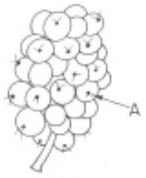
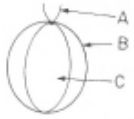
155. Mulberry



155a. Entire sorosis (x0·5)
A. Stigma

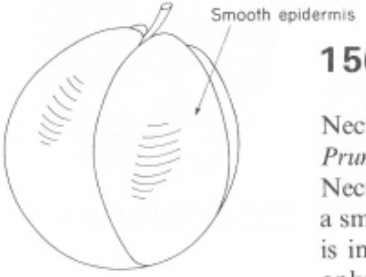


155b. Scheme of a single fruit, L.S. (x10)
A. Stigma
B. Actual fruit (a berry)
C. Fleshy part developed from the sepals

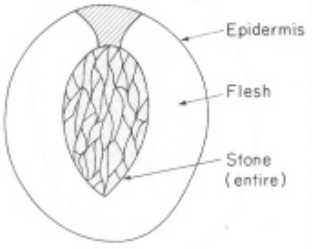
155. MULBERRY (*Morus nigra*)

Mulberry is the fruit of a small tree, *Morus nigra*, a member of the family Moraceae. It is native to Iran and the Caucasus and was extensively cultivated in Europe until the sixteenth century, mainly as a food for silk worms. It was later superseded by the white mulberry, *M. alba*, which is indigenous to China and has been exploited in the Far East for many thousands of years.

The black mulberry, *M. nigra*, was cultivated also for its fruit. Superficially, the fruit resembles the blackberry, but it develops from the whole inflorescence and forms a single structure called a sorosis. The true fruits of this sorosis are the achenes, borne on a spike and united into a sorosis by the swollen fleshy perianths and axis. Mulberries can nowadays rarely be obtained on Western markets, despite the fact that they are juicy, sweet fruit, tastier than blackberries, loganberries, etc.



156a. Entire fruit



156b. Fruit T.S., stone entire (x0·5)

156. Nectarine

Nectarines are drupes borne by a variety of peach, *Prunus persica* var. *nectarina* (family Rosaceae). Nectarines are smaller than peaches (160) and have a smooth surface lacking epidermal hairs. The tree is indistinguishable from the peach tree, and can only be distinguished by the fruits. They develop either from a seed or a bud of the peach as a mutation, and conversely a peach may originate from a seed or bud sport of the nectarine. The character for pubescence, which is the greatest difference between the peach and the nectarine, behaves as a dominant character: if a peach homozygous for pubescence is crossed with a nectarine homozygous for lack of pubescence, the offspring will be only peaches; and if a heterozygous peach is crossed with a nectarine the offspring will consist of peaches and nectarines in the ratio 1:1.

156. NECTARINE (*Prunus persica* var. *nectarina*)

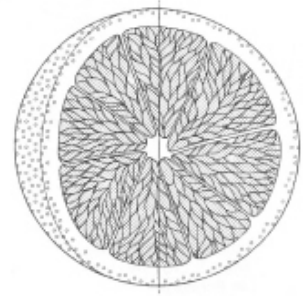
157. Orange

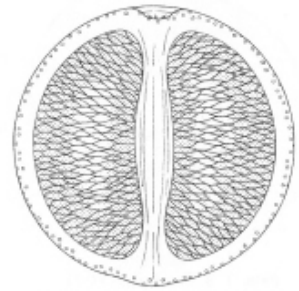
Oranges are the most popular hesperidia of *Citrus* spp. They are the fruits of *Citrus sinensis* and *C. aurantium*, both of which are considered by some botanists to be merely varieties; in this case their names would be *C. aurantium* var. *sinensis* and var. *amara*. *Citrus aurantium* (or *C. a.* var. *amara*), also known as the SEVILLE ORANGE or BITTER ORANGE because of its bitter taste, is used only for the preserve, marmalade (from the Greek *melimelon*—"honey apple"); while the sweet orange is *C. sinensis* (or *C. a.* var. *sinensis*). There are three fundamental types of sweet oranges: normal ones with orange flesh and flavedo, NAVEL oranges, and BLOOD oranges with red flesh. In navel oranges a second row of carpels develops, and this opens to the exterior at the apex forming an umbilicus, a navel-like structure in the rind. The first navel oranges probably originated at Bahia in Brazil at the beginning of the nineteenth century.

Oranges are native to Indochina or China and had already spread to India in prehistoric times. However, they were first brought to Europe by the merchants of Genoa in the second half of the fifteenth century. Shortly afterwards, orange seeds were taken to America by Colombus on his second voyage to the New Continent.

Oranges are consumed as a table fruit, as marmalade or as a juice and also in many composite dishes. The rind is discarded when the fruit is eaten raw but it forms an integral part of marmalade and it may also frequently be used as a flavouring. The peel may be candied and used in cakes, or chocolate coated as a confectionery item.

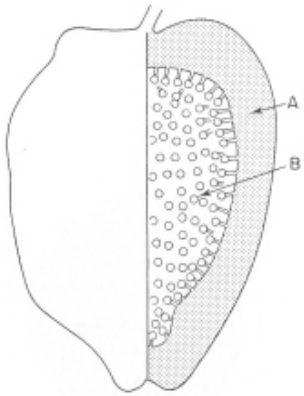
There is also an inedible kind of orange called BERGAMOT orange, which received its name from Bergama, a town in Turkey. It is cultivated in southern Europe for oil extraction. Its scientific name is *C. aurantium* var. *bergamia*.



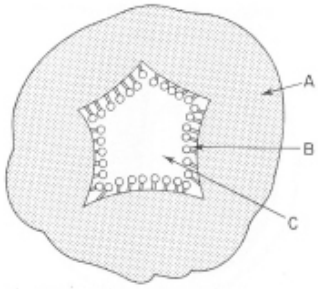


157. ORANGE (*Citrus sinensis*) (x0·5)

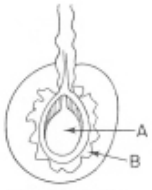
158. Papaya



158a. Berry, half entire, half L.S. (x0·2)
A. Pericarp
B. Seed embedded in sarcotesta



158b. T. S. of the berry (x0·2)
A. Pericarp
B. Seeds with sarcotesta
C. Hollow cavity



158c. Seed (x3)
A. Seed
B. Sarcotesta

158. PAPAYA (*Carica papaya*)

Papaya or PAWPAW is the fruit of *Carica papaya* (Caricaceae). It is a small tree native to tropical America but now cultivated in all the tropical regions of the world. The stem, 2–10 m tall, is hollow, usually unbranched and covered with prominent leaf scars. The palmisect leaves have a long hollow petiole and are clustered near the apex of the stem. The fruits are fleshy berries developing from the female inflorescence which is a corymb. Pawpaw berries vary in shape and size according to variety, being either elongated or almost spherical. The elongated kind measures 7–30 cm in length and reaches up to 9 kg in weight. The skin is orange and smooth and the edible part, the fleshy mesocarp and endocarp, encloses the large cavity of the ovary which is lined with seeds. The seeds are surrounded by a sarcotesta, a mucilaginous material developed from the integuments. Every part of the plant contains latex in which two proteases, papain and chymopapain, are present. These proteolytic enzymes are harvested with the latex by tapping the unripe fruit. Latex from the immature fruit is collected in an earthenware or porcelain vessel and then dried and sold in pulverized form, mainly as a meat tenderizer.

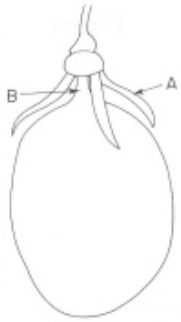
The berries are consumed as a table fruit, either for breakfast or as a dessert, and they are also used for the preparation of jams. Canning of the fruit has started only in recent years. The unripe fruit is boiled and used as a vegetable, mostly as a substitute for vegetable marrow.

159. Passion Fruit

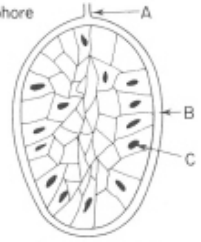
Passion fruit is the berry of *Passiflora edulis* (Passifloraceae), a vine native to Brazil. The edible part of the berry, which is borne on a stalk-like gynophore, is formed by the mucilaginous arils of the numerous seeds. The arils with the seeds are eaten straight from the shell formed by the pericarp, or are added

to fruit salads. Jams and jellies are also prepared from the passion fruit. The main producers are Australia, South Africa, New Zealand and Hawaii; from Hawaii they are exported to the U.S.A.

There are many other species of *Passiflora* that yield edible fruits, the most important of which is *P. quadrangularis*, also a native of tropical America. In this species the pericarp is fleshy and is eaten together with the arils surrounding the seeds. The name *Passiflora* (passion flower) refers to the symbolic resemblance of the floral parts to Christ's Passion: the three stigmata represent the nails of the Cross, two for the hands and one for the feet; the crown of thorns is symbolized by the filamentous processes forming the "corona", while the five anthers represent the wounds.



159a. Entire berry
A. Calyx
B. Gynophore



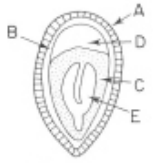
159b. L. S. of the berry
A. Gynophore
B. Pericarp
C. Seed in juicy aril

159. PASSION FRUIT (*Passiflora edulis*) (x0·5)

160. Peach

The peach tree yields fruits which are typical drupes. It is a small tree called *Prunus persica* (Rosaceae) which is native to China and reached Europe in Roman times. Today peaches are cultivated also in the U.S.A., South Africa and Australia; they require a warm climate but do not grow in the tropics. There are many varieties of cultivated peaches which can be generally divided according to the colour and firmness of the flesh as well as the separation of the stone from the fleshy part. Peaches with the stone not adhering to the flesh are called freestones, while those with a stone that adheres firmly to the flesh are described as clingstones. The flesh is usually white or yellow, but there are some peaches that have red flesh. White, soft-fleshed peaches, common in Europe before the Second World War, have almost completely disappeared from the markets, while the yellow clingstone peaches, suitable for canning, have taken their place. The "cling peaches" with a firm flesh are more easily transported and stored, and they also have a more attractive colour.

160a. L. S. of the fruit (stone undissected)

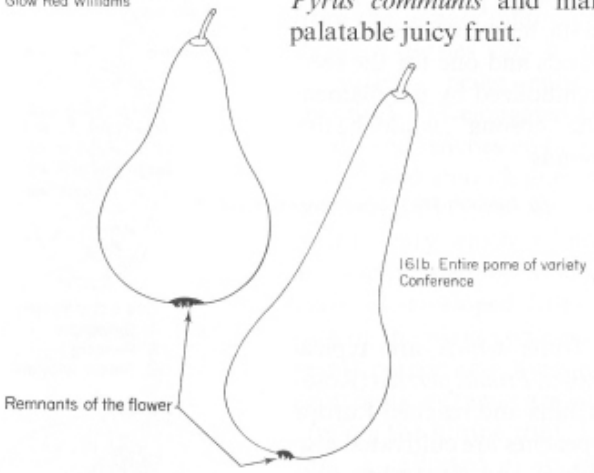


160b. Stone, L.S.
A. Stony endocarp
B. Testa
C. Endosperm
D. Nucellus
E. Embryo

160. PEACH (*Prunus persica*) (x0·5)

161. Pear

The fruit of the pear tree, *Pyrus communis* (Rosaceae) is a pome like the apple or quince. The tree is native to Europe and western Asia, where the wild pear is still found. The pear was mentioned by Homer and the ancient Romans already recognized several kinds of pears, but it seems that they were all of poor quality, suitable only for cooking. Nowadays, there are several thousand subspecies of *Pyrus communis* and many of them yield very palatable juicy fruit.



161. PEAR (*Pyrus communis*) (x0·3)

Pears were introduced into England mainly from France, which is still the largest producer of pears in the world. The kinds 'Doyenne du Comice' (*ca.* 1700) and 'Jargonelle' (*ca.* 1600) are the oldest cultivated varieties and are also grown in England for the production of excellent table fruit. The varieties 'Belissime d'Hiver', 'St. Germain', 'Catillac' and 'Black Worcester', on the other hand, are good for stewing. In the eighteenth and nineteenth centuries English plant breeders produced many excellent varieties of pear, e.g. 'Conference', 'Fertility', 'Monarch', 'Williams bon Chrétien' and 'Glow Red Williams'. Of these varieties it was mainly 'Williams bon Chrétien' that were introduced into the U.S.A., where they are called 'Bartlett', after the name of the horticulturalist who

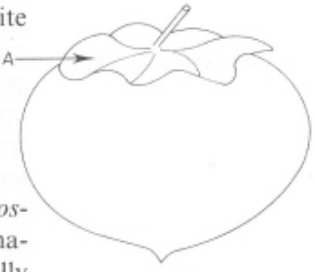
first took them here. Another kind of pear no less popular in the U.S.A. than 'Bartlett' is the 'Kieffer' pear, which originated as a cross between the common pear and the SAND or CHINESE PEAR, scientifically called *Pyrus pyrifolia* var. *culta*. The sand pear is native to China and its flowers appear just before the leaves. The large fruit has a deciduous calyx and hard flesh. It is often used in hybridization with the common pear, and in the case of 'Kieffer' pear it contributes immunity against fire blight. In England many varieties brought from France, e.g. 'Glou Monceau', 'Marie Louise' and 'Louise Bonne', grow very well, while other varieties, e.g. 'Olivier de Serres' and 'Passe Crassane', will only grow in warmer climates such as in France and Italy.

Pears have never achieved the popularity of apples, mainly because they cannot be stored for such a long period. The comparatively perishable pears are eaten either fresh or preserved, mainly by canning. Dried pears were very popular before the invention of modern preservation methods. Anatomically, pears differ from apples by the presence of sclereids in their parenchymatous flesh. These sclereids, appearing in small groups, give the pear a special granular texture.

Today the largest producers of pears are France, the U.S.A. and Germany, and they are exported mainly from South Africa, Australia and New Zealand, where pears were introduced by the white man only about 100 years ago.

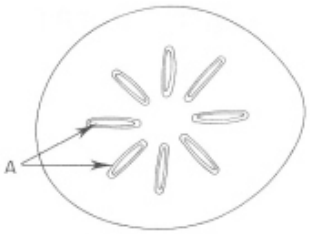
162. Persimmon

Persimmon is usually the fruit of the species *Diospyros kaki*, a tree belonging to the family Ebenaceae and native to the Far East. It was originally cultivated in China and Japan, and it is therefore also known as the CHINESE DATE PLUM. Today persimmon is cultivated throughout the warmer parts of the world, e.g. in the South of France and other Mediterranean countries, as well as in the U.S.A.



162a. Entire berry
A. Calyx

162. PERSIMMON or KAKI (*Diospyros kaki*) (x0·5)

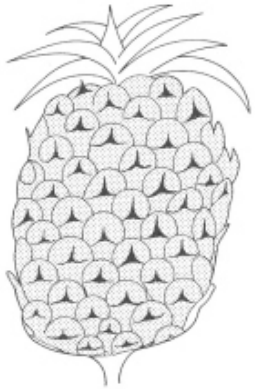


162b. T.S. of the berry
A. Seeds (T.S.)

162c. Seed

The fruit is a berry resembling a tomato in colour, shape and size, but the seeds are large, almond-shaped and few in number. The epidermis is thin, as in the tomato, and an enlarged calyx adheres to the base of the fruit. Persimmon has a delicious flavour and may be eaten as a dessert fruit, or it may be consumed dried or candied. In the U.S.A. a native species, *Diospyros virginiana*, occurs, but its fruit is very inferior to *D. kaki*. Another well known species is *D. lotus*, yielding DATE PLUMS and cultivated in the Orient and Italy.

163. Pineapple



163. PINEAPPLE (x0·3)

Pineapple is considered by many people as the best and most palatable fruit of all. It is a sorosis produced by a cultivated species, *Ananas comosus*, belonging to the monocotyledonous family Bromeliaceae. The botanical name *Ananas* is the name given to the fruit by American Indians and it has also been adopted as the common name in all European languages except English. The pineapple is a perennial or biennial herbaceous plant native to tropical South America. It consists at first of a rosette of fleshy, but stiff, long leaves with prickly margins. Later, leaves crowded spirally on the main axis are added to the rosette. After 12–25 months the main axis produces from its terminal bud a peduncle bearing the inflorescence of sessile red-purple flowers, arranged spirally on the axis and each subtended by a bract. The axis terminates in a crown, or rosette of small leaves. This crown is used for vegetative propagation of the pineapple, but small shoots developing on the peduncle just beneath the fruit are also used for this purpose. The whole inflorescence is converted into a single fruit, a sorosis, by the coalescence of the peduncle and the berries, developing from the individual flowers and numbering up to 100 or more. The sepals and bracts coalesce into the rind of the sorosis. Before consumption the pineapple must be deprived of the rind and crown as well as the centre of the fruit,

formed from the peduncle, which becomes woody. For this reason slices of pineapple are ring-shaped. Pineapples are popularly consumed in the form of juice, but most often raw or preserved, usually alone but sometimes with various meat dishes, chiefly with ham.

Pineapples are cultivated in almost all tropical countries. The main producers are the U.S.A. (Hawaii), China, Formosa, Malaysia and the Philippines, Australia, South Africa and Madagascar. The best pineapples come from Hawaii, which is the largest exporter of canned pineapple; here the cultivation of pineapples has reached its peak and even their fruiting is controlled. Instead of pollination the development of the fruit is induced by plant hormones, because *Ananas comosus* produces no seeds.

The wild form of *A. comosus* is unknown but other species still grow wild in Brazil. They differ in many ways from the cultivated pineapples; their fruit is smaller, not so juicy and contains very many seeds.

164. PLUM (prune)
(*Prunus domestica*) (x0·5)

164a. Greengage

164b. Zwetschke

164c. Prunes

164. Plums and Prunes

Most plums are the fruits of a small tree, *Prunus domestica*, a Caucasian species belonging to the family Rosaceae. *P. domestica* probably originated from a cross between the sloe (*P. spinosa*), used for the production of home-made "wine" and spirits, and the cherry plum, *P. cerasifera*. Among the varieties of *P. domestica* are greengages, 'Pershore' and 'Victoria' plums, while the cherry plums or MYROBALANS are small, spherical, red or yellow plums. The popular small, blue plums called DAMSONS (a corruption of the name of Damascus) as well as the golden-yellow MIRABELLES, belong to the species *P. insititia*. This species may, however, in fact be only a variety of *P. domestica*.

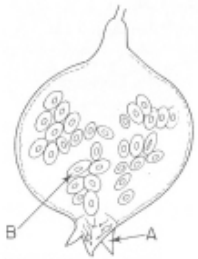
All varieties of plum, and there are about 900 of them, are drupes. Plums are eaten as a dessert fruit or in the form of jams, in pies, dumplings, etc.

Plums are especially popular in the territory of the former Austro–Hungarian monarchy, where a special kind of plum is grown. They are oval, about 5 cm long, dark blue, and with a bloom; they are called in German ZWETSCHKEN or ZWETSCHGEN, and their botanical name is *P. domestica* var. *oeconomica*. In Slavonic languages they are called SLIVY, from which is derived the name *slivovitz*, a brandy made from Zwetschken.

Plums may also be dried and they are then known as PRUNES. In Britain the best prunes are dried greengages.

165. POMEGRANATE (*Punica granatum*)

165a. Entire berry (x0·3)
A. Persistent calyx



165b. L.S. of the berry (x0·3)
A. Calyx and styles
B. Seeds in sarcotesta

165c. T.S. of the berry (x0·3)
A. Seeds in sarcotesta

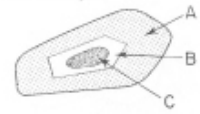
165. Pomegranate

Pomegranate is the fruit of *Punica granatum* (family Punicaceae), a shrub or small tree native to Iran. It was held in great esteem in ancient times in Mesopotamia and Egypt, and the Jewish king Solomon was said to have an entire orchard of pomegranates. Pomegranates spread at a very early date to the West, from Iran via Asia Minor to the Mediterranean region up to Portugal and they were also taken at a very early date to the Far East via India. Today pomegranates have become a fruit of most tropical and subtropical countries, but in the West (in Europe) pomegranates were very popular only until the nineteenth century, since when their popularity has declined although they are still marketed in very small quantities. They have had a better fate in India and the Far East where they are still consumed in large quantities.

The generic name is derived from *malum punicum* (apple of Carthage), as the Romans called them. In Portugal they are called *roman*, a corruption of the Arabic *rumman*, which in turn is a corrupted transcription of the Semitic name *rimmon*.

The fruits are berries, but the edible part develops not from the seedbox wall but from the outer seedcoat. The edible part is the purple pulp, completely surrounding the seeds which are contained

within the leathery rind and together with the locular septa represent the whole pericarp. The inner seed coat is stone-like. The fruit can be eaten alone, but normally it is used for preparation of sherbets. If it is used in this way, pomegranate is in fact a flavouring plant and not a fruit in the commercial sense.

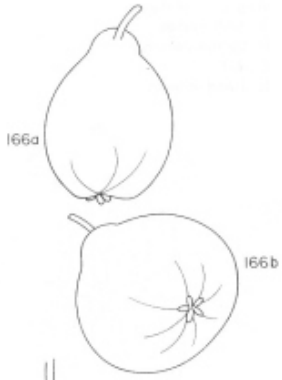


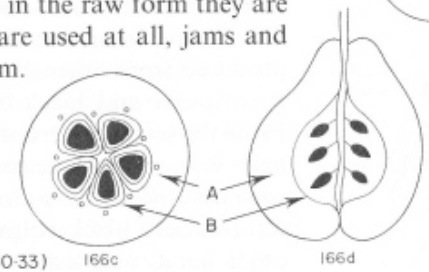
165d. Seed (x2)
A. Juicy sarcotesta
B. Stone like testa
C. Embryo

165. POMEGRANATE (*Punica granatum*)

166. Quince

Quinces are pomes borne on a shrub or small tree closely related to the genus *Pyrus*. This plant, *Cydonia oblonga* (Rosaceae) is a native of western Asia (Iran, Anatolia, etc.) and its fruit was already consumed by the ancient Romans. The species *C. oblonga* has 5 varieties: *C. o.* var. *lusitanica*, *C. o.* var. *maliformis*, var. *marmorata*, var. *pyriformis* and var. *pyramidalis*. At present, quinces are not held in much esteem and in the raw form they are almost inedible. If they are used at all, jams and jellies are made from them.





