (Bitterroot)

Gentiana lutea is a tall perennial herb with striking orange-yellow flowers. The rhizomes and roots are dug out in the fall, sliced and dried. They contain several glucosides that are valuable as a tonic for they can be used with iron salts.

Ginseng

Ginseng has been used in China since ancient times, where it is used to cure an array of diseases. In America ginseng is used as a stimulant and stomachic.

Ipecac

Several species are the source of this well-known drug, but the main source consists of the dried rhizome and roots of *Cephaelis ipecacuanha*. The main ingredient is Emetin, a white, bitter, colorless alkaloid. Ipecac is used as a diaphoretic emetic and expectorant. It is valuable in the treatment of amoebic dysentery and pyorrhea.

Jalap

This is a resinous drug obtained from the tubers of *Exogonium purya*, a twining, morning glory-like vine of the woodlands of eastern Mexico. The roots are collected and dried over fires. Jalap is used as a purgative.

Licorice عرق سوس

This is a product that is known from ancient times. The roots are dried in sheds for several months and are shipped in cylindrical pieces. Licorice is used in medicine as a demulcent and expectorant and to disguise the flavor of medicinal preparations. However, most of the supply is used as a flavoring material in the tobacco and candy industries and in the manufacture of shore polish. There are also many other industrial uses for licorice. It has a compound, glycyrrhizin, that is 50-times sweeter than sugar.

Drugs from the Bark of Plants

Cascara

Cascara is obtained from the reddish-brown bark of the western buckthorn, *Rhammus purshiana*, a tree of the northwestern United States and southwestern Canada. The bark is peeled in long strips

during the summer and dried on racks. It is stored for a year before being used as a tonic and laxative.

Curare

Curare can cause progressive paralysis and eventual cardiac failure. These lethal effects are due to several alkaloids. One of these, curarine, has now been available to medicine for use in shock therapy, and as an ideal muscle relaxant. Curarine is also used for chronic spastic conditions, in surgical operations and tetanus and as a powerful sedative.

Quinine

One of the most important of all drugs, quinine has been a boon to mankind because it is the only adequate cure for malaria. Although some synthetic products are available, they only complement quinine and are not substitutes for it. Quinine is obtained from the hard thick bark of several species of the genus *Cinchona*, evergreeen trees of the Andes of South America.

Drugs from Stems & Woods

Ephedrine

This is an alkaloid from the Asiatic *Ephedra sinica*. *E. equisetina* and other species of the same genus. These shrubs are low growing, dioecious, leafless with slender green stems. The drug is extracted from the entire woody plant. In modern times it has been used in the treatment of colds, asthma, hay fever and other medical purposes.

Guiacum

This is a hard resin that exudes naturally from the stems of the lignum vitae trees, *Guaiacum offininale* and *G. sanctum*. It hardens into round, glassy greenish-brown tears. It is acquired from incisions, from the cut ends of logs or from pieces of the wood. Gum guaiac is used as a stimulant and laxative. It is also a good indicator of oxygen in the air. Lignum vitae, or Ironwood, trees are evergreens native to the West Indies and other Neotropical regions.

Drugs from Plant Leaves

Aloe

Aloes are obtained from several different sources. Curacao or Barbados aloes are from *Aloe barbadensis* of the West Indies, Socotrine aloes from *Aloe perryi* of East Africa and Cape aloes from *A. ferox* of South Africa. These are tropical and subtropical fleshy plants with showy flowers. The leaves contain a resinous juice with several glucosides. Aloes have been used as purgatives and as additions to skin salves. They seem to aid in the healing process of wounds.

Belladonna

Atropa belladonna is the source of this old and important drug. The dried leaves and tops and to some degree the roots contain the drug. They contain several alkaloids among which hyoscyamine and atropine are most important. Belladonna is used externally to relieve pain and internally to curb excessive perspiration and coughs. Atropine is used to dilate the pupil of the eye and as an antidote for organophosphorus insecticide poisoning.

Cocaine

Leaves of the coca shrub, *Erythroxylon coca*, and related species contain cocaine. About 100 pounds of leaves yields one pound of the drug. Cocaine has been used as a local anesthetic and as a tonic for digestion and treatment of nervous conditions. It is addictive when used habitually. Some evidence suggests that cocaine was used in Ancient Egypt

Digitalis

Foxglove, *Digitalis purpurea* is native in Southern and Central Europe and has been used to treat disorders of the heart. The dried leaves are dried for use. It contains a glucoside, digitoxin. Its action improves the tone and rhythm of the heart beats thereby making contractions more powerful and complete. As a result more blood is sent from the heart, which aids circulation and improves body nutrition and hastens waste elimination.