166a,b. Entire pomes
166c. T.S. of the pome
166d. L.S. of the pome
A. Receptacular part of the flesh
B. Cartilaginous endocarp

166. QUINCE (*Cydonia vulgaris*) (x0·33)

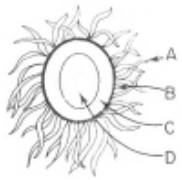
167. Rambutan

Rambutan, *Nephelium lappaceum*, is an evergreen tree reaching 12–15 m, and native to the Malaysian lowlands. It belongs to the family Sapindaceae in common with *Litchi chinensis*, sometimes also known as *Nephelium litchi*. Its fruits, also similar to litchis, are nuts borne in clusters, and with seeds surrounded by an aril, but in contrast to litchis, the pericarp is covered with soft spines 1–1·5 cm long. The fruit is red or sometimes yellow when ripe.

PULASAN is another arillate fruit yielded by the species *Nephelium mutabile*, which grows in South East Asia, chiefly in Indonesia.

167a. Entire nuts borne in clusters

167b



167b. L. S. of the nut
A. Soft spines
B. Brittle pericarp
C. Aril
D. Seed in testa

167. RAMBUTAN (*Nephelium lappaceum*) (x 0·5)

168. Raspberry

Raspberry is the name given to the fruit of *Rubus idaeus* (Rosaceae), a wild shrub native to Eurasia. It is an aggregate fruit, easily detachable from its swollen receptacles, in contrast to the blackberry in which the receptacle does not separate from the drupelets. The etaerio of druplets of the raspberry surpasses all other species of the genus *Rubus* in flavour and fragrance. In America raspberries are produced from other species: red raspberries from *R. strigosus* and black ones from *R. occidentale*. From the seventeenth century onwards, raspberries have been cultivated, and red cultivated varieties were obtained from a cross between *R. idaeus* and *R. strigosus*. Black cultivated raspberries, on the other hand, originated from the species *R. occidentale*. Purple raspberries are hybrids between black and red cultivated varieties, and yellow raspberries also exist, but they are cultivated only in a few localities as a freak.

168. RASPBERRY (*Rubus idaeus*) (x 1)

Raspberries are eaten fresh or preserved by canning or freezing; or a syrup is prepared from them which is used for a soft drink—for this use they should be included under flavourings. In Europe only wild raspberries were collected at one time, but today cultivated ones appear on the market, and in Britain they are in fact the only raspberries available commercially. According to Pliny, the wild Eurasian raspberry, *R. idaeus*, received its name from Mount Ida in Asia Minor, which was overgrown with this shrub.

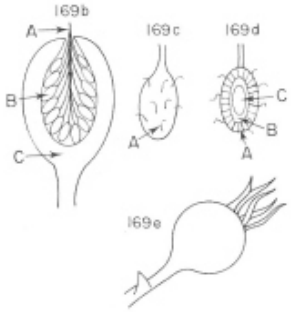
169. Rose Hip

Rose hip is the name given to the false, accessory fruit of roses; the edible part is the hollow, swollen, fleshy receptacle (torus) which is red in colour when ripe. The actual fruit of *Rosa* spp. (Rosaceae) is an etaerio of achenes enclosed within the receptacle. Only the hips of some of the wild species (e.g. *Rosa canina*) can be considered as fruits of any commercial significance. They cannot be eaten in their natural state because the achenes are covered with hooked, hairy outgrowths which must first be removed, and the empty fruit wall must then be cooked and made into jams, jellies or syrups.

Rosehips are used today because of their high vitamin C content. During the Second World War, insufficient supplies of the usual fruits and vegetables compelled the Germans to look for unconventional sources of vitamin C, and crews of submarines and ships were supplied with rosehip syrup. In 1940, Sabalitschka published a paper in *Forschungsdienst* entitled "The use of rose hips in the vitamin C supply for the German nation", in which he claimed that the entire fruit of *Rosa rugosa*, a shrub native to China and Japan, but also cultivated in Europe where it occasionally becomes naturalized, contains 515 mg per 100 g fresh weight and 1660 mg per 100 g dry weight of vitamin C in the fruit. British research started later, and in 1946 Melville and Pike published a report. They found that the lowest level of vitamin C in British rose hips occurs in *R. arvensis* (75 mg per 100 g of receptacle wall), while the commonest European species, *R. canina*, native to Eurasia and North Africa, contains 493 mg per 100 g of fruit wall, and *R. villosa* (or *mollis*) as much as 1303 mg per 100 g. However, Bukin and Zubkova had already reported in 1937 that another species of *Rosa*, *R. acicularis*, which is native to the southern fringes of the Arctic, contains as much as 4·75% dry weight of vitamin C; and, according to Canadian workers, this enormous concentration may be even higher—up to 7·6% dry weight has been found in *R. acicu-*

169a. Fruit (A) and leaf (B) of *Rosa canina* (C) Prickle (D) Stipule (x 0·5)

169. ROSE HIP (false fruit of *Rosa* spp.)



laris and it was reported that the species *R. laxa* contains even more (8–10% dry weight).

A special kind of *Rosa villosa* (*mollis*), *R. villosa* var. *pomifera*, is also used to produce a home-made wine. Rose wine was already known to the ancient Romans and has been made in Central Europe up to the present time. The wild rose also serves as a beverage plant by the use of its leaves: an infusion is prepared from the dried leaves which is known by Germans as *Deutscher Tee* (German tea).

169b. Rose hip (x1·5) A. Remnants of the styles
B. Etaerio of achenes
C. Fleshy hollow receptacle

169c. Entire achene (x4) A. Hook-like hairs of the pericarp

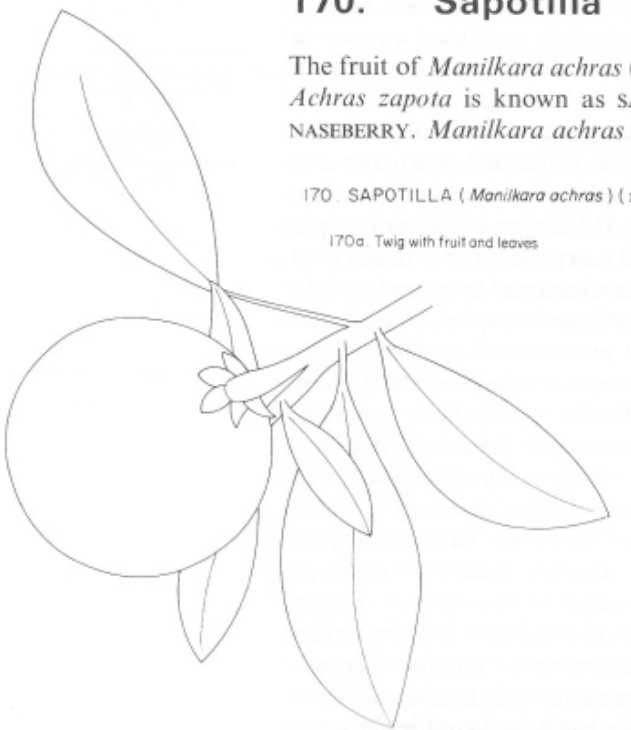
169d. Achene, L.S. (x4) A. Pericarp
B. Testa
C. Seed

169e. Rose hip of *Rosa rugosa* (x0·5)

169. ROSE HIP (false fruit of *Rosa* spp.)

170. Sapotilla

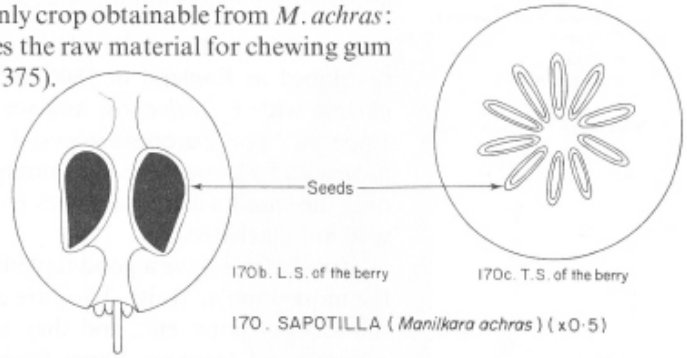
The fruit of *Manilkara achras* (syn. *M. zapotilla* or *Achras zapota* is known as SAPOTILLA, CHIKU or NASEBERRY. *Manilkara achras* is an evergreen tree



170. SAPOTILLA (*Manilkara achras*) (x0·5)

170a. Twig with fruit and leaves

up to 20 m in height, belonging to the family Sapotaceae and native to Mexico and Central America. It was cultivated in America long before the continent was discovered by Europeans. The fruit is a globose or ovoid berry, 5–10 cm in diameter, and it contains about 14% sugar, chiefly sucrose. The sweet pulp is translucent and has easily separable, black seeds embedded in it; the fruit is greyish to brownish while the translucent pulp is yellowish-brown. The Spaniards considered fresh *Manilkara achras* to be the best fruit of the neotropics and introduced it at an early date to the Philippines, from where it spread to Malaysia. However, the fruit is not the only crop obtainable from *M. achras*: its latex provides the raw material for chewing gum (see Chicle—p. 375).

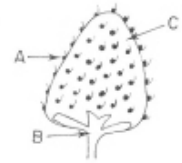


170b. L.S. of the berry 170c. T.S. of the berry

170. SAPOTILLA (*Manilkara achras*) (x0·5)

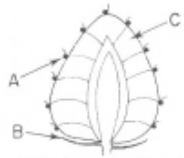
171. Strawberry

Strawberry, the false, accessory fruit of *Fragaria* spp. (Rosaceae), is the juicy, swollen receptacle bearing on its surface an etaerio of achenes, the true fruits. *Fragaria* spp. are perennial herbs which readily reproduce by means of runners, creeping stems producing new plants at intervals from buds that develop roots and shoots. They are native to the temperate zones of Eurasia and America. The species *F. vesca* grows wild in the northern hemisphere and in Europe has given rise to the ALPINE strawberry, *F. vesca* var. *semperflorens*, which grows northwards from the Alps and produces new fruit during the whole growing season. Another species of the northern temperate regions is *F. moschata*, which yields the most aromatic fruit of



171a. Cultivated strawberry of American origin (x0·5)
A. Achenes
B. Calyx
C. Swollen torus

171. STRAWBERRY (*Fragaria* spp.)



171b. L. S. of cultivated strawberry (xO·5)
A. Achenes
B. Calyx
C. Swollen torus

171c. Actual fruit, an achene (highly magnified)
A. Stigma
B. Style
C. Actual achene

171. STRAWBERRY (*Fragaria* spp.)

all strawberries. The giant strawberry originated from the American species *F. virginiana*, which grows in the eastern part of the U.S.A., and *F. chiloensis*, which is distributed along the western coast of America from Alaska across California to southern Chile. The large cultivated strawberries appearing on the market are mainly derived from crosses between these American species. In 1714 strawberries were brought to Europe that were cultivated by the Indians of Chile and were as large as walnuts; these giant strawberries captured the imagination of European and American plant breeders, who tried to obtain the same result by hybridization of American species. The first variety comparable to the modern large strawberries was developed in England in 1806 by crossing *F. virginiana* with *F. chiloensis*, and was called 'Keen's Imperial'. The European types, *F. v.* var. *semperflorens* and *F. vesca*, are very rarely cultivated and only the small wild strawberries collected from the wild are marketed.

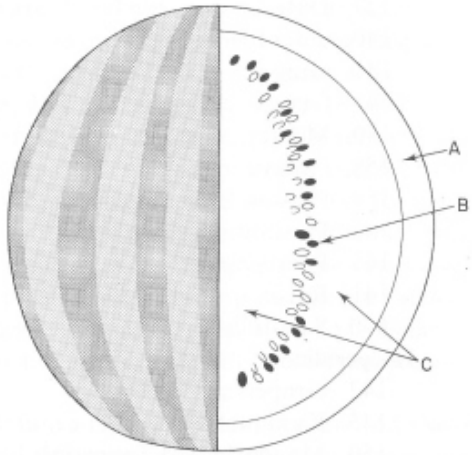
Strawberries have a good flavour and are one of the most popular fruits. They are eaten fresh or in the form of jams, etc., and they are preserved by canning and freezing. Eaten fresh, they are normally served with cream and they are used with whipped cream as fillings for cakes and pastries.

172. Watermelon

Watermelon is the pepo of *Colocynthis citrullus* or *C. lanatus*, formerly known as *Citrullus vulgaris* (family Cucurbitaceae). It is a vine native to Africa, but it was introduced into India in early prehistoric times; a name for it occurs in Sanscrit, and it was also known by the Egyptians at least as long ago as 4000 B.C. They remain a popular fruit to this day.

Watermelon is one of the largest fruits consumed by man, and they may weigh 25 kg or even more. An average-sized watermelon measures about 36 cm in diameter and is spherical in shape. Its rind is usually dark green and the flesh red, containing

dark brown seeds, but there are also oblong varieties about 75 cm in length. The colour of the rind and flesh also varies: some watermelons have a pale green or cream rind and the flesh may be pinkish, yellow or whitish. The flesh is sweet and watery, and in dry, hot countries, where watermelons grow best, they provide a substitute for drinking water. The seeds, which vary in colour according to variety, are sometimes chewed, particularly in southern China. They may also be ground and used as pseudo-cereals for bread-making. Watermelons are cultivated all over the world in tropical, subtropical and warm parts of temperate regions, e.g. southern and southeastern Europe.



172. WATERMELON (*Colocynthis citrullus*) (xO·25)
A. Rind
B. Seeds
C. Flesh

Morphological Survey of Fruits (FRU)

I. SIMPLE

1. Dry

Legume

129. Carob

2. Fleshy

Berry

124. Banana
126. Bilberry
128. Carambola
131. Ceriman (berries with the spadix)
134. Cranberry
135. Currant
137. Date
140. Gooseberry
141. Grape
143. Guava
149. Mamey
158. Papaya
159. Passion fruit
162. Persimmon
165. Pomegranate
141. Raisin
170. Sapotilla

Hesperidium

142. Grapefruit
145. Kumquat
150. Mandarin and Tangerine
157. Orange
182. Shaddock
150. Ugli

Hesperidium-like

123. Bael

Pepo

154. Melon
172. Watermelon

Pome

121. Apple
148. Loquat
153. Medlar
161. Pear
166. Quince

Drupe

122. Apricot
125. Barbados Cherry
132. Cherry, Sour
133. Cherry, Sweet
144. Huckleberry
151. Mango
156. Nectarine
160. Peach
164. Plum

Accessory fruit

130. Cashew apple
169. Rosehip
171. Strawberry

II. AGGREGATE

Etaerio of berries

136. Custard apple

Etaerio of druplets

127. Blackberry
147. Loganberry
168. Raspberry

III. MULTIPLE AND COMPOSITE

Siconium

139. Fig

Sorosis

61. Breadfruit
85. Jack-fruit
155. Mulberry
163. Pineapple

IV. ARIL

120. Akee
138. Durian
146. Litchi
152. Mangosteen
167. Rambutan

V. NUTS

This chapter deals with edible seeds contained within a hard or brittle shell and commercially considered as nuts. In the true botanical sense a nut is an achenial fruit, a dry and indehiscent fruit with a separable, hard, woody pericarp enclosing a single seed. Most commercial nuts are the stones of drupes (e.g. coconut, almond, walnut, etc.) or mere seeds (e.g. Brazil nuts, pine nuts) and only a few are true nuts in the botanical sense. The true nuts belonging to the commercial group are: hazel nut, sweet chestnut, acorn and beechmast, and all of them belong to the order Fagales. They also display a special feature, an outer covering of the nut which in the case of hazel nut (family Betulaceae) is an involucre, and in the case of the three other true nuts which are all members of the family Fagaceae (or Cupuliferae) a cupule, as the alternative family name suggests. The cupule is probably derived from an annular outgrowth of the axis and not from bracteoles, as was formerly believed. Other true nuts which do not belong among the commercial nuts may be commodities falling within another group of vegetable materials used for human consumption. For example, the water chestnut, a true nut eaten in the form of flour in prehistoric times in central Europe, must be considered as a pseudo-cereal, while litchi, also a true nut, is classified as a fruit because of its fleshy aril.

The nuts of commerce usually contain a large proportion of fats and also a considerable amount of protein, and their chemical constitution determines their special usage. Only the acorn and sweet chestnut are starchy nuts, and for this reason they may be used as pseudo-cereals. Most nuts are devoid of vitamin C and in the few that do contain it there is only a very small quantity. Vitamin A also occurs rarely and scarcely. But nuts are much richer than fruits and vegetables in the B vitamins, as shown below in Table VII. The data in the table are derived from the U.S.D.A. "Agriculture Handbook" (full details given with Table I, p. 18), except those for acorn, Java almond and oyster nut. Table VII shows that Java almonds contain the largest percentage of fats (72·0%), closely followed by pili nuts (71·1%) and pecan nuts (71·2%). Pine nuts are the richest in proteins (31·1%), while of the angiosperm nuts the richest are oyster nuts (27%), peanuts (26%) and black walnuts (20·5%). The maximum for vitamin A occurs in black walnuts (300 international units per 100 g edible portion); vitamin B_1—thiamine—in peanuts (1·14 mg per 100 g) and B_2—riboflavin—in almonds (0·92 mg per 100 g) which also contain the

Table VII

Chemical composition per 100 g edible part of nuts.

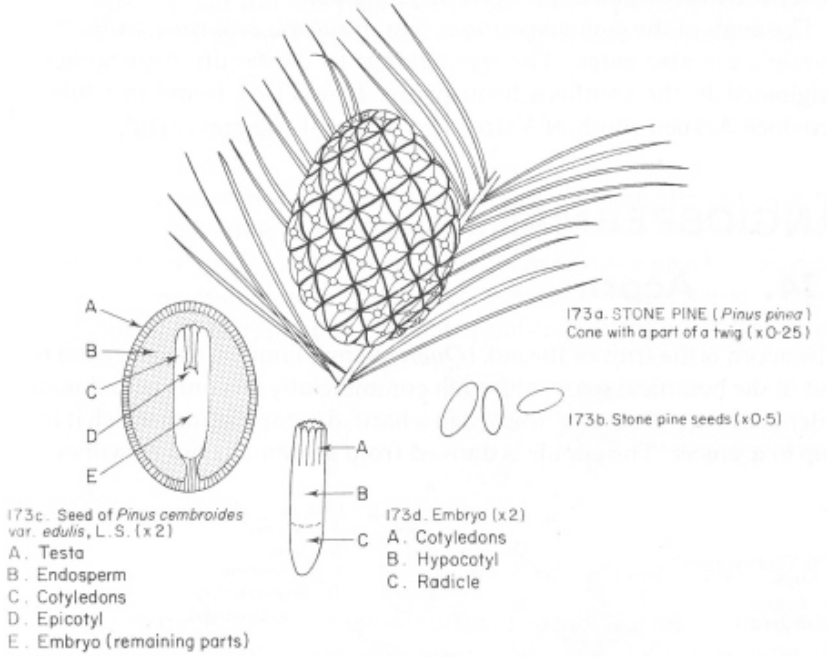
Name of the nut	*Water*	*Proteins*	*Fats*	*Carbohydrates*	*Vitamins (A in international units, others in mg)*				
					A	*Thiamine*	*Riboflavin*	*Niacin*	*C*
	%	%	%	%					
GYMNOSPERMAE									
173. Pine nut (Pignolia, dry)	5·6	31·1	47·4	11·6	—	0·62	—	—	—
ANGIOSPERMAE									
174. Acorn, dry	13·9	7·9	4·5	67·8	—	—	—	—	—
175. Almond, dry	4·7	18·6	54·2	19·5	0	0·24	0·92	3·5	tr
176. Beechnut, dry	6·6	19·4	50·0	20·3	—	—	—	—	—
177. Brazil nut, dry	4·6	14·3	66·9	10·9	tr.	0·96	0·12	1·6	—
(130.) Cashew nut, roasted	5·2	17·2	45·7	29·3	100	0·43	0·25	1·8	—
178. Chestnut, Sweet fresh	52·5	2·9	1·5	42·1	—	0·22	0·22	0·6	—
179. Coconut (meat), fresh	50·9	3·5	35·3	9·4	0	0·05	0·02	0·5	3
dry	3·5	7·2	64·9	23·0	0	0·06	0·04	0·6	0
180. Hazel nut, Filbert, dry	5·8	12·6	62·4	16·7	—	0·46	—	0·9	tr
Hickory nut, dry	3·3	13·2	68·7	12·8	—	—	—	—	—
Java almond, dry	—	13·0	72·0	7·0	—	—	—	—	—
181. Macadamia, dry	3·0	7·8	71·6	15·4	0	0·34	0·11	1·3	0
182. Oyster nut, dry	3·5	27·0	66·0	—	—	—	—	—	—
183. Peanut, dry, raw	5·6	26·0	47·5	18·6	—	1·14	0·13	17·2	0
184. Pecan, dry	3·4	9·2	71·2	14·6	130	0·86	0·13	0·9	2
185. Pili nut, dry	6·3	11·4	71·1	8·4	40	0·88	0·09	0·5	tr
186. Pistachio nut, dry	5·3	19·3	53·7	19·0	230	0·67	—	1·4	0
187. Sunflower nut, dry	4·8	24·0	47·3	19·9	50	1·96	0·23	5·4	—
188. Walnut, Black, dry	3·1	20·5	59·3	14·8	300	0·22	0·11	0·7	—
Italian, dry	3·5	14·8	64·0	15·8	30	0·33	0·13	0·9	2

highest quantity of niacin (nicotinic acid). Vitamin C, where it occurs at all, is present only in trace amounts or in very small, insignificant quantities, its maximum (a mere 3 mg per 100 g) being found in fresh coconuts.

GYMNOSPERMAE

173. Pine Nut

Many species of the genus *Pinus* (family Pinaceae) yield edible seeds. These seeds, in common with those of all gymnosperms, are naked, developing directly on the ovuliferous scale which is the upper part of the double structure called the megasporophyll. When the ovule ripens and forms a



173. PINE NUT (*Pinus* spp.)

seed, the upper surface of the ovuliferous scale splits off, adding a wing to the seed. The winged seeds of *Pinus* spp. are endospermous and multicotyledonous, and sometimes the wing is only rudimentary. *Pinus* spp. are native to the northern hemisphere, where they grow in temperate regions, but they also grow in mountainous parts of the tropics. In Europe the seeds of *Pinus pinea* are those that are mainly eaten; this is a species native to the Mediterranean region and commonly known as the Italian stone pine, occurring from

Portugal to Asia Minor. Its seeds, which bear only a rudiment of the wing, are known commercially as *pignolias* (their Italian name is *pinocchio*).

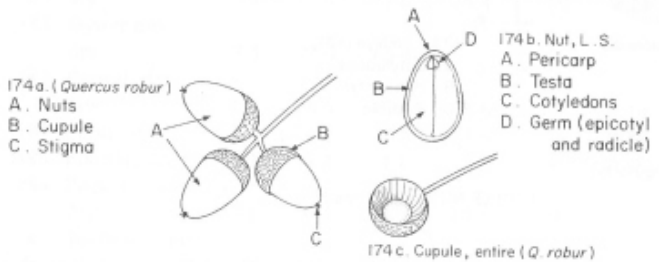
Another European pine yielding edible seeds is the Swiss stone pine, *Pinus cembra*; this species is also popular in Siberia, where the seeds are consumed in large quantities and are even exported via Archangel. In Norwegian ports they are known as Russian nuts. The seeds of another species, *Pinus koraiensis*, are eaten in China, Korea and Japan. However, most of the pine species with edible seeds are found in North America; the seeds were eaten mainly by the natives who collected the entire strobili (cones) or obtained the seeds in huge quantities from the nests of pack rats, which store them for the winter. The best American pine nuts are the seeds of *P. cembroides* var. *edulis* and *P. cembroides* var. *monophylla*. Pine nuts are still to be found in local markets in the U.S.A., in those regions where pines yielding good nuts grow, but today their economic importance is very small.

The seeds of the gymnospermous tree *Araucaria araucana*, called "monkey puzzle", are also eaten. The tree belongs to the family Araucariaceae and originated in the southern hemisphere. It was first found in Chile, in the province Arauco south of Valparaiso, hence the name.

ANGIOSPERMAE

174. Acorn

The acorn is the fruit of the oak (*Quercus* spp., family Fagaceae) and is a true nut in the botanical sense, although commercially it is only occasionally considered as one. The nut is inserted in a hard, dry cupule, into which it fits like a cup in a saucer. The cupule is derived from an annular outgrowth of the axis



174. ACORN OF OAK (*Quercus* spp.) (x0·5)

and covers about a third of the nut. The nut itself contains the edible portion, an exalbuminous seed with two massive cotyledons storing food, mainly in the form of carbohydrates. The epicotyl and hypocotyl with the radicle are small and occur at the pointed end of the nut. Unlike other true nuts of the Fagales, the acorn is solitary in the cupule.

Quercus spp. are indigenous to all continents except Australia, but they grow only in temperate and subtropical regions. The commonest European oak is *Q. robur* (*Q. pedunculata*), with stalked (pedicellate) fruits, while the less common European species, *Q. petraea* (*sessiliflora*), has sessile acorns. Some oaks are deciduous, others evergreen; the evergreen oak of the Mediterranean region is the holm oak, *Q. ilex*, growing mainly in Spain and Portugal. This is the only species with palatable acorns which can be eaten as dessert nuts and which, therefore, are considered commercially as nuts. Other species yield nuts that may only be used to substitute for cereal grains and in this respect oak should be classified as a pseudo-cereal. Seeds of acorns used in this way are ground and bread is made from the flour; such a method of using acorns was mentioned by Theophrastus, the first known botanical writer. Acorns are still used for bread-making in poor areas such as the south of Italy, where the soil will not yield cereals and where poverty prevents the purchase of flour from elsewhere; otherwise, acorns are used as fodder.

175. Almond

Almonds are the most popular commercial nuts; botanically they are the stones of drupes, enclosing the edible seed. They are borne by *Prunus amygdalus* (family Rosaceae), a small tree closely related to the peach. It appears to be native to the eastern part of the Mediterranean region, from where it spread westwards to Europe. The first European cultivators of almonds were

175. ALMOND (*Prunus amygdalus*) (x0·5)

the Greeks, and the Romans therefore called almonds "Greek" nuts. Today they are cultivated in all temperate regions, but they do not grow in the tropics. The almond tree was introduced into America (California), Australia and South Africa from Europe.

There are two varieties, *Prunus amygdalus* var. *dulcis* and *P. a.* var. *amara*, but the latter variety is not edible because of its bitterness, due to the presence of the glucoside amygdalin in the seeds. In the presence of the enzyme emulsin, also present in the seed, amygdalin is broken down into glucose, benzaldehyde and poisonous hydrocyanic acid, which is responsible for the bitter taste. Bitter almonds are used for the expression of almond oil and volatile substances, because they are cheaper than the sweet (edible) almonds,

and for this reason they are often mixed with the sweet variety. According to most authorities, the sweet almond is never bitter when ripe.

The greenish covering in which the useful seed is enclosed is leathery and useless. When the drupe is ripe this covering, which is derived from the epicarp and mesocarp, opens and the stone falls out. The shell of the stone differs in hardness according to the subvariety: those with the thinnest shells are known as paper-shelled and are the most popular because of their ease of preparation; the other kinds have a more or less hard shell and the hardest are the least in demand. Entire almonds (i.e. almond seeds) are eaten either peeled or with the testa, a thin dark brown skin which peels off easily when the seed is boiled. Almonds consumed as dessert nuts may be roasted and salted after removal of the testa, or they may be added to chocolate, or used decoratively for cakes and pastries. Almonds with or without the testa are also often used ground for special doughs or creams by pastrycooks (e.g. marzipan). Almonds added in small quantities to cakes and pastries, and even to savoury sauces and meat, should be considered as a flavouring or decorative material rather than as nuts.

176. Beechmast

Beech nuts or beechmast are true nuts produced by *Fagus* spp. (family Fagaceae). Pairs of three-angled nuts are enclosed in a common fleshy, spiny cupule which splits into four valves when the nuts are ripe. Beech is a large and robust tree native to the temperate zones of the northern hemisphere and forming huge forests in central Europe and North America. The typical European beech is *Fagus sylvatica* while the American one is *F. grandifolia*. Beechmast are used today almost entirely as animal fodder but in emergency, such as during the First and Second World Wars when they were collected in Germany and Austria, they are used as human food for their high fat content.

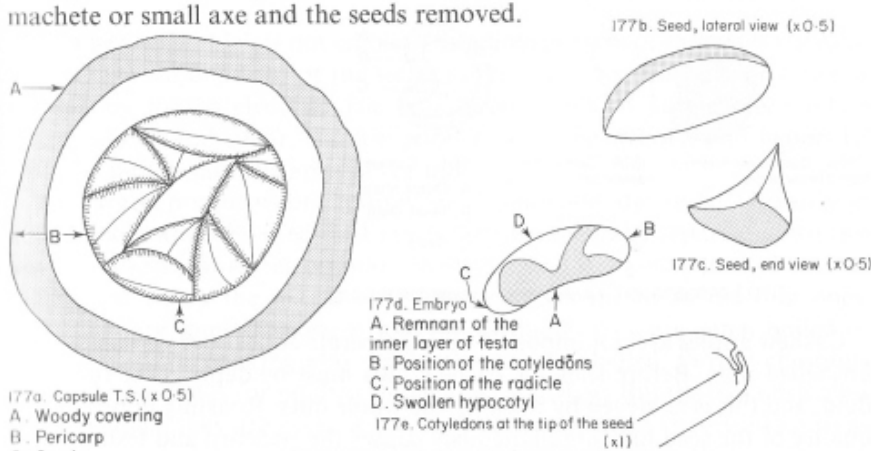
176a. Two nuts in the cupule (x0·5)
176b. Opened cupule showing two nuts (x0·5)
176c. T. S. of the nut (x1·8)
A. Pericarp
B. Testa
C. Folded cotyledons

176. BEECHMAST (*Fagus sylvatica*)

The oil may be extracted and used for human consumption. Alternatively, beechmast may be eaten fresh or roasted as nuts, or, as an emergency measure, ground and used as a substitute for coffee. In poor countries beechmast are ground into flour and used in bread-making, and it seems that, in common with acorns, they were functionally the ancestors of cereals.

177. Brazil Nut

Brazil nuts, one of the most important nuts commercially, are the seeds of *Bertholletia excelsa* (family Lecythidaceae), a tall tree native to the tropical regions of Brazil. The tree grows wild in the forests of Amazonia and also in the Guianas, Venezuela and Bolivia, but is of economic importance only in the region of Amazonia, from which the nuts are exported. The nuts are always gathered from the wild, and the tree is never cultivated. Attempts to introduce it into other regions such as Malaysia, Java and the West Indies were unsuccessful. The Brazil nuts consist merely of the seed with a thick, hard, woody shell developing from the testa, and they are contained in a kind of woody, indehiscent capsule, that may grow as large as a human head. The exalbuminous seeds are triangular in transverse section but the embryo, the edible portion, is smooth and rounded. The hypocotyl, which forms the bulk of the embryo, is excessively swollen. The cotyledons with the epicotyl and the radicle are very tiny and occur at opposite poles of the hypocotyl. Thus the edible portion consists almost entirely of the swollen hypocotyl. The seeds are arranged close together in the centre of the capsule, inside a covering derived from the pericarp, usually with 24 seeds in a single capsule. The capsules are collected when they fall from the tree, but they cannot be gathered on windy days—since the trees often reach a height of 40–50 m, the falling fruits can easily kill a man. The collected capsules are opened with a machete or small axe and the seeds removed.



177b. Seed, lateral view (x0·5)
177c. Seed, end view (x0·5)
177a. Capsule T.S. (x0·5)
A. Woody covering
B. Pericarp
C. Seeds
177d. Embryo
A. Remnant of the inner layer of testa
B. Position of the cotyledons
C. Position of the radicle
D. Swollen hypocotyl
177e. Cotyledons at the tip of the seed (x1)

177. BRAZIL NUT (Nut of *Bertholletia excelsa*)

The export of Brazil nuts began in 1836, and for a long time they were always exported in the shell (testa). Today, however, they also reach foreign markets ready shelled, because of the invention of special shelling equipment. Pará is an important marketing centre of Brazil nuts and they are often also called Pará nuts after the town. Brazil nuts are usually eaten raw as dessert nuts or in the form of a nut-chocolate.

[130.] Cashew Nut

Cashew nuts are the actual fruits, the drupes, of *Anacardium occidentale* (Anacardiaceae), a tropical tree up to 12 m tall and native to Brazil. The name cashew is derived from the native name *acajú* which the Portuguese wrongly transcribed as *cajú*. Portuguese colonizers had introduced cashew trees from Brazil to their colony of Goa in India by the sixteenth century and from there the plant spread into other parts of the Indian subcontinent. Today India is the largest exporter of cashew nuts but a large proportion of them are of African origin and are sent to India only for processing. The pericarp of the nut consists of two shells between which is a resinous layer containing an acrid fluid which has a corrosive effect on the skin similar to carbolic acid. It produces blisters on the fingers if one attempts to break the shells manually or on the lips if one tries to open the drupe by biting. The cashew nut is kidney-shaped, about 3 cm long and contains a single exalbuminous seed which is the edible part of the fruit. The drupe surmounts a swollen pedicel, the so-called cashew apple, an accessory, juicy false fruit. Despite the fact that it is called a cashew *apple* it has a pear-like shape and is a soft, shiny structure, red or yellow in colour when ripe; it is 10–20 cm in length and 4–8 cm in width. The cashew apple is a very popular fruit among the natives where the tree grows, and they are said to enjoy them much more than the true fruit, the cashew nut.

130a. Cashew nut detached from cashew apple

130b. Seed of the cashew nut

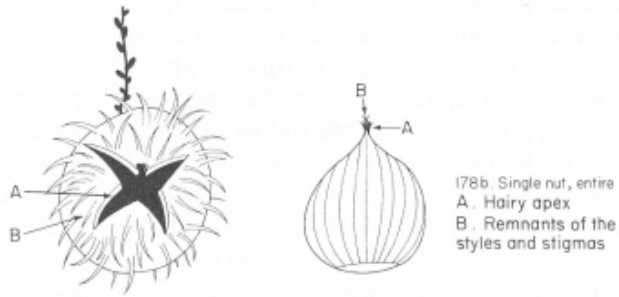
130c. Cashew nut, T.S.
A. Outer shell
B. Inner shell
C. Seed

[130.] CASHEW NUT (*Anacardium occidentale*) (x0·5)

Cashew apples are not imported into temperate zones, and neither are the unshelled nuts. Before shelling, cashew nuts must be deprived of the acrid fluid, and this is achieved by roasting the whole nuts. Roasting improves the quality of the seed and simultaneously causes the pericarp and testa to peel off. Thus imported cashew nuts are always mere roasted embryos.

178. Chestnut

SWEET CHESTNUTS are true nuts, not to be confused with horse chestnuts, which are seeds borne in the capsules of *Aesculus hippocastanum* (Hippocastanaceae). The botanical name of the sweet chestnut tree is *Castanea sativa*, and in common with oak and beech it is a member of the family Fagaceae. It is indigenous to the Mediterranean region and was taken northwards by the Ancient Romans, beyond the Alps. In the more northerly regions (e.g. Britain), however, the fruit does not develop properly and remains degenerate. In Britain the sweet chestnut is also called the SPANISH CHESTNUT because it was mainly imported from Spain. The nuts occur two or three at a time in a common green, fleshy and spiny cupule which splits into four valves when the fruit is ripe. Each nut is surrounded by a hard, dark



178a. Up to three nuts in a common cupule, splitting into four valves
A. Nut(s)
B. Cupule

178b. Single nut, entire
A. Hairy apex
B. Remnants of the styles and stigmas

178. CHESTNUT, SWEET (*Castanea sativa*) (x0·5)

brown pericarp which is not edible. The edible portion of the nut is the exalbuminous seed deprived of the testa, i.e. the embryo, the bulk of which is formed by the cotyledons. The two large, wrinkled cotyledons contain mainly starch and sugar, and are poor in fats. The epicotyl and hypocotyl with the radicle face the apex of the nut.

The largest producers of chestnuts are France and also Italy, where about 200 varieties are cultivated. In France they are generally separated into two kinds—CHANTAIGNES, the ordinary chestnuts, and MARRONS, those of a better quality, of which the marrons of Lyon are recognized as the best ones. Chestnuts are sometimes eaten raw but normally they are eaten boiled or roasted, and the cooking also makes them easily shelled. Puréed chestnuts are used in stuffings for poultry, especially for turkey. But the most delicious form in which they are eaten is beaten with sugar, when they are known as *marrons glacés*. Despite the fact that the *marrons glacés* of France are such an expensive delicacy, chestnuts are still the staple food of peasants living in some of the poor regions of southern Europe (e.g. Italy); in this case they are ground into a flour (*farina dolce*) which is used for porridge or even for bread-making.

The sweet chestnuts native to America are *Castanea dentata* and *C. pumila*; the latter has a very good flavour, but has no commercial value because of its

small size. *C. dentata*, on the other hand, is a huge tree reaching a height of 30 m and yielding large and tasty nuts, but unfortunately this species has been almost completely annihilated by a parasite. It used to grow mainly in the central and eastern parts of the U.S.A.

The commonest sweet chestnut native to China is *C. mollissima*; that of Japan is *C. crenata*, bearing large nuts that have a very poor flavour, but which are used as a vegetable to substitute for potatoes.

The common HORSE CHESTNUT (*Aesculus hippocastanum*), on the other hand, was for a long time an unknown plant, until the first seed was sent to transalpine Europe in 1557 from Constantinople by a Flemish doctor, Quakleben, who was attached to the Austrian embassy. It was received in Vienna by the well known botanist Matthiolus who called it *Castania equina*, a literal translation of its Turkish name *kastane*, which refers to their use in preparing a meal for mixing with the fodder of horses suffering from broken wind. In 1576 the first horse chestnut tree was grown in Vienna from the seed brought from Constantinople and soon afterwards its cultivation spread throughout France and England. Nowadays the horse chestnut is one of the commonest trees beyond the Alps, but it is native to Albania and Greece, not to the Himalayas as was previously thought.

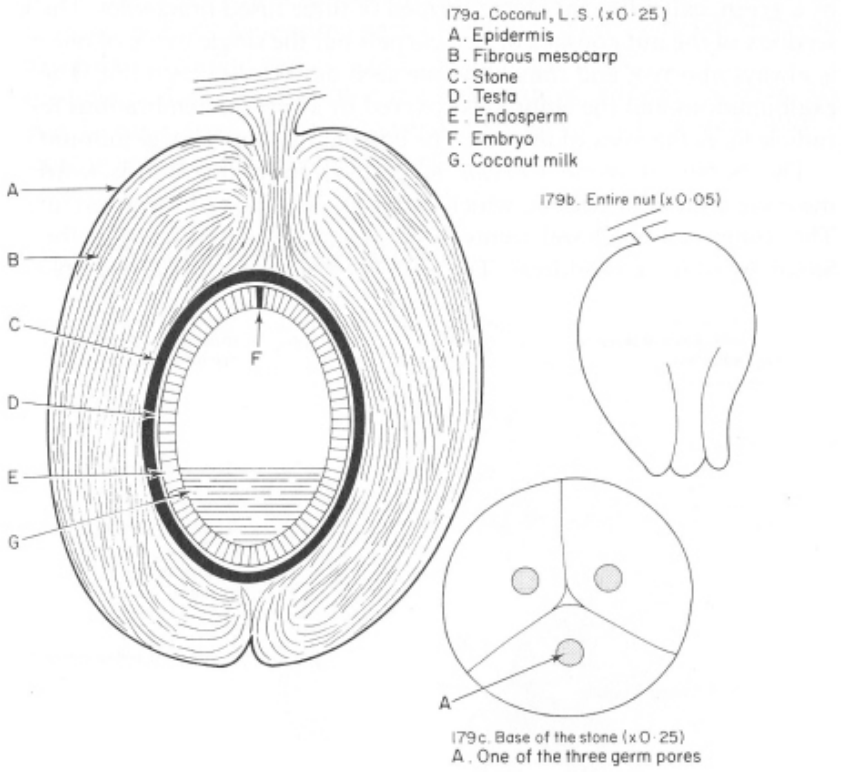
The seeds of horse chestnut have a bitter flavour owing to the presence of tannins which are extracted from the bark and utilized in tanneries. The bitter taste and the presence of other compounds make the seeds unsuitable for human consumption, and neither do horses or most domesticated animals eat them, but they are eaten by deer, squirrel, etc. There are only three edible species of horse chestnut, and these are the American species *A. californica* and *A. octandra*, and the Japanese *A. turbinata*. All three types of horse chestnut are used like sweet chestnuts.

179. Coconut

Coconuts are the stones of the drupes borne by the coconut palm, *Cocos nucifera*, a member of the monocotyledonous family Palmae. It seldom reaches 30 m height and the entire drupe measures an average 30 cm in length and 18 cm in width. The almost spherical stone or "nut" is surrounded by a fibrous coat that develops from the mesocarp and yields the commercial fibre called coir. The epicarp gives rise to the outermost, tough covering, and the endocarp to the woody stone sold as coconut. The seed is endospermous (albuminous) and the endosperm forms a thick inner lining to the stone, enclosing a large central cavity partly filled with coconut milk. The embryo is very small and is situated beneath one of the three fingerprint-like depressions at the base of the coconut, on the surface of the stone. Each depression indicates a carpel, but it is always only one seed that develops in the syn-

carpal ovary. Thus the edible part of the coconut is the endosperm and the milk derived developmentally from it. The endosperm is eaten raw and usually fresh; but dried endosperm, known as COPRA, is used mainly for the extraction of oil or in confectionery. Coconut oil is the commonest vegetable oil.

Coconut palms probably originated on the islands in the Malayan Archipelago, but today they are distributed throughout all the tropical regions of



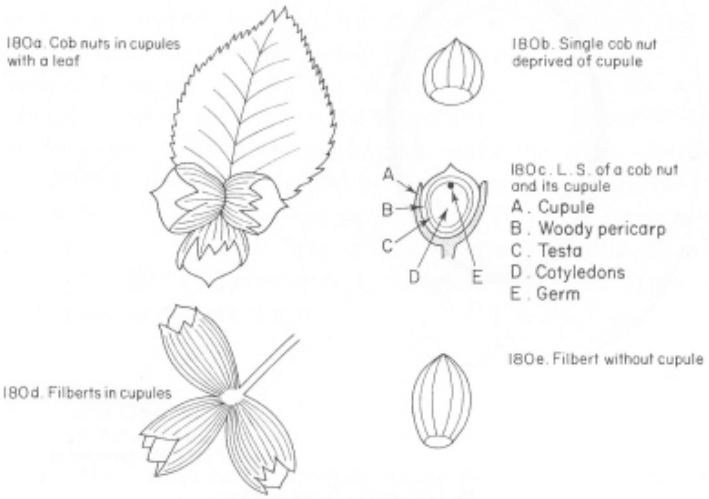
179. COCONUT (*Cocos nucifera*)

the world. However, India, Ceylon, Malaya, Indonesia and the Philippines are still the main producers, while large plantations are also found in Brazil, Mexico and the West Indies. Coconuts float and they may therefore have been spread by water currents. It sometimes happens that coconuts are carried by the Gulf Stream from Central America to Norway, but transport for such long distances can never end successfully; the plant is only able to grow in tropical countries and even if it were able to survive in Norway the coconut would not germinate because its viability is short-lived. The coconut palm is certainly one of the oldest and commonest food plants and its name occurs in Sanscrit, the oldest Indo-European language.

180. Hazel Nut

Hazels are true nuts borne by species of the genus *Corylus*, shrubs or small trees belonging to the family Betulaceae. They are native to the temperate regions of the northern hemisphere. Wild hazel nuts were already gathered and used by the Romans, but today they are mainly derived from cultivated hazels. The nuts occur in pairs or in threes and each is at least partly covered by a green, calyx-like involucre formed of three fused bracteoles. The woody seedbox of the nut consists of two carpels but the single ovule of one of them is always abortive and thus only one seed develops in each nut. The seed is exalbuminous and the embryo is covered by a brown membranous testa; the radicle faces the apex of the nut. The cotyledons store a large amount of fats.