Eucalyptus

The mature leaves of the blue gum, *Eucalyptus globulus*, contain an essential oil that is used in medicine. Their extensive root system may play a role in drying-out mosquito breeding habitats. Eucalyptus oil is obtained from the dried leaves. It is used in the treatment of throat and nose disorders, malaria and other fevers. The colorless oil is yellow with a unique pungent odor.

Henbane

Henbane, *Hyoscyamus niger*, is a coarse smelly herb native to Europe and Asia. It has assumed weed status in other parts of the world. The leaves and flower tops contain several poisonous alkaloids: hyoscyamine and scopolamine. Henbane is used as a sedative and hypnotic. It acts in a similar manner to belladonna and stramonium, but is less powerful.

Lobelia

The Indian tobacco, *Lobelia inflata*, is the source of this drug that is secured from the dried leaves and tops of wild or cultivated plants. An alkaloid in lobelia is used as an expectorant, antispasmodic and emetic. Amerindians knew its properties. Some evidence suggests that tobacco was used in Ancient Egypt.

Senna

Senna is an ancient drug that is obtained from dried leaflets and pods of several species of *Cassia* that are indigenous to arid regions in Egypt and Arabia. Alexandrian senna is from *Cassia acutifolia* and East Indian or *Tinnavelly senna* is from *C. angustifolia*. Both species are cultivated in India. Leaves are picked, dried in the sun and baled. Senna is used as a purgative.

Stramonium

Thorn apple or Jimson weed, *Datura stramonium*, is the source of stramonium. The plant is highly poisonous and occurs worldwide although its origin was thought to be in Asia. However, Amerindians knew of its narcotic properties. The drug is extracted from the dried

leaves and flowering tops. The active principles are alkaloids that include hyoscyamine, atropine and scopolamine. The drug has been used as a substitute for belladonna for relaxing the bronchial muscles in asthma treatment. It has also been used in Asia for its narcotic effects.

Wormwood

A perennial plant of Northern Asia, Northern Africa and Europe, wormwood, *Artemisia absinthium*, is the source of an essential oil obtained by steam distillation from dried leaves and tops of the plant. The greenish liquid has been used in liniments. Over dosage can result in deleterious consequences. Its principal use is to flavor the liqueur absinthe, the use of which is prohibited in some countries. Absinthe contains other aromatics as well as wormwood. The plant has been grown in Oregon and Michigan.

Drugs from Flowers

Chamomile

Chamomile, *Matricaria chamomilla*, is a Eurasian daisy like plant that has become cultivated in many places. The dried flower heads contain an essential oil infusions of which are used as tonics and gastric stimulants. The flower heads of the Russian or garden chamomile, *Anthemis nobilis*, are used for similar purposes but also in poultices for bruises, sprains and arthritis.

Santonin

The Levant wormseed, *Artemisia cina*, contains a valuable drug known as santonin derived from the dried unopened flower heads. This is a small semi shrubby perennial of Western Asia. Most of the supply has come from Turkestan, although the species has been grown in the Northwestern United States. This drug is a good remedy for intestinal worms and has been used for this purpose for centuries.

Drugs from Fruits & Seeds

Colocynth

The bitter apple, *Citrullus colocynthis*, has a spongy pulp that when dried is the source of the glucosidal drug colocynth. The plant is native to warm parts of Africa and Asia, but has been distributed worldwide and cultivated in the Mediterranean area. The fruits resemble oranges, and the rind is removed while the white bitter pulp is dried and shipped in balls. It is a powerful purgative.

Opium

One of the most useful and yet vicious drugs, opium is derived from the dried juice or latex of unripe capsules of the opium poppy, *Papaver somniferum*. The poppy is an annual with showy white flowers. Following petal fall the capsules are incised with a knife and the white latex exudes and soon hardens in the air. It is scraped off and shaped into balls or cakes, which are often wrapped in the poppy petals. Crude opium is a brownish material containing as many as 25 alkaloids, the most important and most powerful being morphine and codeine. Due to the narcotic and sedative action opium and its derivatives are used to relieve pain, relax spasms and induce sleep.

Wormseed

American wormseed, *Chenopodium ambrosioides* is native to South and Central America. It has also been cultivated in many areas for its natural oil. The oil is obtained by distillation from the fruits and is used in the treatment of hookworm infections.

Drugs from Lower Plants

Antibiotics

These are substances produced mainly by certain harmless microorganisms that deter the growth and activity of various pathogenic bacteria. Molds, actinomycetes and bacteria are the chief sources, although antibiotics are also present in higher plants.

Penicillin

Best known of the antibiotics is penicillin. It was accidentally discovered in 1929 and reexamined in 1937. Soon it was recognized as an extremely valuable substance for combating staphylococcus, streptococcus and gas gangrene infections. It is acquired mainly from *Penicillium notatum*. In gelatin substrate the mycelium excretes penicillin turning all to liquid. The crude penicillin is recovered, purified and dehydrated. It is an organic acid and readily forms salts and esters. Other species of *Penicillium*, particularly *P. chrysogonum*, also produce the antibiotic. Penicillin is highly selective in its action and is effective against gram-positive bacteria. It is nontoxic and particularly useful in the treatment of bacterial endocarditis, gonorrhea, mastoiditis, local infections and certain types of pneumonia.

Streptomycin

Streptomyces griseus furnishes this antibiotic. Streptomycin is especially effective against gram-negative bacteria and is used in the treatment of tularemia, empyema, urinary and local infections and some forms of tuberculosis, peritonitis, meningitis and pneumonia.

Aureomycin

Streptomyces aureofaciens, which was isolated in 1948 from soil, produces aureomycin. It is more versatile than penicillin or streptomycin by attacking not only gram-positive and gram-negative bacteria, but also the Rickettsiae, which had previously been immune to chemical assault. It has been used to combat forms of virus pneumonia, osteomyelitis, undulant fever, whooping cough and eye infections and where the patient has developed resistance to the other antibiotics or to sulfa drugs.

Chloromycetin

This is a pure crystalline substance produced by *Streptomyces venezuelae*. Chloromycetin, like aureomycin, is effective against the Rickettsiae. It is useful in the treatment of undulant fever, bacillary urinary infections, primary atypical pneumonia, typhus fever, typhoid fever, scrub typhus, Rocky Mountain spotted fever and parrot fever.

Terramycin

Terramycin is secreted by *Streptomyces rimosus*. It is valuable in treating common forms of pneumonia, typhoid fever, streptococci and many intestinal and urinary tract infections. It is also effective

against gram-positive and gram-negative bacteria, Rickettsiae and large viruses. It is somewhat different in therapeutic action from the other antibiotics.

Neomycin

This antibiotic that is produced by an organism resembling *Streptomyces fradiae*, has been used to treat tuberculosis.

Other Medicinal Substances

Agar

This is almost pure mucilage secured from various species of red algae. Japan used to be the principal producer of this product in the eastern coast of Asia. The principal species used were *Gelidium cartilagineum* on the Pacific Coast and *Gracilaria confervoides* on the Atlantic Coast. The algae are collected, bleached and dried, and the mucilaginous material is extracted with water. Agar reaches the marked in flakes, granules or strips that are brittle when dry but become tough and resistant when moist.

The medicinal value of agar is in its absorptive and lubricating action. It is frequently used in a granular condition to prevent constipation. However, its greatest use is as a culture medium for bacteria and other fungi. In dentistry is has been valuable for making impressions for plates and molds. Cosmetic, silk and paper industries have found it valuable and is may also be used extensively as food.

Ergot

This is the dried fruiting body of a fungus, *Claviceps purpurea*, which is parasitic on rye and other grasses. Wheat ergot is equally good as a drug. Ergot is used mainly to increase the blood pressure, especially in cases of hemorrhages following childbirth and other uterine disturbances.

Kelp الاعشاب البحرية

In Europe, the United States and Japan; several of the larger brown algae have been used as a source of iodine, potash and other salts. Kelp was also used as a source of acetone and kelp char, a bleaching carbon. There has also been attention given to the medicinal value of these seaweeds. Other species, mainly *Laminaria digitata* have been exploited as a source of algin, a valuable colloid extensively used in the drug, food and other industries. Algin or its salts, sodium alginate, is used as a suspending agent in compounding drugs; in lotions, emulsions and hand pomades; as a sizing for paper and textiles and in ice cream.

Lycopodium

Lycopodium clavatum and other club mosses contain about 50 percent fixed oils and so are but little affected by water. They are used as a covering for pills, as a diluent for insufflations and as a dusting powder for abraded surfaces.

Beverage Plants and Beverages

There has always been a search for beverages that are palatable and refreshing. Thousands of plant species have been utilized throughout history, but very few of these have ever become of commercial importance. They are divided into nonalcoholic and alcoholic beverages.