The botanical name *Corylus* is derived from the Greek word *korys*, meaning a hood or helmet, which refers to the shape of the green involucre. The common name hazel seems to be of similar origin: *haesil* is the Anglo-Saxon word for a headdress. The wild species native to Europe are *Corylus*



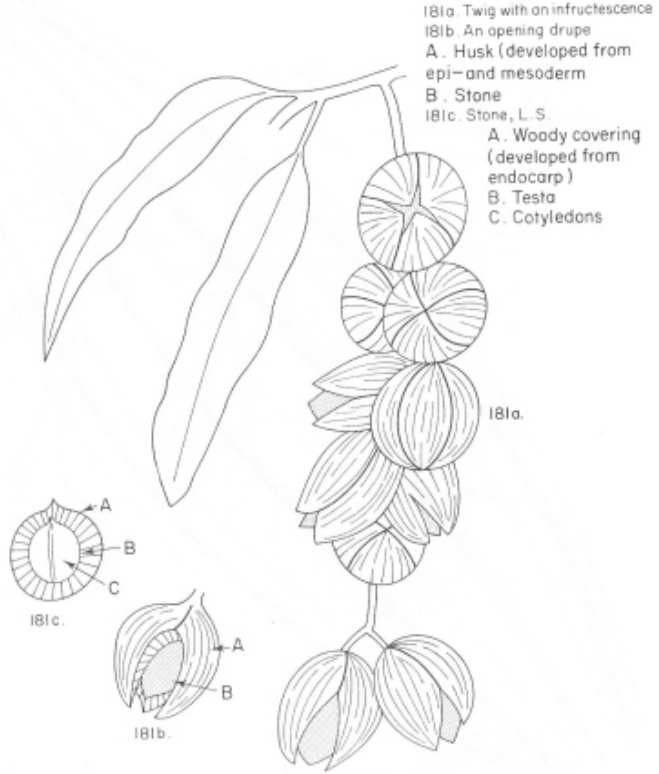
180. HAZEL NUT (*Corylus* spp.) (x 0·5)

avellana and *C. maxima*. The latter is a more robust species from the southern parts of Europe. Present-day cultivated hazels are derived from these species; the cultivated species in Britain are known as COB NUTS and FILBERTS, of which cob nuts seem to have been developed from *C. avellana* and filberts from *C. maxima*. The two types can easily be distinguished by the involucre; the involucre of cob nuts covers the nut only partially, while filberts are surrounded completely by it. It is possible that filberts received their name from their large involucre, if we are to believe the explanation that it is a corruption of "full beard". However, another, perhaps more credible,

etymological explanation is that the Saint's Day of St. Philibert is on 22 August, when the hazel nuts are usually ripe. The specific epithet of *C. avellana* is derived from the name of the town Avellino in Campagna, for centuries the largest centre of the hazel nut industry in Italy. Spain is another leading exporter of hazel nuts; Spanish hazels are normally known as Barcelona nuts, and they differ botanically from the varieties described above. Both Spanish and Turkish hazel nuts are derived from a wild Turkish species, *C. colurna*. In North America the two native species are *C. americana* and *C. rostrata*. Both American species yield nuts with an excellent flavour but they are too small to achieve commercial importance.

The edible portion of the fruit is the seed with or without the testa, and they may be eaten fresh, dried or roasted; they may also be added entire or ground to chocolate, pastries, biscuits etc.

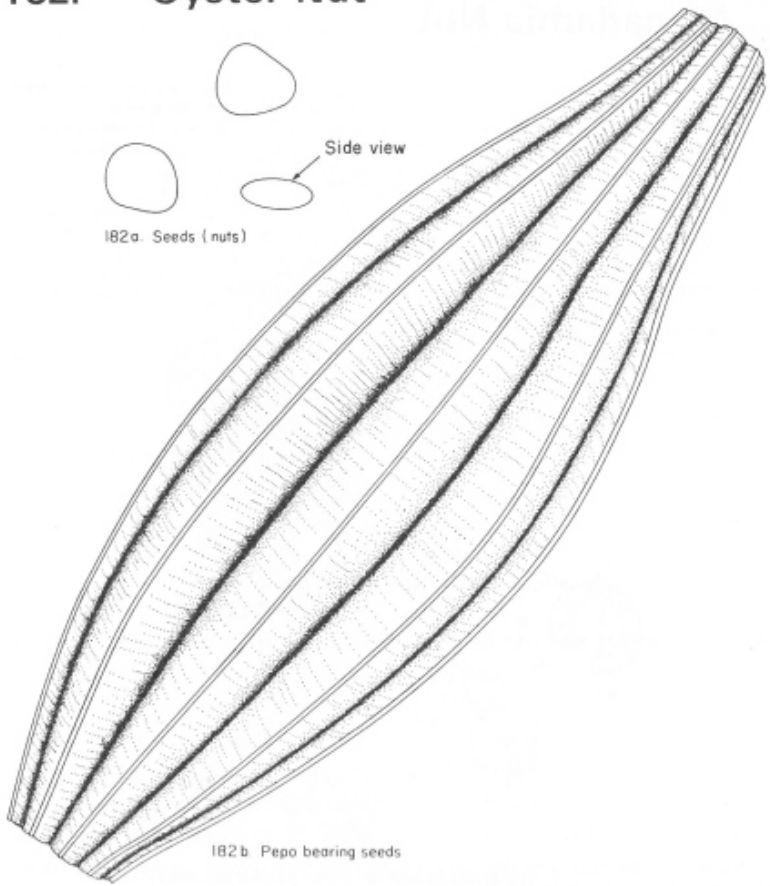
181. Macadamia Nut



181. MACADAMIA NUT (*Macadamia ternifolia*) (x 0·5)

Australia has contributed only a single type to the commercial category of nuts—the stones of *Macadamia* spp. (family Proteaceae). The best known species is *M. ternifolia*, which was discovered in 1870. In 1892 it was introduced to Hawaii, where 60,000 trees were planted, and today Hawaii is the only country where *Macadamia* trees are cultivated. The nuts, also called QUEENSLAND NUTS OR AUSTRALIAN HAZEL NUTS (because of their similarity to hazels), have a smooth, round shell, and the seed together with the husk measures about 2 cm in diameter. The husk covering the stone splits when the seed is ripe. The stone is generally very hard and thick but the variety *M. ternifolia* var. *integrifolia* yields drupes with thin-shelled seeds. The nuts of another cultivated species, *M. tetraphylla*, contain a single exalbuminous seed with a high proportion of fats (66%).

182. Oyster Nut

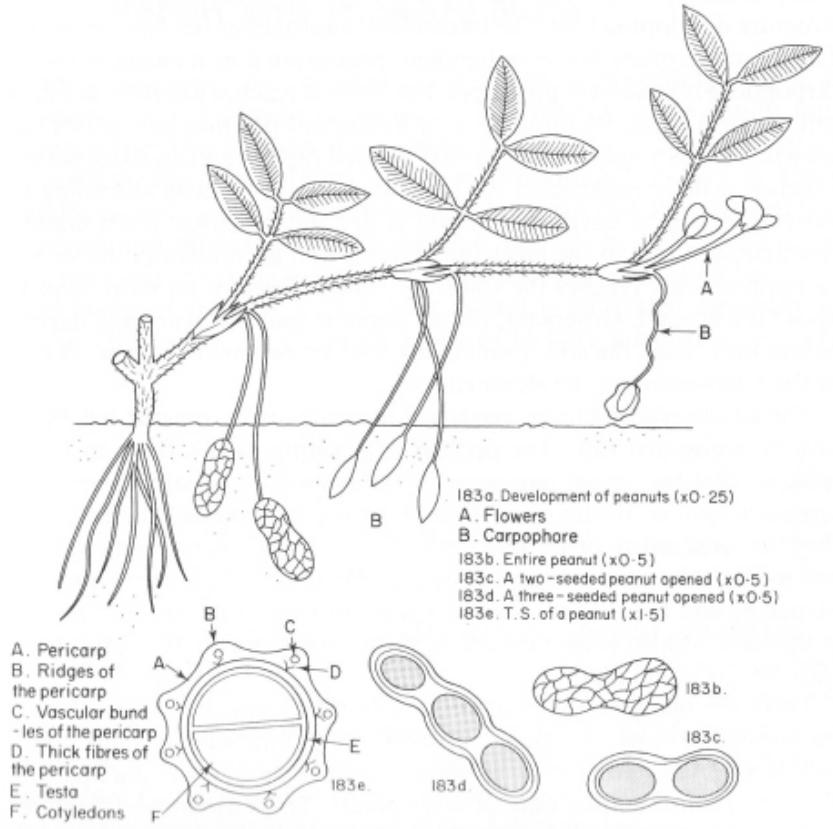


OYSTER NUT (*Telfairia pedata*) (x 0·25)

Oyster nuts are the seeds of a pepo, the fruit of an East African vine, *Telfairia pedata* (family Cucurbitaceae). The seeds, embedded in the flesh of the gourd, are circular and flattened, measuring almost 5 cm in diameter and barely 0·5 cm in thickness. The gourd itself is a large pepo up to 60 cm long and 20 cm thick. It contains 70–100 seeds, and when they are ripe the gourd bursts and scatters them. Oyster nuts are almost unknown in Europe and only a few British chocolate manufacturers import them for use in the production of nut chocolate. However, they are an important food material in their native area of East Africa because they contain large quantities of proteins as well as of fats.

183. Peanut

Peanuts, the commonest commercial nuts, eaten all over the world, are the seeds of *Arachis hypogaea*, a cultivated leguminous species. The plant, which is not known in its wild form is a native of South America and was cultivated



183. PEANUT (*Arachis hypogaea*)

there long before the discovery of the New World. Peanuts were found in Peru in excavations dated at about 800 B.C. The Portuguese introduced peanuts from Brazil to East Africa in the sixteenth century and at the same time the Spaniards brought them from South America to the Philippines, from where they spread to India and all the tropical areas of the Far East. Thus peanuts have been cultivated in the Old World for several centuries.

Some cultivated peanuts have an erect stem, while others are prostrate and creeping. The erect plants produce the fruits (legumes) which contain the edible seeds, along the main roots, while the prostrate plants bear their legumes scattered along the stems. The pods that develop underground next to the aerial shoot can be harvested more easily than the pods buried along the prostrate stems, and therefore the erect varieties are usually preferred to the creeping ones. The plants are sown on ridges like potatoes and the soil must be kept loose to enable the developing fruit to become buried in it. The flowers develop above the base of the stem in compressed spikes and immediately after pollination the non-essential flower parts wither away; the ovary is then pushed into the soil by means of a carpophore, a stalk-like structure developing from the intercalary meristem at the base of the ovary. The tip of the ovary becomes lignified, protecting it as it enters the soil. The carpophore is positively geotropic, but when it reaches a certain depth in the soil, at most 6 cm, its tip turns to a horizontal position and ceases further growth. At this stage the ovary starts to swell rapidly and an indehiscent pod, which is usually constricted between the seeds (1–5 seeds according to the variety), begins to develop. The pod is dry and reticulate when mature; its reticulation is due to the mechanical tissue that accompanies the veins. The carpophore only reaches the soil if the flower develops no more than 18 cm above the ground. Otherwise, the carpophore and the ovary will degenerate before they reach the soil. Peanuts are also known as GROUNDNUTS because of their subterranean development.

The edible exalbuminous seeds are normally eaten roasted but they may also be consumed raw. The process of roasting causes them to lose their testa, so that the actual part eaten is the embryo, consisting mainly of two large cotyledons. Entire or split embryos are often added to chocolate and they are used entire or ground for various confectionery products; roasted and salted, they are used as an appetizer. Peanuts in the form of a paste after blanching and roasting are used as a substitute for butter (peanut butter) but in this case, as also when they are used for expressing oil, the plant should be classified as an oil plant.

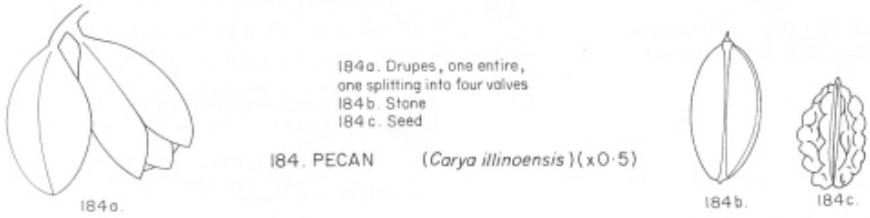
There are many cultivars of peanut, but they may be divided into three traditional groups—Virginia, Spanish and Valencia peanuts. Virginia cultivars may be either erect or spreading (creepers), while the Spanish and Valencia groups consist only of erect plants. The Virginia and Spanish cultivars yield pods usually containing two seeds, which in the Virginia group

have a dormancy period of 30 days or more, and may be very large. In contrast, the Spanish cultivars have small seeds with no dormancy period. Valencia plants also yield small seeds without dormancy but the pods are not constricted between the seeds, as compared with the Spanish ones, and the seeds are 2–5 in number.

The biggest producers of peanuts today are India and China, but neither country exports peanuts in any large quantity and they use them mainly for domestic consumption. On the other hand, the biggest exporter of peanuts is Nigeria. The quantity of peanuts entering the world markets is nearly 1·3 million tons yearly and of this, 0·5 million tons is supplied by Nigeria. The majority of the exported peanuts comes to Europe, where France is the largest consumer, requiring almost half of the total quantity; this is explained by the fact that the peanuts are mainly used for oil extraction. Great Britain, where peanuts are not preferred as a source of oil, imports only about one sixth of the total quantity entering world trade.

184. Pecan and Hickory Nuts

Hickories, *Carya* spp., are an American genus of trees yielding drupes of which the stones are considered as nuts. They belong to the family Juglandaceae, which also includes the walnuts. The species *C. illinoensis*, or *C. pecan*, yields the best nuts, which are known internationally as PECANS. Their exalbuminous seeds are similar to those of walnuts but they are enclosed in a thin, smooth and shiny shell; and unlike the husk of the walnut, the green husk surrounding the stone splits into four valves. The pecan is native to the southern states of the U.S.A. and Mexico and is cultivated especially in Texas and Oklahoma. All the other kinds of hickory nuts are eaten only

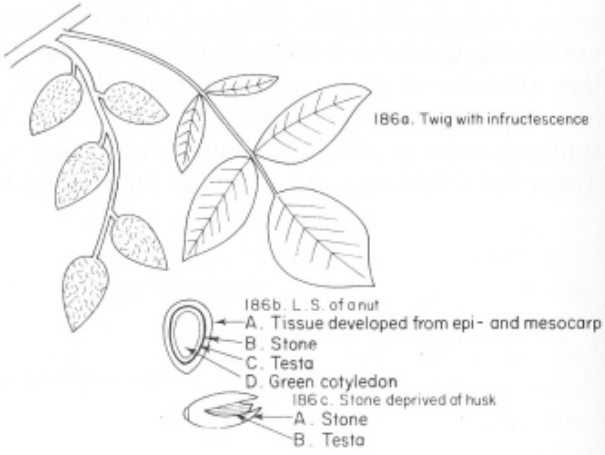


locally and grow in the northern parts of the U.S.A. The most popular kind of hickory nut is the stone of the species *C. ovata*, the so-called shag-bark hickory, in which the thin-shelled stones are embedded in a thick fleshy husk. When the seed is ripe, this husk opens into four valves. Other hickory nuts popular in the U.S.A. are the stones of *C. laciniosa* (BIG SHELL-BARK HICKORY), the PIGNUTS of *C. glabra* and MOCKERNUTS of *C. tomentosa*. Pecan and all the hickory nuts were an important food of the American Indians.

185. Pili Nut and Java Almond

Pili nuts are the stones of drupes borne by the trees *Canarium luzonicum* and *C. ovatum*, members of the family Burseraceae native to the Philippines. *C. commune* is cultivated in Java and its stones are known as JAVA ALMONDS, although this species is indigenous not to Java but most probably to the Moluccas. Java almonds are of lesser importance because their kernels are too small and their shells too hard. However, the hardness of the shell is likewise a disadvantage of pili nuts. Fortunately, cultivators in the Philippines have succeeded in developing a variety with a thinner shell and this has improved their economic potential. The stones of wild *Canarium* spp. are often many-seeded but the cultivated varieties are single-seeded as a result of the abortion of the other ovules. Pili nuts, as well as Java almonds, are exalbuminous seeds and their cotyledons store a high proportion of oil: according to the available data, Java almonds are the richest in fats of the commercial nuts, containing 72% fatty materials. The fleshy, plum-like drupes of some *Canarium* spp. are also eaten for their oily mesocarp; for this purpose, green unripe drupes are harvested and pickled like olives. In this form they are known as CHINESE OLIVES (they are popular mainly with the Chinese), and should be classified as vegetables or flavouring plants.

185. PILI NUT (*Canarium album*) (x 0·5) Fruit and leaf



186. PISTACHIO (*Pistacia vera*) (x 0·5)

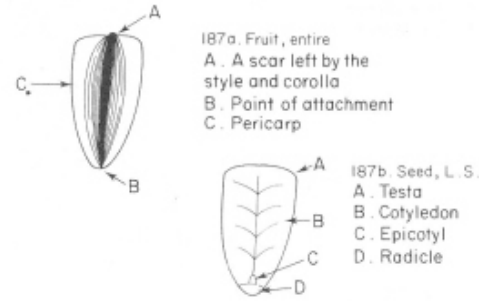
186. Pistachio Nut

Pistachio nuts are exalbuminous seeds enclosed in the stones of drupes borne on a small tree, *Pistacia vera* (family Anacardiaceae). This tree grows in very dry conditions, in poor soil and also at high altitudes. It is able to withstand low winter and high summer temperatures. Wild pistachio trees still occur in mountainous regions of Russia and Turkestan. Today, pistachios are cultivated mainly in Turkey, Syria, Israel, Greece, Italy, France, Spain and Morocco, as well as in Persia and India. They have even been introduced into new countries and are cultivated on a large scale in California, Texas and Arizona. Pistachios differ from other nuts in having green cotyledons. The drupe of *Pistacia* is dry and the shell thin, and when the seed is ripe the stone opens at one end; thus it is easy to remove it by hand without cracking the shell.

Pistachio nuts have been cultivated for at least 3000 years, and are very popular in Arab countries and India, but not many varieties have been developed. They were brought to Rome by the governor of Syria, Lucius Vitellus, at the end of the reign of Tiberius. In Europe today they are valued mainly for the green colour of their cotyledons and are used especially for decorating cakes and pastries. As dessert nuts they are eaten either raw or roasted and salted.

187. Sunflower

The sunflower, *Helianthus annuus*, is a tall annual, belonging to the family Compositae and develops an etaerio of achenes from the huge disc florets. The plant may reach a height of 3·5 m and the capitulum may measure up to 40 cm in diameter. It is a native of America and was brought to Europe from New Mexico in 1510 as a decorative plant. It has never been found in the wild state. It was an important food plant (for its achenes) to the American Indians, who have cultivated it for at least 2000 years. The eating of raw or roasted and salted seeds of the sunflower achenes started in Russia in the eighteenth century, and it seems also that the Russians were the first people to use sunflower seeds for extracting an edible oil. Burkill (1935), however, in his "Dictionary of the Economic Products of the Malay Peninsula", contradicts this view, claiming that the first sunflowers cultivated for the expression of oil were grown in Bavaria in 1725.



187. SUNFLOWER (*Helianthus annuus*) (xl)

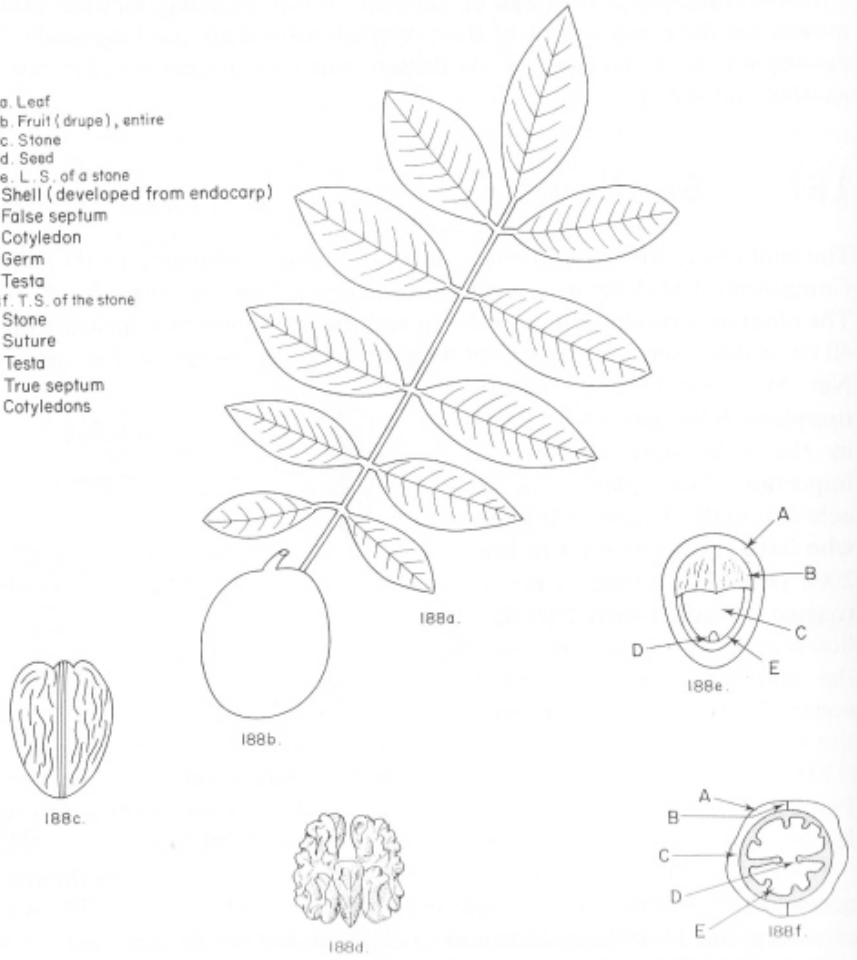
It is common practice in Russia to consume the seeds raw, taking the entire achene in the mouth and then spitting out the inedible pericarp. The seeds contain about 13–20% proteins and 25–35% oil, but the Russians also claim to have produced varieties with 50% oil.

188. Walnut

The tree *Juglans regia* (Juglandaceae) yields dehiscent drupes of which the stones are known as walnuts. In America, where they are imported, they are called English walnuts, while in Europe they are mainly known as Italian or French nuts, in spite of the fact that they are Persian in origin! The name walnut itself is apparently a corruption of their original name, GAULE NUTS, while their scientific name *Juglans* is derived from *glans Jovis*, as they were called by the Ancient Romans.

The walnut, as the stone of a drupe, is covered by a smooth fleshy green husk. The stone contains a single seed developing in a bicarpellary gynoecium and the fusion of the two carpels is marked by the conspicuous suture of the

188a. Leaf
188b. Fruit (drupe), entire
188c. Stone
188d. Seed
188e. L. S. of a stone
A. Shell (developed from endocarp)
B. False septum
C. Cotyledon
D. Germ
E. Testa
188f. T.S. of the stone
A. Stone
B. Suture
C. Testa
D. True septum
E. Cotyledons



188. WALNUT (*Juglans regia*) (x0·5)

stone; the stone opens along this suture when the seed germinates. The lower part of the seedbox cavity is divided by a septum and thus each cotyledon becomes two-lobed, occupying the space on either side of the partition. Further, smaller, lobes arise from many other incomplete septa. When the seed is ripe, the husk opens and the stone falls to the ground. The surface of the stone is wrinkled, showing the suture of the carpels in the median vertical plane. The seed, the edible part of the walnut, consists mainly of two large cotyledons storing fatty substances; when it is dry it is eaten entire, complete with the testa. However, the testa of very fresh walnuts can be peeled off; this improves the flavour, as the fresh testa has an unpleasant bitter taste. Dried walnuts cannot be deprived of the testa, but fortunately the testa loses its bitter taste when it is dried and thus does not spoil the flavour of the embryo.