Nonalcoholic Beverages With Caffeine

Beverages with caffeine content are used worldwide for their stimulating and refreshing qualities. Each ancient center of civilization had its own beverage plants. Coffee that originated in regions adjacent to Southwestern Asia is now used by over half the world's population. Tea that is associated with Southeastern Asia is used by over half the world population. Cocoa is a product of tropical America and which today serves as booth food and drink for many worldwide. There are other less known beverages that are equally important. These include maté, a principal drink in South America; khat, used in Arab countries; guarana, another South American drink that has higher caffeine content than any other beverages.

Caffeine is an alkaloid with definite medicinal values. It acts as a diuretic and nerve stimulant. It is harmful in large quantities so it is present only in very small amounts, rarely over two percent, in beverages. Especially children should avoid excessive quantities of such beverages.

Coffee

Coffee is one of the most important beverage plants from a commercial viewpoint despite the fact that tea is in wider usage. The coffee plant is believed to be native to Abyssinia. It was brought to Arabia in about the 16th Century and that area produced most of the crop for 200 years. Coffee gradually was introduced elsewhere in the world tropics.

Coffee Cultivation and Preparation

Coffee can be grown in the tropics from sea level to an altitude of 6,000 ft. and thrives best at the higher elevations with 4,500 ft being optimum. Under cultivation the plants are grown directly from seed, or seedlings are transplanted at 6-foot intervals. The plants begin to bear in their third year with the best yield obtained from the fifth year until about 30 years.

The coffee berries are generally picked individually by hand when fully ripe, although in Arabia and parts of Brazil they are stripped off or allowed to fall to the ground. After picking and sifting or winnowing to remove the debris, coffee is prepared for the market by either the dry or the wet procedure. In the former the berries are spread out on drying floors and exposed to the sun with precautions taken to protect them from the rain. In the wet method the berries are run through a pulping machine that removes the skin and part of the pulp. They are finally dried by the sun or artificial heat.

After drying the brittle parchment is cracked and removed by hulling machines and the silver skin is rubbed off in polishing machines. The seeds or “coffee beans” are then graded and packed in burlap bags for shipment.

Before coffee is sold it is usually ground. Trade coffee is often made up of different blends. The roasted coffee beans contain 0.75-1.5 percent caffeine and a volatile, Caffeol, which is responsible for the aroma and flavor. Glucose, dextrin, proteins and fatty oil are also present. The oil tends to become rancid if coffee is stored unrefrigerated.

Tea

Tea, *Camellia sinensis*, native to Assam India and China, is the most popular caffeine beverage in the world. It is prepared from the dried leaves. In China it was originally valued only for medicinal properties, but since the 5th Century it has been the principal beverage. The word "*tea*:" is from "*te*" that is used in one of the Chinese dialects in place of the more universal "*cha*." Tea arrived in Japan around 1,000 A.D. It was known in Europe in the 16th Century but did not become widely used until the 17th Century (Hill 1952).

Tea Preparation

Preparation of tea from the fresh leaves generally is as follows: The leaves are first exposed to the sun or heated in shallow trays until they become soft and pliable. Then they are rolled by hand or by machine. This curls the leaves and removes some of the sap. Finally, the curled and twisted leaves are completely dried in the sun, over fires or in a current of hot air. In the final product, called green tea, the dried leaves are dull green with an even texture and quality. In making black tea, the leaves are fermented after rolling by covering them and keeping them warm. This causes them to lose their green color and changes their flavor. After fermentation the leaves are dried in the usual manner. Sometimes the way tea is shipped after

fermentation alters its flavor. Some of the highest quality teas have had their flavor created during long voyages at sea. Drying the leaves with fragrant flowers, such as jasmine, and then sifting out the dried flowers prepare scented teas.

Tea contains 2-5 percent Theine, an alkaloid identical with caffeine, and a volatile oil and considerable tannin (13-18 %). When an infusion is made with hot water, the alkaloid and the oil dissolve out and the resulting beverage has a stimulating effect and a characteristic taste and aroma.

Cocoa & Chocolate

Both chocolate and cocoa are prepared from seeds of the cacao or Cocoa tree, *Theobroma cacao* that is native to the lowlands of tropical America. It is the most nutritious of all beverages.

Cocoa & Chocolate Preparation

Commercial cocoa and chocolate are prepared from the processed seeds or “beans” in European and American factories. The beans are first cleaned to remove any impurities and are then sorted. They are next roasted at a temperature of 257-284 deg. Fahrenheit in iron drums. This develops the flavor, increases the fat and protein content and decreases the amount of tannin. The shells become dry and brittle and the seeds are now easy to grind. The beans are now passed between corrugated rollers that break the shells into small fragments. These are removed in a winnowing machine. The seeds or “nibs” are finally ground to an oily paste, constituting the

“liquor” or bitter chocolate, which is the beginning point for further processing.