Walnuts are eaten entire as dessert nuts or they may be ground and added to doughs and creams used in confectionery. Split cotyledons are used for decorating tarts, cakes, etc. and fragments are added to chocolate. Whole drupes are also eaten if they are pickled unripe, before the stone develops.

Some *Juglans* spp. are native to North America and the best American walnuts are yielded by the species *Juglans nigra*, the American black walnut tree. Its disadvantage is its very hard shell, sculptured like the shell of the European walnut, but black. It is practically impossible to crack it without breaking the shell.

Morphological Survey of Nuts of Commerce (NUT)

GYMNOSPERMAE

Seed

173. Pine nut
173. Araucaria nut

ANGIOSPERMAE

Seed

of an achene
187. Sunflower nut

of a nut
174. Acorn
176. Beechmast
178. Chestnut, Sweet

of a capsule
177. Brazil nut

of a legume
183. Peanut

of a pepo
182. Oyster nut

of a drupe
175. Almond
[130.] Cashew nut
179. Coconut
180. Hazel Nut
184. Hickory Nut
185. Java Almond
181. Macadamia nut
184. Pecan
185. Pili Nut
186. Pistachio Nut
188. Walnut

VI. PLANT EXTRACTS

Under the heading "Plant Extracts", plants are included that are used for the extraction of different materials either useful as food or necessary for processing foods of vegetable or animal origin. The former are the nutritive materials obtained from food plants (sugar, starch, proteins and fats), and the latter are the non-nutritive compounds such as gums, dyes and smoke. The gums have increased in importance mainly in recent times, becoming the stabilizers, binding agents, emulsifiers, thickeners, etc. which serve for the amelioration of our foodstuffs in the modern food industry. Another group of non-nutritive extracts from plants are the flavouring agents, e.g. flavour extracts from fruits and the essential oils extracted from spices; these will not be considered here but will be discussed in the next chapter. The extracts are mere organic compounds without any histological structure, unlike cereals, fruits, vegetables or nuts, and they are obtained either by exudation or by mechanical or chemical means.

STARCH PLANTS

All the cereals and pseudo-cereals, as well as some vegetables (e.g. beans, potatoes and breadfruit) supply us with starch. However, starch from such sources does not need to be extracted and the whole histological structure loaded with starch grains (i.e. the whole starchy seed, tuber, etc. complete with its cell walls, proteins and other materials) is used in the form of flour for human consumption. There are, on the other hand, also plants from which pure starch is extracted for nutritional purposes; these are called starch plants, and the most important examples are arrowroot, cassava and sago palm. Potato is also a starch plant but the starch extracted from it is generally considered as unfit for human consumption; it is used for industrial purposes and only rarely in food preparations. Flour is also produced from potatoes and this brings them into the category of pseudo-cereals; potato flour in normal circumstances is used for special culinary purposes and is sold as farina, but in emergencies such as wartime, it is used as a substitute for cereals, mainly as an additive in bread.

189. Arrowroot

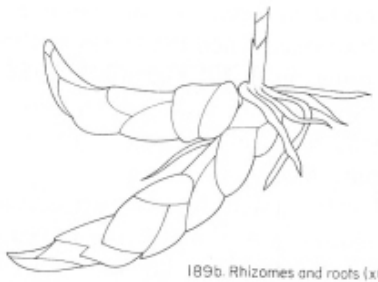
Arrowroot, *Maranta arundinacea*, is a tropical herbaceous perennial native to the American tropics and is a member of the monocotyledonous family Marantaceae. Arrowroot produces rhizomes containing starch, and these are harvested when the leaves of the plant turn yellow, i.e. when the mature rhizomes reach 20–30 cm in length and about 2·5–5·0 cm in diameter. They are covered with small brown or whitish scales which fall from the rhizome, leaving scars on its surface. The development of the rhizomes takes about 11 months.

The harvested rhizomes are cleaned and peeled, and are then washed and grated; the grated material is mixed with water and the mixture strained. The filtered fluid is then allowed to settle out in the form of starch grains, and the starch is dried in the sun and then pulverized. This pulverized material is the commercial arrowroot starch.

Arrowroot is also derived from other plants. The so-called QUEENSLAND ARROWROOT is the monocotyledonous plant *Canna edulis* of the family Cannaceae, native to the West Indies but cultivated chiefly in tropical Australia, in Queensland. Its starchy rhizomes are purple in colour and mature in 8 months. They are used for extracting starch but may also be eaten as a vegetable, whereas the rhizomes of *Maranta* arrowroot are usually not eaten because they are too fibrous. In Brazil arrowroot is also obtained from cassava or manioc (*Manihot esculenta*) and in this case it is known as BRAZILIAN ARROWROOT. Arrowroots of Old World origin include *Curcuma angustifolia* and two species of *Tacca*: *T. leontopetalodes* and *T. pinnatifida*. These are called EAST INDIAN ARROWROOT and their rhizomes, as well as yielding starch, may also be eaten as a vegetable although they have a poor taste and are not easily digestible. A further substitute for the true arrowroot is a gymnospermous plant, *Zamia floridana*, one of the few surviving primitive species that constitute the family Cycadaceae. It yields a starch called FLORIDA ARROWROOT which is extracted from its tuberous underground stem (rhizome). The starch of arrowroots in general is very easily digestible and hence it is used in baby foods and dietetic products. Arrowroot starch is often preferred to flour in ordinary cooking for thickening soups and sauces; unlike flour, it does not add a mealy taste.

189. ARROWROOT (*Maranta arundinacea*)
Starch grains (x 200)

189a. Flowering stem (x0·5)



189b. Rhizomes and roots (x0·5)

189c. Whole plant with Rhizomes and roots (x0·04)

189. ARROWROOT (*Maranta arundinacea*)

[69.] Cassava (Tapioca)

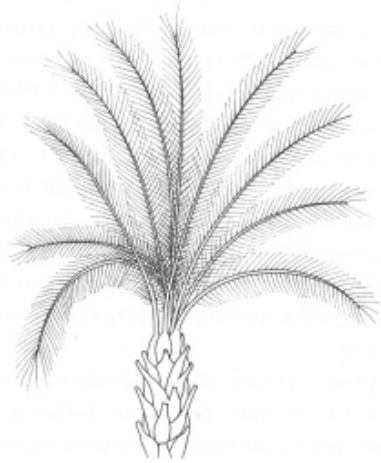
Starch is often extracted from the root tubers of cassava or manioc (*Manihot esculenta*), which has already been discussed in a previous chapter. For this purpose the tubers are first peeled and grated, and the starchy juice is then expressed under pressure from the grated material. The fine starch particles settle out from the juice and if the damp starch is heated on flat pans, the individual starch grains burst, and it then aggregates into small pellets. In this form the starch is known as TAPIOCA. The main exporters of tapioca are Brazil, the West Indies and Indonesia.

[69] CASSAVA (*Manihot esculenta*)
Starch grains (x 200)

190. Sago Palm

Sago palm, *Metroxylon sagu*, is a member of the family Palmae native to south Asia and cultivated mainly in Malaya and Indonesia. The edible starch is derived from the pith of the stem. The entire palm is cut down and its stem is chopped into portions 90–120 cm long, which are then split vertically and the pith removed from them. This takes place just as the palm starts flowering, i.e. when the pith is packed with starch as a reserve food. The removed pith is ground and repeatedly washed and strained. The strained material is then dried, forming small pellets known as sago. A single sago palm yields about 300–400 kg of sago.

190. SAGO PALM (*Metroxylon rumphii*)
Starch grains (x 200)



190. SAGO PALM (*Metroxylon sagu*)
aerial part

Sago is also extracted from another species of *Metroxylon*, *M. rumphii*, which grows in New Guinea, the Moluccas and the Malayan archipelago, as well as from other palm genera, e.g. toddy palm (*Caryon urens*), sugar palm (*Arenga saccharata*), and American cabbage palm (*Oreodoxa oleracea*). Furthermore, the name sago palm is given to some gymnosperms of the family Cycadaceae, because of their similarity to the palm tree and sometimes also because their starch is sold in pellets like sago. The cycads that yield starch from the stem include *Cycas* spp.

On the other hand, there are also cycads that bear seeds from which flour is produced. *Dioon edule* is a Mexican species of cycad yielding the flour for tortilla pancakes, and native to southern parts of Africa is *Encephalartos caffer*, the so-called Kaffir bread which has an enormous strobilus measuring up to 92 cm in length. In Africa young cycad leaves are eaten by natives as a vegetable.

OIL PLANTS

Edible oil plants are all those plants with fruits or seeds from which edible oil can be expressed. Plant oils are used for human consumption or for industrial purposes; although industrial oil plants are classified in a different category from food plants, this does not mean that industrial oils derived from plants are always inedible. For example, linseed oil is used in the West only as an industrial oil while in Russia and eastern European countries the seeds of flax are cold-pressed and the oil obtained from them is used for cooking. Most of the plants used for the expression of oils have already been described because they are used in other ways and can be classified as cereals, vegetables, fruits or nuts. Only the commonest and most important of these will be dealt with again, e.g. maize (*Zea mays*), coconut palm (*Cocos nucifera*), olive (*Olea europaea*), peanut (*Arachis hypogaea*), soya bean (*Glycine max*) and sunflower (*Helianthus annuus*). Others will not be considered in detail. These include: oil expressed from bitter almonds (*Prunus amygdalus* var. *amara*) and used mainly in confectionery; avocado (*Persea americana*)—in the U.S.A. an oil is derived from the fruit wall and is used occasionally for salads and mayonnaise; Brazil nut oil which is expressed from the seeds (nuts) of *Bertholletia excelsa* and is consumed by American Indians in the forests of the Amazon; and hazel nut oil (from *Corylus avellana* and other species) which is suitable for the production of margarine and may be used as a table oil for salads.

There are, on the other hand, many plants used for human consumption as producers of other useful substances, and which yield inedible industrial oils, e.g. walnut, pistachio, hickory. Walnut oil is generally used in the production of paints and cosmetics and only rarely in cooking; if it is to be used for culinary purposes the walnuts cannot be treated with steam and the oil must be expressed by the cold method.

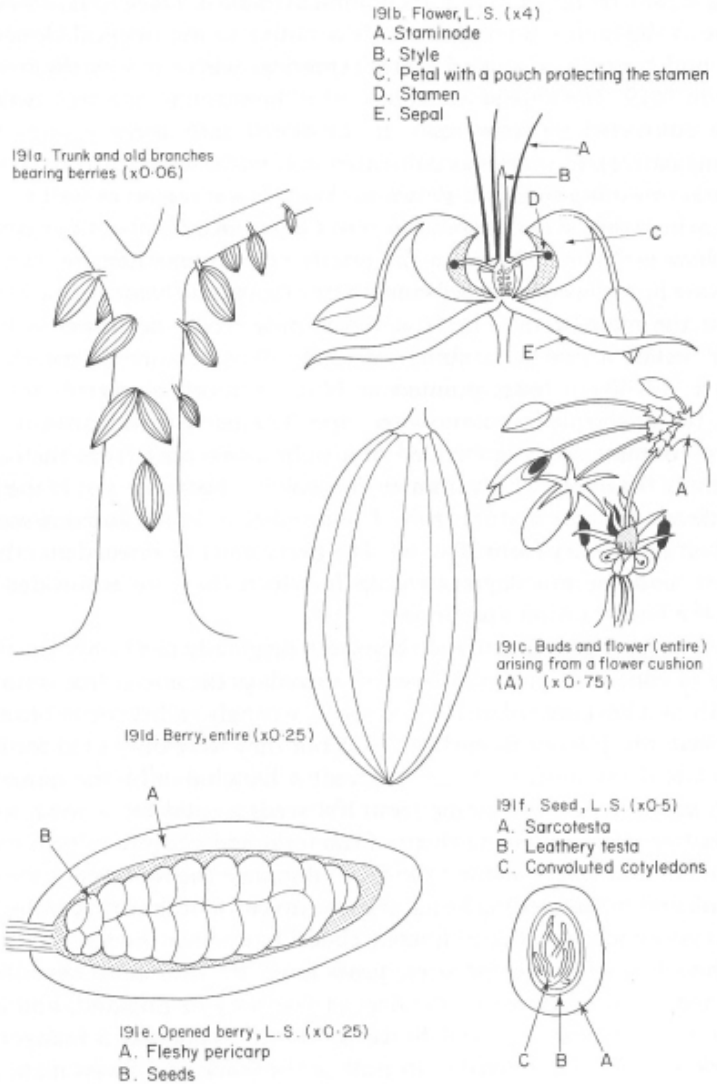
This chapter also omits some edible oil plants that have not already been mentioned in other sections but which are too exotic and not of essential importance. Examples of such plants are some members of the family Dipterocarpaceae, bearing berries of which the seeds are used for expressing oil. These are: *Madhuca longifolia*, which yields Illipe butter; *M. latifolia*, from which Mowra butter is derived; *M. motleyana*, the source of Catian fat; and *M. butyracea*, which yields Phulwara butter. These fats are consumed in their natural state by local people but a large quantity is shipped to Europe and other continents for production of margarine and eventually as substitutes for cocoa butter in the production of chocolate. Another substitute for cocoa butter is Borneo tallow, known also as green butter of Indonesia. This is derived from kernels of *Shorea seminis* var. *martiana* and var. *pinanga*, which belong to the family Dipterocarpaceae mentioned above. In the Far East, in China and Japan, tea-seed oil is expressed from *Camellia sasanqua*; after refining, this is used as a human food.

191. Cocoa

Cocoa is a small tropical tree usually reaching a height of 6–8 m but occasionally it may be 12–14 m tall. Its botanical name is *Theobroma cacao* and it belongs to the family Sterculiaceae. It is native to the tropical slopes of the Andes and possibly also to Central America, where it was discovered by Cortez in 1519. *Theobroma cacao* has never been found in a truly wild state, but its cultivated varieties may be classified into three groups; *criollo* (meaning native), the varieties cultivated in Central America and Venezuela; *forastario* (meaning foreign), grown in the Amazon region as well as in West Africa, where they were introduced into Ghana in 1879 from Fernando Po; and *trinitario*, hybrids between the *criollo* and Amazonian *forastario*. The flowers are borne in compressed cincinnate cymes and always on old branches, even on the main stem. The fruit developing from the flower is a berry, wrongly called a pod in commercial usage. It is a more or less elongated structure, 12–40 cm long, pointed or blunt, smooth or warty, and green, yellow, red or purple in colour when ripe. The berry is indehiscent and the pericarp contains seeds embedded in a pulp developing from the outer integument of the ovule. The fruits are often solitary because most of the flowers fail to develop into a mature fruit. The number of exalbuminous seeds in a single berry may vary from 20 to 60. The berry must be opened and the seeds removed, and the mucilaginous pulp in which they are embedded is lost during the fermentation and drying.

Only the seeds are useful and they were originally used only for the production of chocolate drinks; however, nowadays the cocoa tree is no longer used only as a beverage plant. Cocoa seeds, wrongly called cocoa beans, were introduced into Europe as early as 1526 but they were only used for making a chocolate drink until 1828. In that year a Dutchman by the name of van Houten succeeded in extracting from the seeds a solid fat, known today as cocoa butter, after depriving them of the testa and germ (i.e. from the cotyledons). His aim was to extract the fat to diminish the richness of the chocolate drink and by succeeding he became the inventor of the drink called cocoa, a de-fatted chocolate. The extracted cocoa butter had no special use until solid chocolate was invented some years later. By 1842 solid chocolate was mentioned in the price list of the firm of Cadbury in England, and in 1847 another English firm, Fry and Sons, produced "chocolat à manger". The invention of chocolate mixed with milk is the work of a Swiss man, Daniel Peter who in 1876 produced the first solid milk chocolate ("Gala Peter"). A few years later, in 1879, there was a great improvement in the processing of chocolate in the form of the invention of fondant chocolate. The inventor was another Swiss, Rudolph Lindt, who replaced the rough, coarsely ground chocolate with a finer version produced by repeated grinding and warming.

The cotyledons of cocoa seeds (forastario) contain 2·4% theobromine and 0·8% caffeine. However, a bar of chocolate contains only theobromine, which does not amount to more than 1·1%.



191. COCOA (*Theobroma cacao*)

The largest producer of cocoa seeds is Ghana, accounting for about 30% of the whole world crop, while Nigeria produces 15% and the remaining African states 13% together. In America, Brazil is the largest producer (20%),

and the total production of Central and South America does not exceed 30% of the whole world crop.

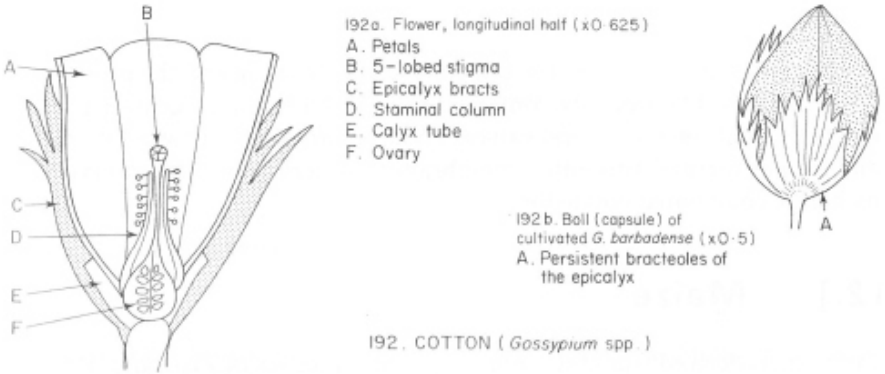
The largest consumer of cocoa products is the U.S.A. (25% of the world production), while Europe as a whole consumes 50% (Germany 13%, Great Britain 10% and the Netherlands 9%).

[179.] Coconut

The coconut palm, *Cocos nucifera*, which has already been described, contains a large quantity of oil in the endosperm of its drupes. The fresh endosperm contains 35% fat and 48% water, while dried endosperm, the so-called COPRA, has 63–70% fat. For the production of either fresh endosperm or copra the stone is broken into two halves. If it is to be converted into copra it is either exposed to the sun or dried over a fire made by burning the empty shells. Fat is extracted from the endosperm by mere pressure, and the remainder with petrol, and after refining and deodorizing with hot vapours the fat is ready to be used for margarine and chocolate. From 3500 to 7000 nuts are required for the production of one ton of copra and one palm yields 25–50 coconuts yearly. The expressed fat is solid. In the U.S.A., Europe and Japan the fat is mainly imported expressed from the copra, while the coconut-growing countries (Ceylon, the Philippines, Indonesia, India, Malaya and Polynesia) export chiefly copra.

192. Cotton

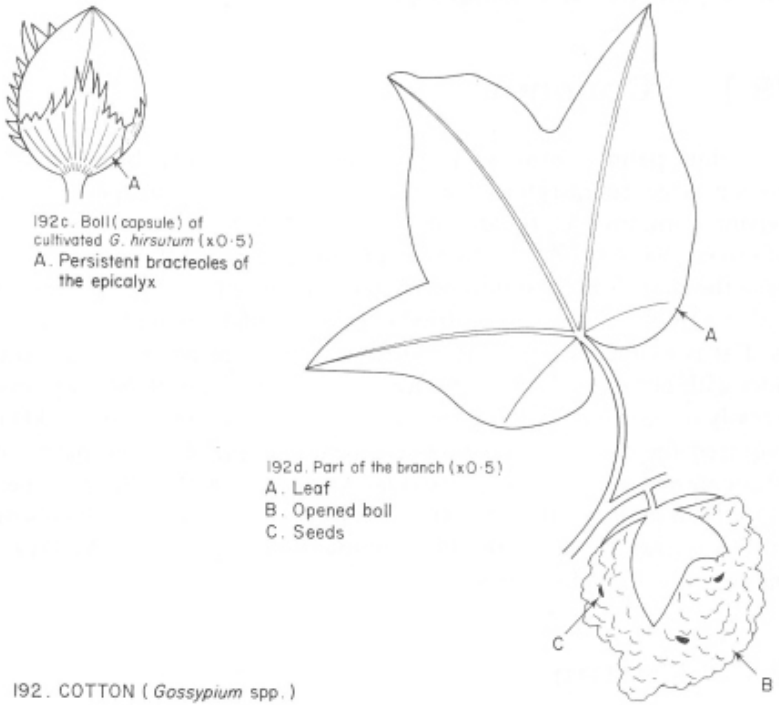
The fibres called cotton, which are in fact not fibres but hairy outgrowths of the epidermal cells of the seedcoat, are produced by *Gossypium* spp. (family



192. COTTON (*Gossypium* spp.)

Malvaceae). *Gossypium* spp. are either annual or perennial shrubs or small trees, growing in the drier parts of tropical or subtropical regions.

They seem to be native to Africa, Asia and America as well as to Australia. The chief producers of cotton today are the U.S.A., Russia, China, Egypt and Mexico. Up to about 1880 the seeds deprived of the cotton fibres were treated as refuse, but since then an edible oil has been extracted from them.



192. COTTON (*Gossypium* spp.)

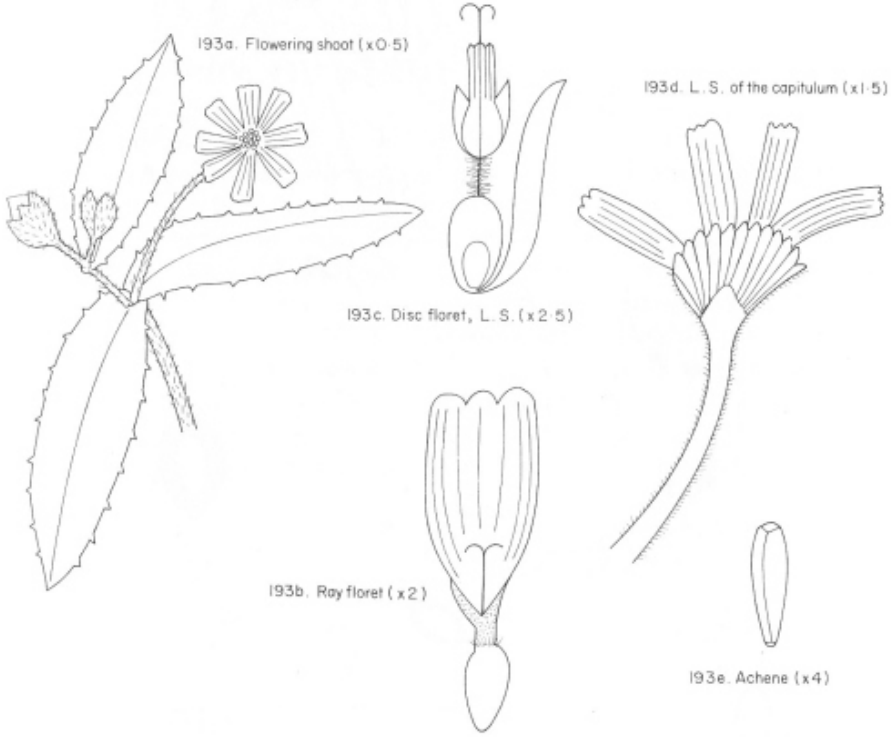
This semi-drying oil is used for salad dressings, cooking and the production of margarines. The seeds are contained in a capsule about 2–5 cm long which opens by splitting into several valves. The seeds are small and exalbuminous, and the perisperm forms only a membranous covering over the embryo with its highly convoluted cotyledons.