When cooled and hardened the “liquor” is the bitter chocolate of commerce. Adding sugar and various spices or other aromatic substances make sweet chocolate. Milk chocolate contains milk as well as sugar and spices. Removing about two-thirds of the fatty oil in hydraulic presses and powdering the residue make Cocoa.

Cocoa Butter is the fatty oil present. The cocoa shells are used for beverage purposes, for adulterating cocoa and chocolate, for fertilizer and for livestock feed.

Khat

Catha edulis is a shrub that grows wild in Abyssinia and is cultivated in other parts of Northeastern Africa. The dark-green leaves are used in Arabia to yield khat, a principal beverage. The leaves and buds contain an alkaloid similar to caffeine and are used dried or are chewed fresh for their stimulating effect. The flavor is excellent and the product is worth introducing to other areas.

Fruit Juice

This is the simplest kind of soft drinks that consists of the extracted juice alone or with sugar and water added. Although fresh juice is readily obtainable synthetic flavors have been very common commercial products. The most common types of fruit drinks are lemonade, orangeade, etc. Orange juice, grapefruit juice, tomato juice and pineapple juice are very popular. Sherbets made from

strawberries, raspberries, etc. were more common at earlier times. Grape juice is made by expressing the fresh fruit and heating the liquid to extract the color and to pasteurize it and thus prevent fermentation. Sweet cider, the expressed juice of apples, and perry, obtained from pears, have been widely used. These juices contain wild yeasts and will ferment after 24 hours or so unless they are pasteurized or otherwise treated so as to kill the yeast organisms.

Soda Water

This drink consists of water charged with carbon dioxide and mixed with syrup composed of sugar and various natural or artificial flavorings. Bottled soda, common known as pop, is widely used.

A great quantity of bottled soft drinks are available chief among which are malt beverages, ginger ale, root beer and the cola beverages. The malt beverages are made from malted barley, or other grains, before fermentation has started or progressed very far. They include the “near beers,” that have an alcoholic content of less than 0.5 percent. Ginger ale consists of acidulated sugar, water and carbon dioxide flavored with ginger and capsicum. The cola beverages contain cola obtained from cola nuts that has high caffeine content.

Alcoholic Beverages

Alcoholic beverages have been a part of the human diet from the earliest history.They fall naturally into two classes: (1) the fermented beverages where the alcohol is formed by the fermentation of sugar present either naturally in the source or produced by the transformation of starch and (2) the distilled beverages that are obtained by distillation of some alcoholic liquor.

Fermented Beverages

Wine

Wine is the most important and the oldest of the fermented beverages. It is produced by the conversion of sugar that occurs in fruits or other parts of plants, into alcohol and carbon dioxide. This process of alcoholic fermentation occurs through the agency of wild yeasts that are present on the skins of the fruit. Wine is usually understood to mean the fermented juice of the grape, but specific fruit, such as blackberries, currants, etc. may be the source.

References

- Brücher, H. 1989. *Useful Plants of Neotropical Origin and Their Wild Relatives*. Springer-Verlag, Berlin, Heidelberg, New York. 296 p.
- Hill, A. F. 1952. *Economic Botany. A Textbook of Useful Plants and Plant Products*. McGraw-Hill Book Co., Inc.,
- New York, Toronto, London. 560 p.
- Horn, E. L. 1976. Wildflowers 3. *The Sierra Nevada*. The Touchstone Press, Beaverton, Oregon. 128 p.
- Le Bellec, F. & V. Renard. 1999. *Tropical Fruits*. Editions Orphie, Montpellier, France. 189 p.
- Morton, J. F. 1987. *Fruits of Warm Climates*. Creative Resource Systems, Inc., Winterville, N.C. 505 p.
- Simpson, B. B. & M. C. Ogorzaly. 2001. *Economic Botany. Plants in our World*. McGraw-Hill, Boston. 529 p.
- Vavilov, N. I. 1992. *Origin and Geography of Cultivated Plants*. Cambridge Univ. Press, Cambridge, MA. 498 p.
- Wiersema, J.H.; Dempewolf, H.; Sotelo, S.; Ramírez-Villegas, J.; Castañeda-Álvarez, N.P.; Fowler, C.; Jarvis, A.; Rieseberg,
- L.H.; Struik, P.C. 2016. "Origins of food crops connect countries worldwide". *Proc. R. Soc. B*. 283 (1832): 20160792.