[2.] Maize

Maize oil is derived from the embryos of the caryopses of *Zea mays*. Prior to the commercial production of oil these embryos were lost in the process of milling. Refined maize oil can be used like olive oil for all culinary purposes.

193. Niger Seed

Niger seed, *Guizotia abyssinica* (family Compositae) is a branched annual, 0·5–1·5 m tall, bearing capitula 2–3 cm in diameter that yield achenes. It is a native of Abyssinia but was brought at an early date to India, where it has been extensively cultivated ever since. The seeds yield a yellow edible oil with a pleasant nutty taste. The oil is used mainly for culinary purposes but also for illumination and soap production.

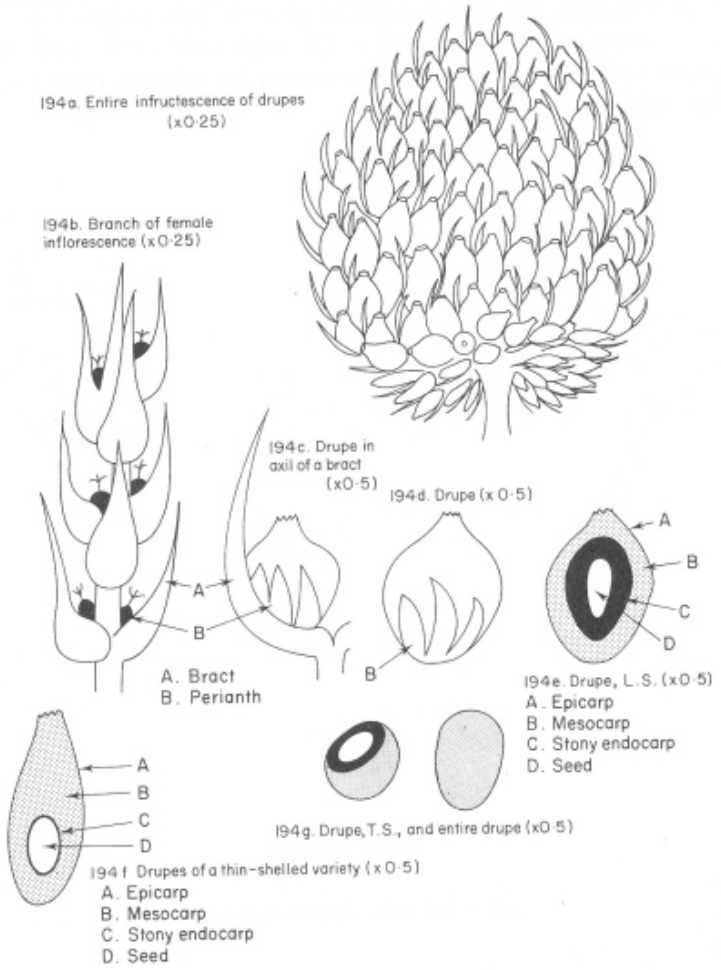


193. NIGER SEED (*Guizotia abyssinica*)

194. Oil Palm

The oil palm, *Elaeis guineensis* (family Palmae, Monocotyledoneae) is native to West Africa but is cultivated today in Malaya, Sumatra, Central America, Venezuela, Brazil, Peru, etc. The plant may be over 10 m tall and as a monoecious plant it produces two types of inflorescence on the same tree.

The male inflorescence is ensheathed in a spathe and consists of a peduncle, usually not longer than 10 cm, bearing spikes with a mass of male flowers which are sunk into the tissue of the spike. The female inflorescence arises from a stouter but shorter peduncle supporting about 150 branches, spikes,



194. OIL PALM (*Elaeis guineensis*)

forming together an ovate compact inflorescence and each branch bearing about 12 flowers. The fruits developing from the flowers are drupes. From the fleshy mesocarp palm oil is expressed while the endospermous seed of the drupe is the source of palm kernel (seed) oil. The endosperm is ruminate and the embryo small. The mesocarp contains 50–65% oil, while the seeds contain between 44 and 53%. The oil of the mesocarp and also of the seeds is solid and is used as a nutritive material, chiefly for the production of margarine.

The palm starts to flower at the age of four years and produces flowers and fruits until it is 50–60 years old. The yield is about 2000 drupes yearly per tree.

The varieties can be classified into four groups according to the structure of the fruit: the group *macrocarpa* contains varieties producing fruits with very thick stony endocarp; the group *dura* has a hard endocarp of intermediate thickness; the group *tenera* produces drupes with a very thin endocarp; and the last group, called *pisifera*, does not form any visible endocarp.

195. Palm Oil of Brazil

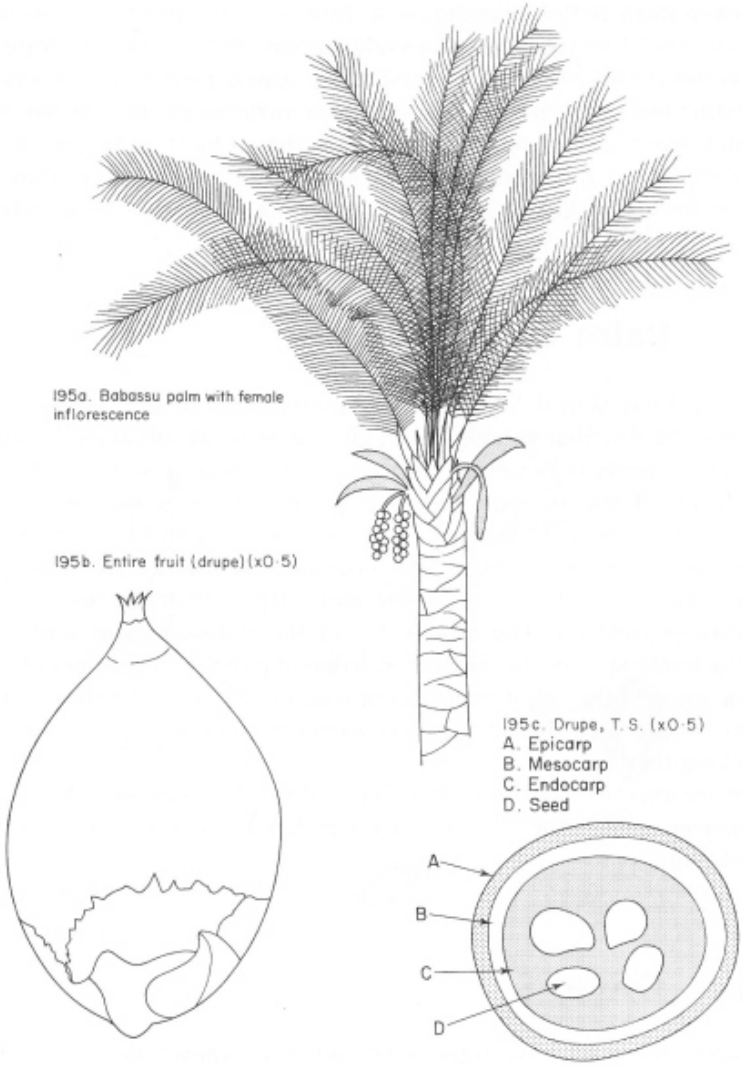
During the First World War, when shipping between the continents was hazardous, the Brazilians succeeded in finding native palms as substitutes for the oil palm. Several Brazilian palms are now used as sources of a solid vegetable oil. These include: BABASSU PALM (*Orbignya martiana* and *O. oleifera*); COHUN PALM (*Orbignya cohune*); LICURI or OURICURI PALM (*Syagrus coronata*) and MURUMURU PALM (*Astrocaryum murumuru*). All these palms yield only palm kernel oil because the mesocarp of their drupes is too thin and mealy to yield oil. The oil content of the endospermous seeds varies according to the species. In the case of babassu palm the seeds yield 63–70% oil, while those of the cohun palm contain about 40% oil. The stones of both palms have very thick shells and it was necessary to invent special machinery for cracking them.

There are also two species of Brazilian palms, the so-called TUCUM PALMS (*Astrocaryum tucuma* and *A. vulgare*) in which both the kernel and the mesocarp yield oil.

(*Illustration on p. 238*)

[93.] Olive

The drupes borne by olive trees (*Olea europea*, family Oleaceae) yield an edible oil which is the most popular cooking and table oil in southern Europe as well as in other Western countries. The oil is non-drying and is expressed from the mesocarp of ripe drupes. The largest producers of olive oil are Spain, followed by Greece, France, Italy, Portugal and Algeria. Nowadays, olives are also cultivated in the U.S.A., Argentina, South Africa and Australia. Olive oil is used for all cooking purposes, as a table oil and also in the canning of sardines. Olive trees do not grow in the tropics, where olive oil is mainly substituted by groundnut oil, and this oil is preferred by people who dislike the taste of olive oil, since groundnut oil is tasteless. Fresh, ripe olives contain 20% oil.



195. OIL PALM of BRAZIL, e.g. BABASSU PALM (*Orbignya martiana*)

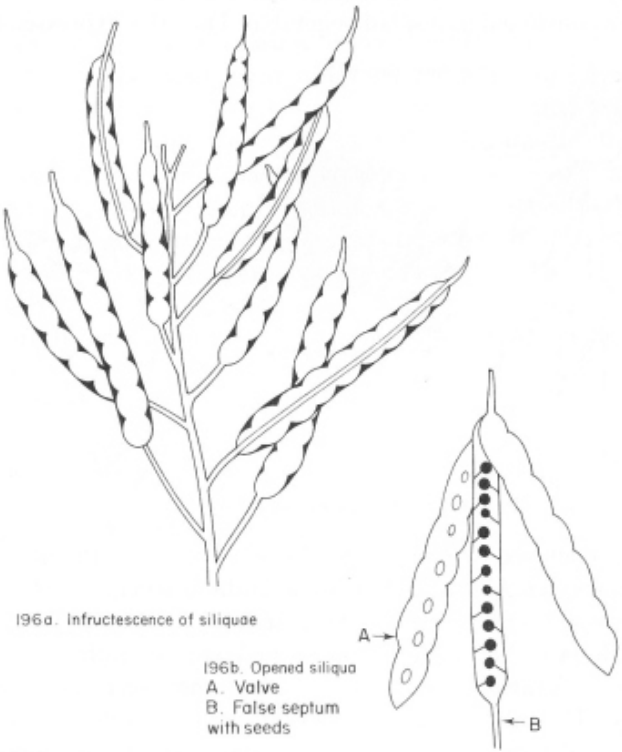
[183.] Peanut (Groundnut)

The oil expressed from peanuts or groundnuts, the seeds of *Arachis hypogaea* (Leguminosae) is one of the most popular vegetable oils. It is used for all cooking purposes, as a salad oil and for the production of margarine. The oil is extracted from the seeds chiefly by hydraulic presses, and the remaining

cake, which has an enormously high protein content, is used as animal fodder; the best quality cakes are ground into flour for human consumption. The advantage of peanut oil over olive oil is its absolute tastelessness. Its consumption shows a steady increase, and even in the period between the First and Second World Wars its output doubled.

196. Rape

Rape oil is the oil derived not only from the seeds of rape (*Brassica napus*) but also from the seeds of other *Brassica* species. The fruit of these members of the family Cruciferae is a siliqua with a false septum to which are attached the small exalbuminous seeds, containing 30–45% oil. Rape was cultivated in ancient times in the Mediterranean area and today is sown in almost all parts of Eurasia, either as a fodder or as a source of oil. It is an annual or biennial herb, 1·2–1·5 m tall, and the siliqua reaches 5–11 cm in length. Its oil is edible and is produced mainly in China, India, Japan, Russia, Sweden and France. Refined rape oil used for salads and for cooking is known commercially as colza oil.



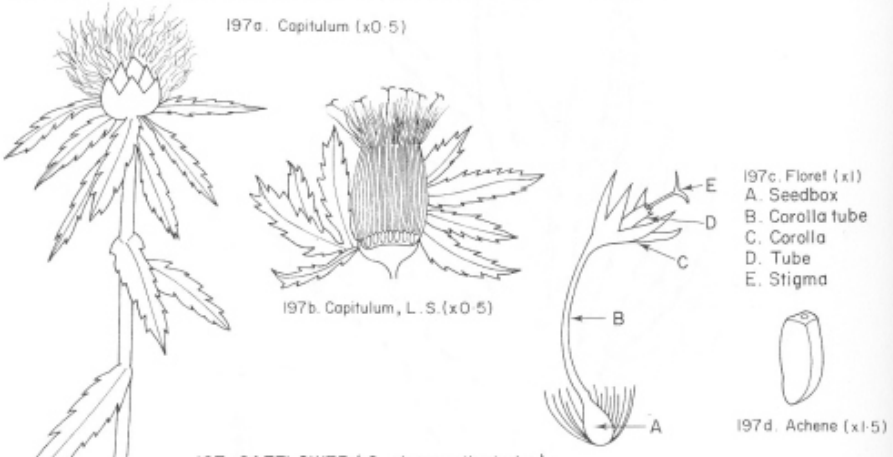
196. RAPE (*Brassica napus*) (x 1)

In India oil is expressed from another kind of brassica, the FIELD MUSTARD, *Brassica campestris*. It is a slender plant 0·3–1·0 m tall bearing siliquae 2·5–5·0 cm long. Field mustard is distinguished as two varieties, *B. c.* var. *sarson* and *B. c.* var. *toria*. The latter is called INDIAN RAPE or TORIA while the former is known as INDIAN COLZA or SARSAN.

There is yet another brassica used for the expression of oil from its seeds. This is called INDIAN MUSTARD (*B. juncea*) and it seems that it is native to Africa but was brought very early to Asia. Today it is an important crop both in Africa and from eastern Europe to China, and it is mainly popular in India. Indian mustard is up to 1 m tall and its leaves may be used as a pot herb. The oil obtained from the seeds, borne in siliquae, is known in India as RAI.

197. Safflower

Safflower, *Carthamus tinctorius*, belongs to the family Compositae and was given its specific epithet because its flowers yield a red and yellow dye. Nowadays, however, it is cultivated more as a source of oil. In addition its leaves are consumed as a salad vegetable. The oil is expressed from the seeds

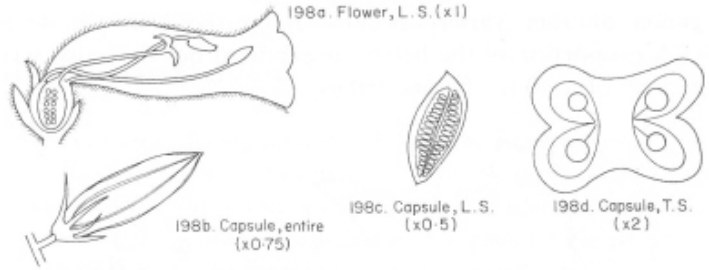


197. SAFFLOWER (*Carthamus tinctorius*)

which are enclosed in achenes. Safflower is native to the mountainous parts of south-western Asia and Abyssinia. India is today the chief producer but safflower is also cultivated on a large scale in the Middle East, some parts of Africa, China and other countries of the Far East. Safflower seeds have been found in the tombs of the Pharaohs, where they were deposited at least 3500 years ago. The oil content of the exalbuminous seed varies between 24 and 36%; it is a drying oil used mainly for paints but is also a popular cooking and table oil in India.

198. Sesame

Sesame, *Sesamum indicum* or *S. orientale*, is an annual herb 1–2 m tall belonging to the family Pedaliaceae. It is native to Africa and was taken at an early date to India; from there it continued to spread and in the first century A.D. it reached China. It is cultivated for its seeds which contain the oil, and are borne in a capsule up to about 3 cm long by 1 cm wide. The capsule is dehiscent and opens by means of two apical pores. It contains many small seeds



198. SESAME (*Sesamum orientale*)

which vary in colour from white, yellow, brown to black according to the variety. The seeds are practically exalbuminous and are very tiny—100 of them together weigh no more than 0·3 g. The oil is extracted mainly for culinary purposes, being used in cooking as well as for the production of margarine. It contains as its principal unsaturated fatty acids oleic and linoleic acids, constituting about 80% of the fats. Only 14% are saturated oils. However, the production of sesame oil is decreasing as a result of competition from soya bean and peanut oils. The sesame seeds contain 45–55% of semi-drying oil.

The largest producer of sesame oil is China, followed by India, Burma, Sudan and Mexico.

According to its usage, sesame may also be classified as a flavouring (see Chapter VII).

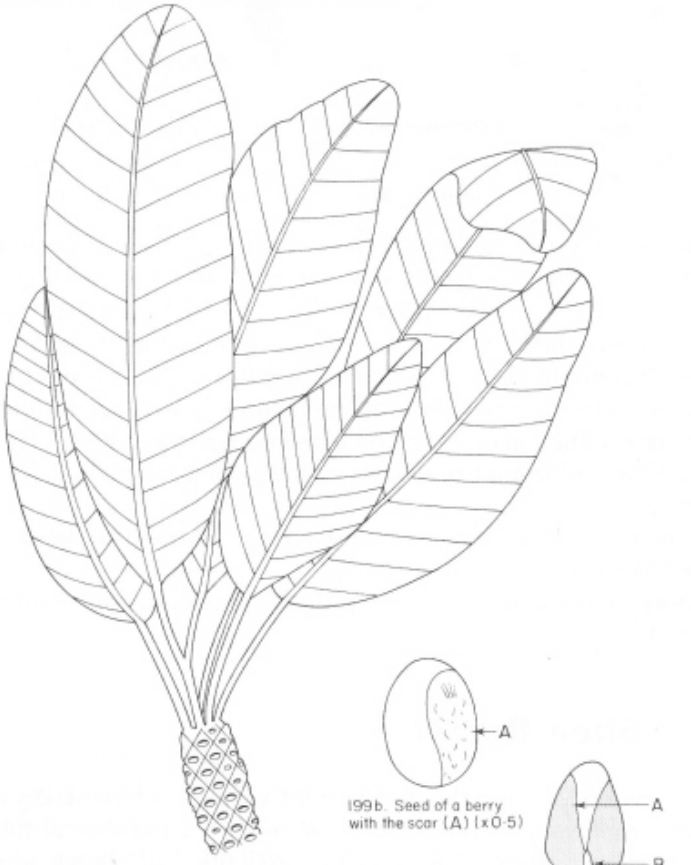
199. Shea Butter

Shea butter is derived from the shea butter tree, known botanically as *Butyrospermum paradoxum* var. *parkii* (syn. *B. parkii*), a member of the family Sapotaceae. It is a medium-sized to rather small tree, 7–13 m tall, growing in drier parts of Central Africa. The mature egg-shaped fruit, about 5 cm long, is a hard berry enclosing in a sweet pulp a single seed, which is almost 4 cm in length, oval and has a shiny brown testa. The pulp, after harvesting, is left to decay and the seeds, called shea nuts, are either exported or the fat is

extracted locally. The main exporting countries are Nigeria, Ghana, Senegal, Mali, the Ivory coast and Upper Volta. In recent years most of the export has been to Great Britain, Japan and Denmark.

The seeds are boiled and the oil (up to 50%) is skimmed from the surface of the water. The fat has a grey colour and a tallow-like consistency. Apart from its use as a cooking fat, shea butter is locally used as an illuminant and as an ointment. In Europe it is used for soap-making, candle production and in cosmetics, while the refined shea butter is used for margarine and in cream fillings for chocolates.

In Uganda another variety occurs—*Butyrospermum paradoxum* var. *niloticum*. A proportion of the berries is exported but they also serve as an important item of food for Nilotic tribes.



199a. Foliage (x0·05)

199b. Seed of a berry with the scar (A) (x0·5)

199c. T.S. of the seed showing cotyledons (A) and germ (B) (x0·5)

199. SHEA BUTTER (*Butyrospermum paradoxum* var. *parkii* or *Butyrospermum parkii*)

[57.] Soya Bean

Soya bean oil is derived from the non-endospermous seeds of *Glycine max* (family Leguminosae). The seeds are produced in pods which are borne in clusters. The variety cultivated for oil extraction contains 14–24% of oil. Soya bean oil, which is a drying oil, is consumed as a salad oil, as a cooking oil and as a raw material for the production of margarines and shortenings. Soya bean oil has been used for centuries in the Far East and it is only in modern times that its use has spread to other continents also.

[187.] Sunflower

Sunflower oil is a semi-drying oil derived from the exalbuminous seeds of the sunflower, *Helianthus annuus* (family Compositae). It produces an etaerio of achenes, each achene containing a single seed. The seeds contain 25–35% oil or even 50% if one takes into consideration the special varieties produced for oil extraction in Russia, the largest producer of sunflower oil.

PROTEIN PLANTS

The post-war population explosion produced many new problems and certainly the most pressing of these is how to supply mankind in the near future with sufficient food. Protein deficiency is already severe in many under-developed countries, mainly in Africa and Asia. The main sources of proteins are meat and fish but the aim is to obtain proteins in larger quantities and more cheaply, from vegetable materials. The plant richest in protein is the soya bean (57) and recently food scientists have succeeded in making the extracted proteins from soya beans palatable. Despite the fact that from time to time newspapers display headlines announcing the invention of "synthetic beefsteak", the creation of "artificial meat" from soya beans, a satisfactory method has only just been invented for changing the texture of soya beans to make them seem like meat. Another recent successful experiment is the "hamburger" made from soya beans that was introduced on the Japanese market. Otherwise, the residue left after the extraction of oil from soya beans, soya bean meal, which is very rich in proteins, has until recently only been used as a fodder and not for human consumption.

SUGAR PLANTS

Sugar plants are important food plants from which sugar (sucrose) is extracted. Sugar was unknown to the ancient nations of the Mediterranean area, and rock paintings show that Neolithic man prepared sweets from honey he collected. The records of the ancient Egyptians also prove that honey was the sole sweetening material known to them and in Russia honey is still a substitute for sugar, at least in remote villages.

However, it should be mentioned that some minor sources of sweetening materials apart from honey were known in the Mediterranean region before the advent of sugar. These are the different sorts of MANNA, mainly resinous exudates. The flowering ash or manna ash, *Fraxinus ornus*, a tree about 10 m tall, produces from incisions a sweet exudate containing up to 80% mannitol, a sugar alcohol known also by the name mannite. It is the only commercial manna and the flowering ash is cultivated today in Sicily and Calabria, but only for medicinal purposes. Another sort of manna is derived from a small shrub about 1 m tall, called camel thorn, *Alhagi maurorum* or *A. pseudalhagi*, growing in the Egyptian and Syrian deserts. This plant exudes a fluid which solidifies on the branches but is easily collected by shaking the twigs over a cloth. Another resinous manna is produced as the exudate of the French tamarisk, *Tamarix gallica* var. *mannifera*, a shrub about 5 m tall growing on the Mediterranean coast. When a scale insect, *Coccus manniparus*, punctures its bark, the plant produces an exudate which falls to the ground where it solidifies during the night.

The true manna which is described in the Bible, a form of nourishment falling from heaven, seems to be quite a different phenomenon. This could be explained as the fall of the lichen *Lecanora esculenta* and perhaps of some other species such as *L. affinis*, *L. fructidulosa* and *L. tartarea*. *Lecanora* ranges from southern Russia to Syria and Iran and when it is dry it can be torn out of the soil by the wind and transported for many miles. In more recent times, such a "rain of food" has been known to occur in Iran in 1854, and in 1891 it occurred in Turkey where it coincided with drought and famine. The Arabs gather the lichens and prepare a bread using them as an admixture with meal. True manna is a food plant belonging to the vegetables together with the algae and fungi. The cyanophyte *Nostoc* (Blue-green algae) sometimes also occurs in the form of true manna, but otherwise it is cultivated as a vegetable in China.

Honey and some kinds of manna were the only known kinds of sweetening in the Mediterranean area until the Arabs introduced sugar into Egypt in the seventh century A.D.

SUGAR (sucrose) was first derived from *Saccharum officinarum*, the sugar cane. The name *saccharum* originates from the Sanscrit word for gravel, *sarkara*, referring to the gravel-like appearance of the lumps of unrefined

sugar. This word has been further corrupted to give the English *sugar*, *sucre* (French), *Zucker* (German), *sachar* (Russian), etc. Sugar was first extracted from sugar cane in India at least 2300 years ago. From India sugar processing was introduced by the Chinese into the countries of the Far East, and by the Arabs to the West. However, it is doubtful whether India is its country of origin, and some authors believe, in the light of modern research, that sugar cane is native to New Guinea from where it spread to Indonesia and the Asiatic continent in prehistoric times. Be that as it may, it is well established that sugar was known in Persia about A.D. 500, and that it was introduced into Egypt in A.D. 641 by the Arabs. The Arabs also brought sugar to Spain 100 years later (in A.D. 755) and supplied the entire western world with sugar during the Middle Ages. Throughout the centuries the price of sugar has remained high, in spite of the fact that the Arabs started cultivating their own sugar cane in many parts of the Mediterranean region. Sugar was as expensive as a precious spice and only rich people could afford it. Towards the end of the Middle Ages the supply of cane sugar diminished, chiefly as a result of the devastation of sugar cane plantations by the Crusaders and other invaders of the Arab Empire. However, when America was discovered, Europeans soon started their own plantations of sugar cane there. Columbus, on his second voyage of 1493 took the sugar cane to the island of Santo Domingo. As soon as slaves from Africa began to be supplied to the New World, the cane sugar industry was well established and could supply Europe with much cheaper sugar than that previously obtained from the Arabs. Thus, by the eighteenth century, sugar was already a common article of commerce in Europe.

When the European continent was cut off from overseas at the beginning of the nineteenth century, during the Napoleonic wars, European people who had become accustomed to sugar imported from the colonies started to produce sugar from beet which will grow under the European climatic conditions and does not require tropical or subtropical regions for its cultivation. However, the work to substitute another plant for sugar cane began as long ago as 1747 when A. S. Marcgraf, a professor of physics at the Academy of Science in Berlin produced a treatise on the high sugar content of beet. This discovery was utilized much later by his successor at the Academy, F. C. Achard, who himself was of French origin. Achard in 1799 succeeded in obtaining an interview with the Prussian king Friedrich Wilhem III and presented him with a loaf of sugar which he had produced from beet. In 1803, with the support of the government, he built in Silesia the first factory for producing sugar from beet. The French continued to lag behind the Germans and Napoleon did not become interested in the production of sugar from beet until 1811, when he was presented with a sugar loaf by B. Delessert who had succeeded in making it from beet at Plassy. The end of the Napoleonic régime almost meant the death of the European sugar industry and its revival did not really start until after the abolition of slavery in 1848. From then on, the

production of sugar from sugar beet flourished and at the end of the last century it greatly exceeded that from sugar cane. However, in the twentieth century the output of cane sugar has again become much larger than that of beet sugar.

Minor sources of sugar are the sugar maple, sorghum and some palms. These form an almost negligible portion of world sugar production, as does the production of malt, maltose sugar for use in confectionery and derived mainly from barley.

Finally, one must include all plants secreting NECTAR, a sugary solution which is consumed by man indirectly in the form of HONEY; this is produced from the nectar by bees, chiefly by the evaporation of water and the hydrolysis of sucrose. In honey about 1% of sucrose remains and the bulk, about 75%, is composed of fructose, glucose and other reducing sugars.

[1.] Barley

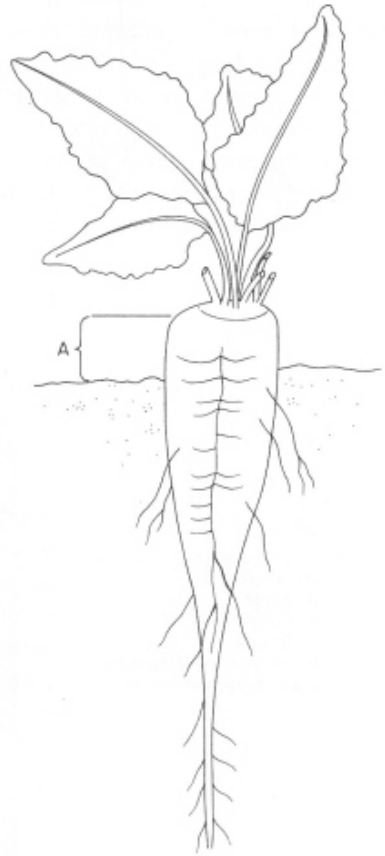
The germinating barley is sweet because it contains malt which may be extracted and dried. Malting is the first step in brewing beer before the alcoholic fermentation begins, but to arrest fermentation and obtain the malt, it is extracted and dried in kilns. Malt is derived from endosperm and is almost pure maltose, a sugar whose sweetening power is much lower than that of sucrose. It is often used for sweetening, for example in a beer which by its addition becomes sweet and dark, but contains a very small amount of alcohol (German *Malzbier*). Some confectionery is sweetened with malt, and malt sweets are popular throughout Britain. Nutritive drinks are also prepared from malt but its main use is without doubt in breweries for brewing beers, when malt is split up into alcohol and carbon dioxide.

[11.] Sorghum

Some varieties of the cereal sorghum, mainly the sweet sorghums or sorgos, are used in the immature state as fodder or as a source of syrup. For this latter purpose, the green, immature stems are harvested and a juice is expressed from them that contains sugar, but in an insufficient amount for crystallization. Sorgos have therefore been used only for the production of syrup, the juice being concentrated by evaporation. However, more recently, in the U.S.A., the difficulties of production of sugar from sorghum have been overcome and today it is possible to obtain sugar as well as syrup, although sugar from sorgos is much more expensive than that from sugar cane or sugar beet. Sorgos syrup is produced for use in cooking, mainly in the southern states of the U.S.A.

200. Sugar Beet

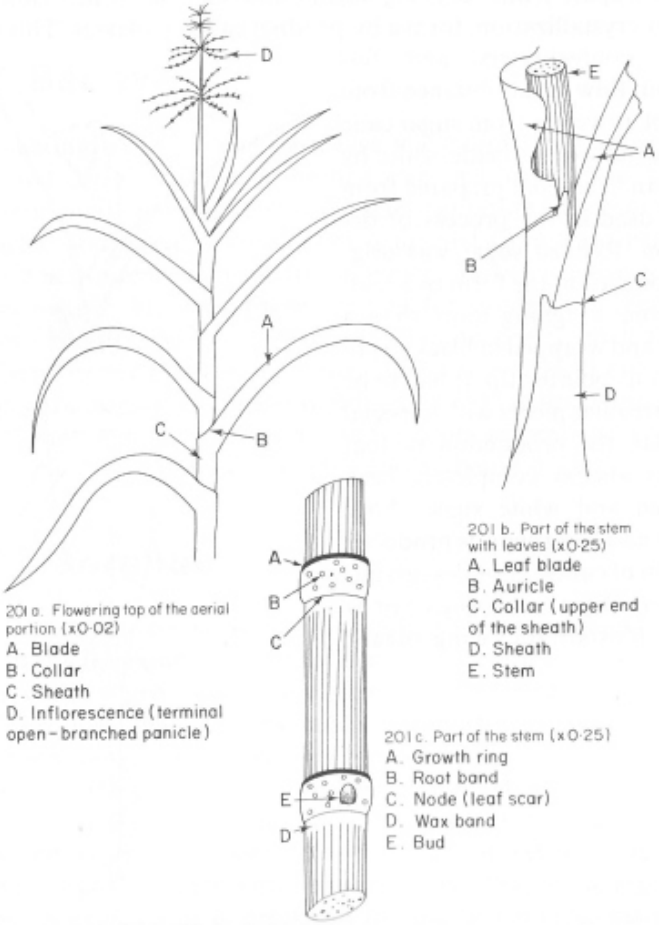
Beet sugar is extracted from *Beta vulgaris* var. *altissima* (family Chenopodiaceae). The part yielding the sugary juice is the swollen taproot which is also partly a swollen hypocotyl. Like all economically important biennial beets, sugar beet is derived from *B. vulgaris* var. *maritima*, a native of the Atlantic and Mediterranean shores of Europe (other derivatives include beetroot and mangold). The juice expressed from the swollen taproot and hypocotyl normally contains 16% sucrose but may reach 20%. Sugar beet grows in the temperate regions and does not even require a hot summer. The largest producers are the U.S.S.R., U.S.A. and France. Sugar derived from sugar beet juice is almost pure sucrose, as is the case with sugar cane. The impurities, apart from reducing sugars and sucrose, which cannot be extracted by crystallization, form a by-product called molasses. This is used for cooking, confectionery and fermentation. Raw sugar obtained from sugar beet as well as from sugar cane is brown, but can be made white by refining, and charcoal prepared from bones is used in the process of decoloration. Refined sugar was originally produced in the form of a loaf, a solid cone weighing more than a kilogram and wrapped in black paper except for its pointed tip. It had to be cut into irregular pieces with a special axe. Today the production of loaf sugar has almost completely been abandoned and white sugar, both from beet and from cane, is produced in the form of cubes, granules (granulated and the finer caster sugar) or as a powder (custard and icing sugar).



200. SUGAR BEET (*Beta vulgaris* var. *altissima*)
A. Hypocotyl (x0·2)

201. Sugar Cane

For many centuries sugar cane was the only plant from which sugar was extracted. It is a large perennial grass (family Gramineae), known botanically as *Saccharum officinarum* and native to south-east Asia. It grows only in tropical and subtropical climates, between the latitudes 35°N and 35°S, and requires a temperature that never falls below 60–62°C. It reaches a height of 2·7–6·0 m and the stem, the source of sugar, is up to 5 cm in diameter. The internodes are usually about 15 cm long and rarely exceed 25 cm. They are limited by conspicuous nodes. Close above each node arises a lateral bud which is associated at the base of the internode with one or more whorls of semi-opaque whitish spots representing root initials. Each bud is



201 a. Flowering top of the aerial portion (x0·02)
A. Blade
B. Collar
C. Sheath
D. Inflorescence (terminal open-branched panicle)

201 b. Part of the stem with leaves (x0·25)
A. Leaf blade
B. Auricle
C. Collar (upper end of the sheath)
D. Sheath
E. Stem

201 c. Part of the stem (x0·25)
A. Growth ring
B. Root band
C. Node (leaf scar)
D. Wax band
E. Bud

201. SUGAR CANE (*Saccharum officinarum*)

capable of developing into a new plant and the cultivated sugar cane is therefore reproduced by cuttings taken from the upper portion of the stem, measuring about 20–25 cm in length. The stem resembles a bamboo stem with its conspicuous internodes. The leaves are alternate and consist of a sheath 20 cm long and a blade 60–120 cm long by 2–10 cm wide. The inflorescence, called a tassel or arrow, is an open, much-branched panicle arising from the terminal internode. The flowers are bisexual but generally do not develop seeds. The part harvested is the stem which is cut off by hand with a knife or cutlass; but in Australian plantations and in Louisiana machinery for cutting the canes has been introduced. The stem, deprived of leaves and flowering tops, is cut into sticks which are then delivered to the sugar factories, where the juice is expressed by milling. The amount of sucrose in the pith of the cane varies from 14 to 17% and the cane is harvested when sucrose is at a maximum since the reducing sugars are unwanted. The harvest usually takes place when the cane starts to flower.

Today the largest producer of cane sugar is India, followed by Brazil and Cuba. Before the Second World War, Java was the second largest producer. Pakistan, the Philippines, the West Indies, South Africa and Australia (Queensland) are further important producers of cane sugar. In the U.S.A. sugar cane as well as sugar beet is cultivated on a large scale but nevertheless a considerable amount is still imported. Most of the sugar imported into the U.S.A. used to come from Cuba, before this state joined the Communist block.

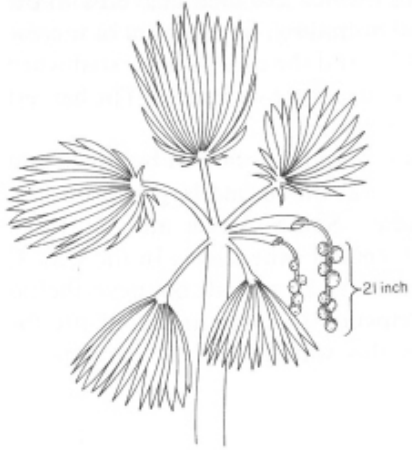
202. Sugar Maple

The species of maple, *Acer nigrum* and *A. saccharum* (family Aceraceae), are the sources of sugar confined solely to Canada. Reports by the earliest explorers show that the sugary material obtained from the trees by tapping their stems was already used by the native American Indians. The maple sugar industry was much more important at one time than it is today, but it still survives. The stem is tapped by boring holes in it and 40–100 l of the sugary sap may be collected from a single tree during the season. The sap is collected in the early spring (February and March) and is mainly converted into a syrup, which is used for sweetening, confectionery and for flavouring tobacco. One litre of syrup is obtained from 30–35 l of the sap.

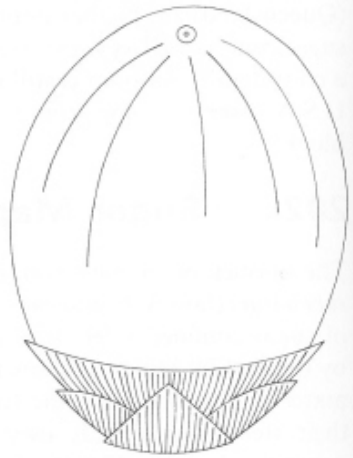
202. SUGAR MAPLE (*Acer saccharum*) Leaf (x0·15)

203. Sugar Palms

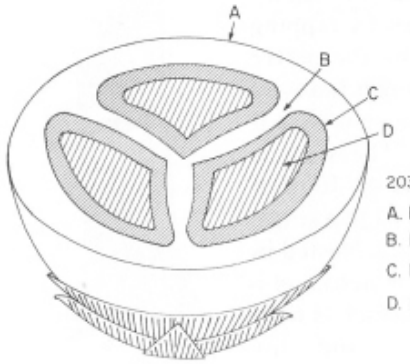
A sugary sap may also be obtained from various palms by tapping their stems or their inflorescences before they open. The sugar-yielding palms include the following: the WILD DATE PALM, *Phoenix sylvestris*; the TODDY PALM, *Caryota urens*; the COCONUT PALM, *Cocos nucifera*; the PALMYRA PALM, *Borassus flabellifer*; and the GOMUTI PALM, *Arenga pinnata*. The sap, of which the sugar content is about 14%, is collected and converted into a syrup by boiling. After cooling this hardens into lumps which are sold. The oldest and largest palm sugar industry is in India.



203a. Palm with fructescence



203b. Entire drupe (x0·5)



203c. T.S. of the drupe (x0·5)
A. Epicarp
B. Mesocarp
C. Endocarp
D. Seed

203. PALMYRA PALM (*Borassus flabellifer*)

204. Nectar Plants visited by bees

Nectar plants are all flowering plants equipped with nectaries producing nectar, a sweet fluid which is collected by insects. The collection of nectar and consequently also of pollen is normally the only reason why insects visit flowers. Pollination results automatically from collection of nectar and is not a deliberate action by the insects visiting the flowers, apart from some rare exceptions. The collected nectar is the food of the insects but is not in itself a human food: it must first be converted into honey by bees.

Bees bred for the production of honey are mostly of the species *Apis mellifera* (Hymenoptera). They collect the nectar by means of their proboscis and the collector bees return with their load of nectar to the hive. There they transfer it to the house bees which process the nectar by means of their mouthparts and then store it in the cells of the honeycomb.

Nectar is a sugary fluid consisting of water in which fructose, glucose and sucrose are dissolved. The proportions of these sugars cannot be stated because they vary considerably according to the species of plant. But nectar consists mainly of fructose, and the amount of sucrose in it is much greater than in honey. Water forms about 55%.

The chemical composition of honey is as follows:

Water	17·20%
Fructose	38·19%
Glucose	31·28%
Sucrose	1·31%
Maltose and other reducing sugars	7·31%
Higher sugars	1·50%
Acids, proteins, minerals	1·00%
Enzymes, pigments, vitamins	2·21%

Nectar is converted into honey mainly by the evaporation of water and the hydrolysis of sucrose by the enzyme invertase which acts on sucrose during its storage for a varying length of time. The other substances are added in small quantities to the nectar by the house bees which handle it in the hive, the enzymes that are added being secreted by the thoracic glands. Bees are able to use nectar for honey production from an extremely large range of flowers but they commonly visit only a single kind until that has been completely exploited. Since nectar is the raw material for honey it must be indirectly considered as a human food and the plants producing it and visited by bees as a type of food plant—sugar plants.

GUM PLANTS

Gums are carbohydrates occurring as natural colloids in plants—in algae, gymnosperms and angiosperms. They can be divided into: (1) *seaweed extracts*, e.g. agar and carrageenan; (2) *tree exudates* and *extracts*, e.g. gum arabic and larch gum; (3) *seed gums*, e.g. carob seed gum and guar gum; and (4) *semisynthetic gums*, e.g. sodium carboxymethylcellulose and methylcellulose. Also belonging among the naturally occurring gums are the pectic substances forming the middle lamella between cells walls, and present in the cell walls themselves. Pectin, one of the pectic substances, is found mostly in fruits, and in northern parts of Europe mainly in apples; for this reason pectin is described under the heading Apple (121).

Pectin is used in the home as well as in the food industry in the production of jellies, jams and marmalade and has always been extremely important. The other extracted gums have mainly been used for various industrial purposes such as finishing textiles, printing calico, in paint preparation, cosmetics, etc. and only recently have gums been used in the food industry. They are now used as adhesives, binding agents, crystallization inhibitors, clarifying and emulsifying agents, foam stabilizers, thickeners, etc.

ALGAE

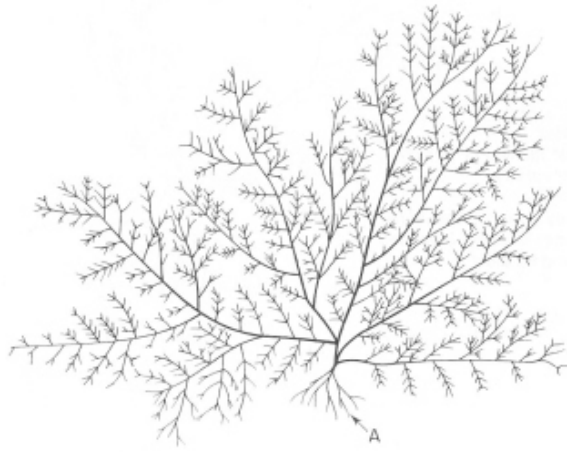
205. Agar

Agar, or originally agar-agar, is produced from special seaweed, *Gelidium* spp. (Gelidiaceae, Rhodophyta). Its production was accidentally discovered by a Japanese innkeeper in 1658, but the name agar-agar is of Malayan origin and means the mucilage derived from a red alga, *Eucheuma* spp. Soon after the extraction of mucilage from *Gelidium* was invented, Japan became the only important exporter of agar, but the name agar was not adopted until the end of the nineteenth century. The most important species of *Gelidium* for the production of agar is *G. amansii* which is similar to Irish Moss. Agar is mostly important as an industrial material and is used chiefly in laboratories as a solid medium for the culture of micro-organisms; it was introduced into bacteriology by the founder of the subject, Robert Koch. Before that, agar was exported to Europe and North America from the Far East mainly for desserts and in Japan and China it was mainly used for sauces, soups and jellies. At the present time, agar is also used in the modern food industry as a thickening agent, emulsifier and stabilizer for sauces, mayonnaise, cakes, beer, cheese, ice creams and candies.

The production of agar is not simple, and its main features are as follows. The harvested algae are dried and partly bleached on the beach. In this state

they are sold to factories, where they are cleaned by beating, pounding and washing in fresh water and then boiled. By boiling the gelatinous matter is extracted and it is then strained off, cooled down and frozen. As the frozen mucilage thaws, water runs out of it and carries with it any impurities, leaving clear agar behind. The agar purified in this way is then dried. Dried agar is soluble in hot water and a 1% solution sets at 35–50°C into a firm gel which melts at 80–100°C. Agar consists of 3,6-anhydro-L-galactose and D-galactopyranose residues in varying proportions.

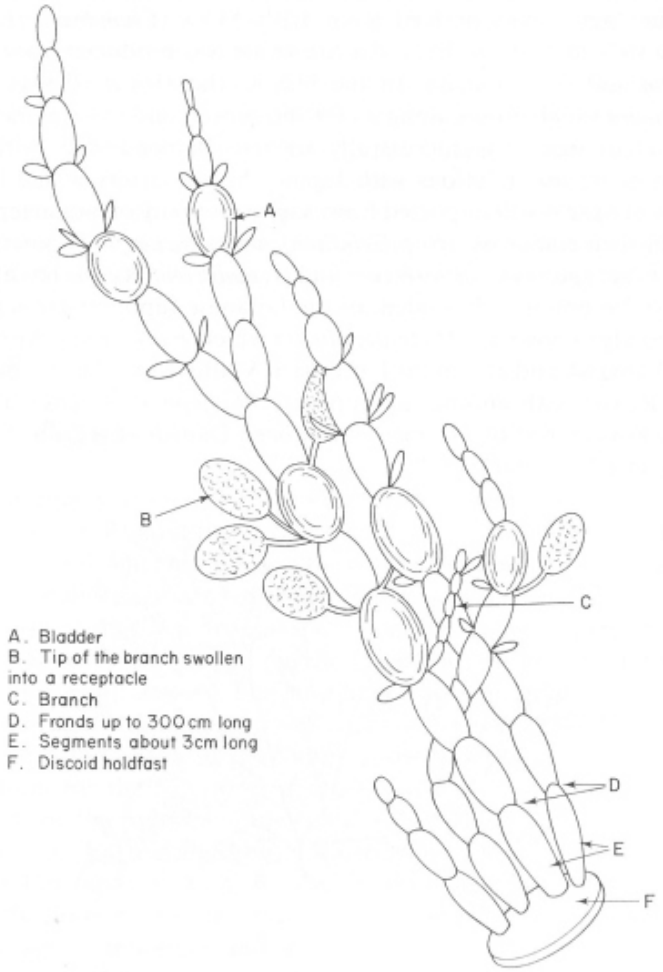
During the Second World War, when the supplies of agar from Japan were cut off from most countries, they tried to produce agar from indigenous algae. In Britain "agar" was derived from Irish Moss (*Chondrus crispus*) and *Gigartina stellata*, while in Ireland a substitute was produced from *Gelidium pulchellum* and *G. latifolium*. In the U.S.A. the alga used was *Gelidium cartilagineum* which grows along its Pacific shores, and the Americans' own production of agar was successfully started. In peacetime, with the resumption of normal relations with Japan, three-quarters of the U.S. consumption of agar is still imported from Japan and only one-quarter supplied from their own resources, from *Gelidium cartilagineum* and sometimes also from the other species *G. arborescens* and *G. nudifrons*. Russia has also found a means of becoming independent of the Japanese supply: agar is produced from a red alga known as *Ahnfeldia plicata* which grows in the Arctic region near Archangelsk and also in the Far East at Vladivostok. The Black Sea also supplies Russia with another agarophyte, *Phyllophora nervosa*. Denmark, when it was occupied by Germany, produced Danish agar from *Furcellaria fastigiata* (see Furcellaran, 208).



205. AGAR–AGAR (*Gelidium amansii*) (x0·5)
A. Holdfast

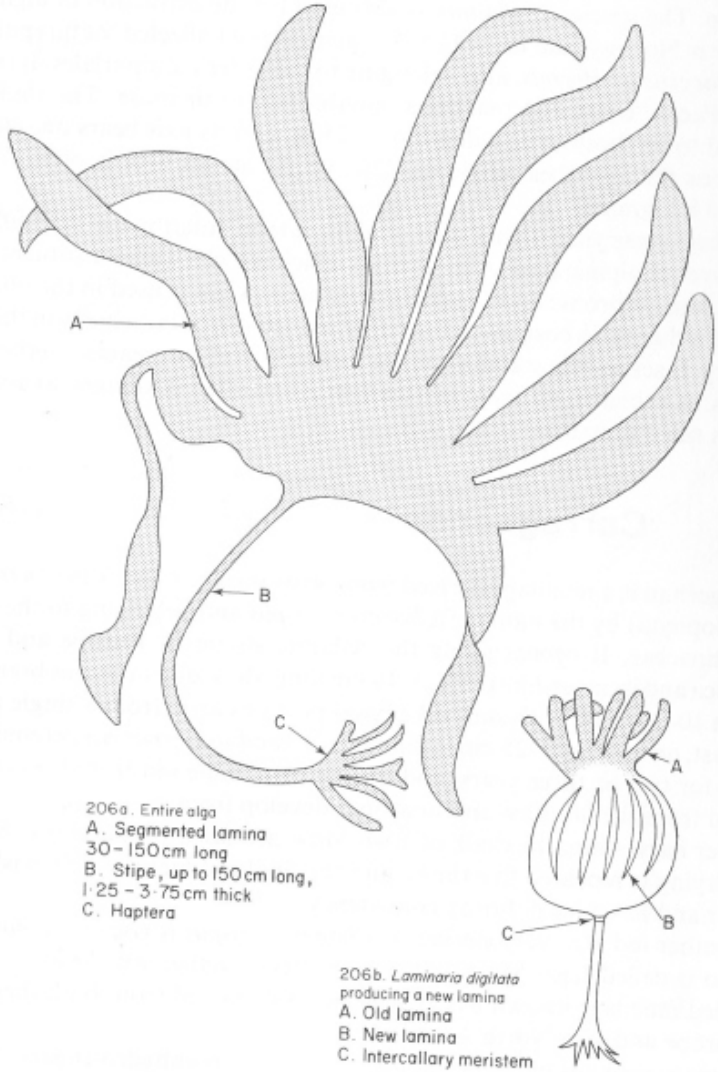
206. Algin

The largest producer of algin, after the U.S.A., is Great Britain and it was a British chemist called E. C. C. Stanford who in 1881 succeeded in extracting alginic acid from seaweeds. In Britain the main source of algin is *Ascophyllum nodosum* (knotted or bladder wrack) or *Laminaria hyperborea*. *L. hyperborea* and *L. digitata* were at one time not distinguished as two species, until the distinction was recognized by Clouston (1800–1885). The two species were then named *L. cloustoni* and *L. digitata*, but the international rules of nomenclature required that the specific epithet *cloustoni* be replaced by the older name *hyperborea*. *Ascophyllum* as well as *Laminaria* are brown algae (Phaeophyta) which grow along the Atlantic shores of Europe and North America. *Ascophyllum* is a close relative of *Fucus*, belonging to the family Fucaceae. Its "stem" is typically segmented and the segments are about 3 cm long, developing at intervals into buoyant bladders about the size of a walnut. The strap-shaped main axis shows mixed, dichotomous and monopodial



A. Bladder
B. Tip of the branch swollen into a receptacle
C. Branch
D. Fronds up to 300 cm long
E. Segments about 3 cm long
F. Discoid holdfast

206A. ALGIN, Sources of – BLADDER WRACK (*Ascophyllum nodosum*)



206a. Entire alga
A. Segmented lamina 30–150 cm long
B. Stipe, up to 150 cm long, 1·25–3·75 cm thick
C. Haptera

206b. *Laminaria digitata* producing a new lamina
A. Old lamina
B. New lamina
C. Intercallary meristem

206B. ALGIN, Sources of – OARWEED (*Laminaria digitata*)

branching. The short lateral axes, with swollen yellow tips 1–2 cm long, represent the receptacle. The thalli arise from a discoid holdfast and are up to 1·5 m long. The other alga yielding algin, *Laminaria hyperborea* or oarweed, consists of a stipe 30–150 cm long arising from a hapteroid holdfast. The stipe on the opposite end enlarges into a broad segmented lamina the same length as the stipe but 60 cm wide. The meristematic tissue is situated between the stipe and the lamina so that a newly developing "blade" carries the old one at its top. The species *L. digitata* is also used for the extraction of algin, for example in Norway, and in the U.S.A. a giant alga is collected for this purpose —*Macrocystis pyriformis*, also belonging to the order Laminariales. It occurs on the Pacific coast and reaches a length of 60 m or more. The thallus is attached to the bottom at a depth of 2–25 m, and its axis bears on one side pendulous thallus lobes, phyloids. The weight of this alga is often several hundred kilograms.

All these algae yield alginic acid or algin, a term describing all the different derivatives of alginic acid. Alginic acid, which is a cell wall constituent, consists of D-mannuronic and L-galacturonic acid. Algin is used in the pharmaceutical industry, in cosmetics, the paper industry, etc., but chiefly in the food industry. It serves as a stabilizer in the production of ice creams, sherbets and cheeses, as a thickening agent in fruit drinks and other beverages, as an emulsifier in salad dressings, etc.

207. Carrageenan

Carrageenan is a mucilage derived from IRISH MOSS or CARRAGEEN, a red alga (Rhodophyta) by the name of *Chondrus crispus* and belonging to the family Gigartinaceae. It occurs along the Atlantic shores of Europe and North America and its moss-like thalli, 5–10 cm long, show dichotomous branching. About 10–20 thalli with stalk-like basal portions arise from a single discoid holdfast, on average 1–25 cm in diameter. *Chondrus crispus* is a perennial alga living for two or three years, and during its lifetime old fronds become detached from the holdfast and new ones develop from it.

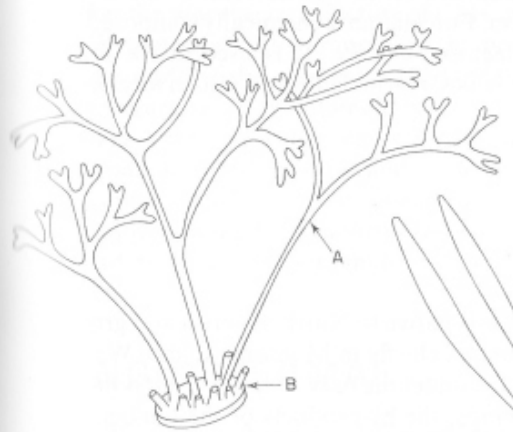
After harvesting, the thalli of Irish Moss are dried on the shore. Soaking and drying is repeated five times, and the final product is a yellowish-white colour and has a hard, horny consistency.

Another red alga very similar to *Chondrus crispus* is *Gigartina mamillosa*. It also is called Irish Moss and is harvested together with true *C. crispus*. Purified mucilage known as carrageenan is extracted from both these algae in Europe and also North America.

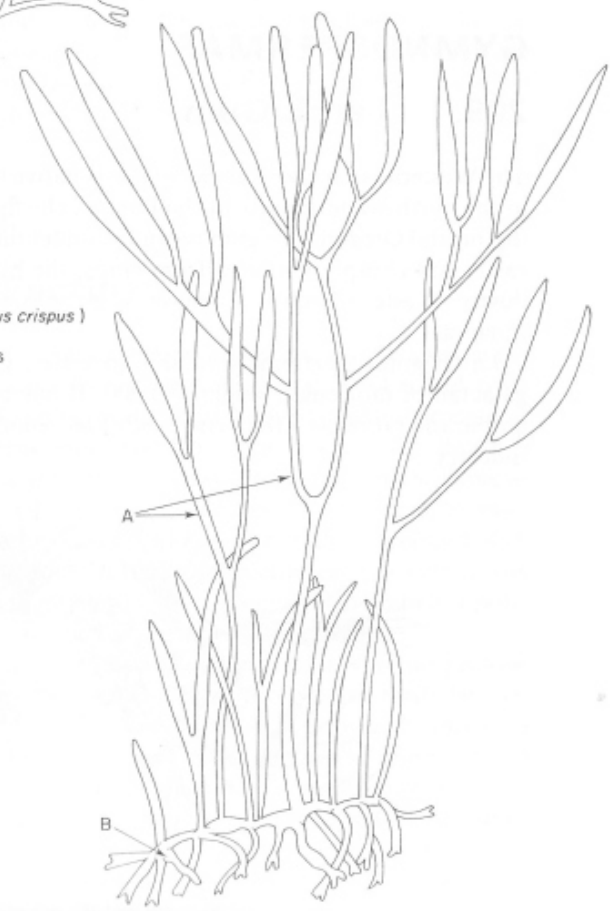
Carrageenan consists of D- and L-galactose, 3,6-anhydro-D-galactose and sulphate ester groups. It is used in the food industry as an agent for improving the "body" of soups, salad dressings, sauces, fruit drinks, etc. It is also a

clarifying and stabilizing agent for beer, and assists in the suspension of the cocoa particles in milk chocolate. It is used in the ice cream industry, mainly to prevent the migration of colours in multi-coloured ices, and has been known for a long time as a constituent of jellies, blancmanges and similar desserts.

In the southern hemisphere (in New Zealand), carrageenan is derived from the species *Gigartina undulata* and *G. clavifera*.



207. CARRAGEEN or IRISH MOSS (*Chondrus crispus*)
A. Frond
B. Discoid holdfast with ten up to twenty fronds



208. FURCELLARAN, source of (*Furcellaria fastigiata*) (x0·5)
A. Frond
B. Branched rhizoids

208. Furcellaran

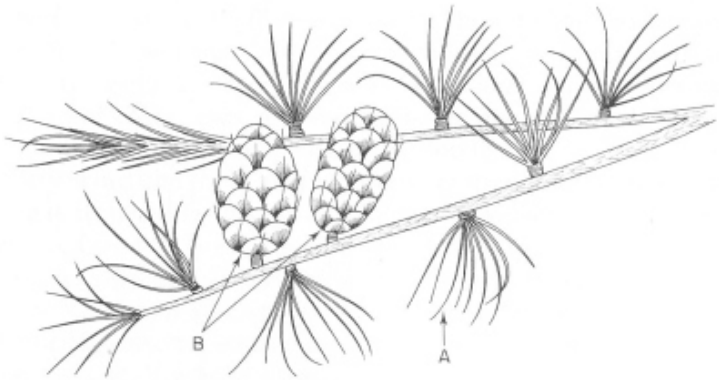
Furcellaran is the extracted mucilage from *Furcellaria fastigiata*, a member of the Rhodophyta belonging to the family Furcellariaceae. It was originally produced in Denmark as a substitute for agar during the Second World War and called Danish agar. The alga is 10–20 cm in height and consists of dichotomously branching, thin cylindrical thalli. The holdfast is hapteroid and reaches a diameter of up to 2·5 cm. Furcellaran is chemically composed of 3,6-anhydro-D-galactose and D-galactose sulphate. It is used in the food industry in puddings, blancmanges, jellies, marmalades and also in meat and fish preservation.

GYMNOSPERMAE

209. Larch Gum

The Western larch, *Larix occidentalis*, is native to North America and grows in the north-western parts of the U.S.A., chiefly in Montana, Idaho, Washington and Oregon. The gum is exuded under the bark of the tree but is more easily and cheaply obtained from chips, the by-products of the lumber industry. Western larch is a conifer, a gymnosperm belonging to the family Pinaceae.

Larch gum is extremely soluble in water. Chemically it is an arabinogalactan of molecular weight 100,000. It has become a substitute for gum arabic and serves as a thickener, stabilizer, emulsifier and binder in the food industry.



209. LARCH (*Larix occidentalis*) (x 0·5)
A. Leaf
B. Cones

210. Sodium Carboxymethylcellulose

Sodium carboxymethylcellulose, or CMC for short, is produced from either wood pulp or cotton linters (short fibres rejected for use in textiles) treated with sodium hydroxide. It is a water-soluble ester of cellulose invented in Germany as a substitute for gelatine during the First World War, but not produced there on a large scale until the outbreak of the Second World War. After the War the manufacture of CMC was developed in the U.S.A. because of its potentiality for improving the performance of detergents. However, today CMC is also used in the food industry, in the production of ice creams, meringues, jellies, pie fillings, etc.

There are some other semi-synthetic derivatives of cellulose used as gums, including methylcellulose and hydroxypropylmethylcellulose; the former was produced for the first time in the U.S.A. in 1938. Both compounds are employed in the food industry for ice creams and other dairy products, for salad dressings, flavour emulsions, bakery products, etc.

ANGIOSPERMAE

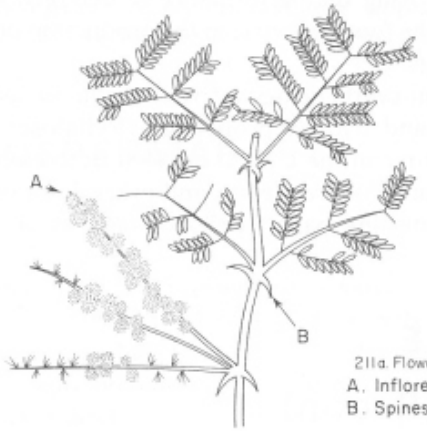
[121.] Apple (Pectin)

Pectin, a pectic substance (protopectin, pectin and pectic acid) is used in the preparation of jellies, jams and marmalades. It is mainly obtained from pomace, the mass of crushed apples produced in the cider-making process, as well as from the rind of citrus fruits and from sugar beet roots. Pectin is present in the middle lamella and in the cell walls of the soft plant tissue as well as in the tissue juices. Chemically, pectin consists of three polysaccharides, each representing one pectic substance. The major compound of all pectins is pectic acid, a polymer of D-galacturonic methyl ester, a methyl ester of a galacturonan. With this there are smaller amounts of an araban, a polymer of L-arabinose, and a galactan, a polymer of D-glactose.

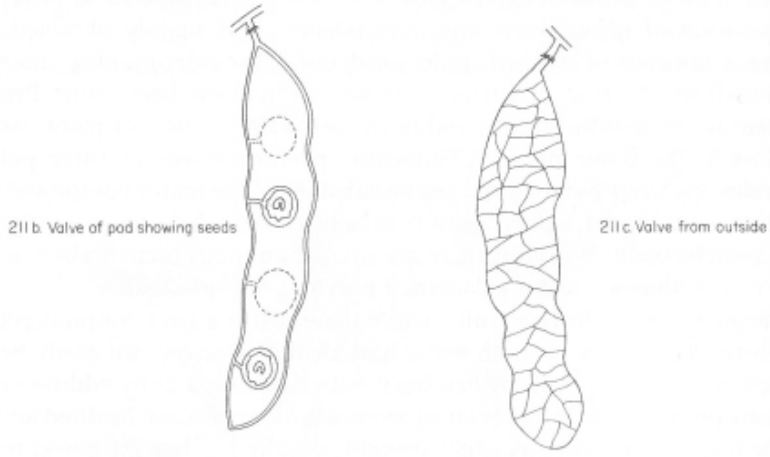
Pectin is present in ripe fruits, while the immature fruit contains pectose, a substance insoluble in both water and alcohol. Pectose can easily be converted into soluble pectin by heating it with dilute acid or by addition of the enzyme pectase. Pectin forms an aqueous solution, or it can be dried and sold in the form of a powder. A small amount, usually 1%, has the power to convert fruit and sugar into gels and it is therefore very important for home preservation of fruit as well as in food factories. The actual extraction of pectin from apple pomace is achieved by the addition of tartaric acid at 0·15% and heating at 100°C for 30 min. Tartaric acid may be replaced by citric, sulphuric or hydrochloric acids.

211. Arabic, Gum

Gum arabic is produced from *Acacia senegal* (family Leguminosae), a small, spiny tree up to 6 m tall and native to the savannahs of tropical Africa. The gum is obtained from an incision in the bark, forming "tears" which are collected after 3–8 weeks and bleached in the sun. The trees are tapped when the fruit is ripe, between January and March. The gum is colourless, odourless and tasteless, and has a high degree of adhesiveness which is exploited, e.g.



211a. Flowering twig
A. Inflorescence
B. Spines



211b. Valve of pod showing seeds

211c. Valve from outside

211d. Seed (side and front view)

211. ARABIC, GUM (*Acacia senegal*) (x 0·5)

as an office glue. In the food industry, gum arabic is mainly used as a flavour emulsion, as a thickening agent in sweets, jellies and chewing gum, and as a stabilizer in beer.

The trade in gum arabic started as early as 2000 B.C., when the ancient Egyptians used it in paint production. From ancient times the bulk of it has been supplied by Sudan and for this reason it has been given the name KORDOFAN or SUDAN GUM. The wild *Acacia senegal* is called HASHAB WADY and the cultivated form HASHAB GENEINA. The name SENEGAL GUM is given to gum arabic derived also from *Acacia senegal* but growing in French West Africa, while in Tanzania it is supplied by another species of *Acacia*, *A. drepanolobium*. Other, New World species of *Acacia* are used as sources of gum arabic in Mexico and Central America.

Gum arabic is a complex calcium, magnesium and potassium salt of an organic acid, arabic acid. It is a polysaccharide compound of D-galactose, L-arabinose, L-rhamnose and D-glucuronic acid. Its molecular weight is between 240,000 and 300,000.

[130.] Carob (Seed Gum)

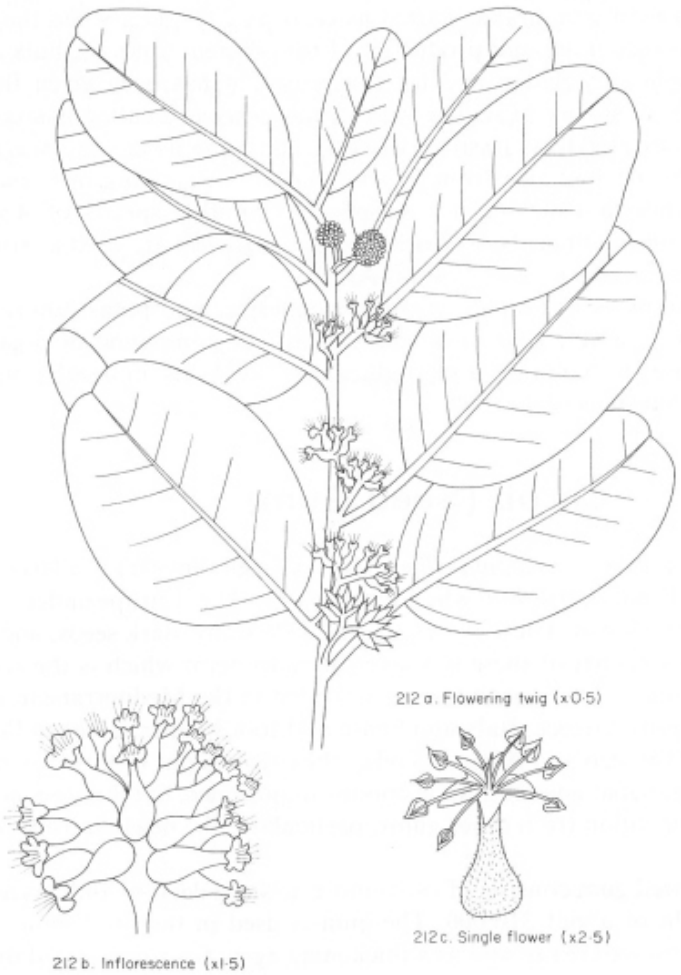
Carob or LOCUST, *Ceratonia siliqua* (family Leguminosae) is a large tree up to 20 m tall, native to Syria, which yields pods sold in Europe under the name of St. John's bread. These pods enclose 10–20 shiny, dark seeds, and underneath the seedcoat of these is a layer of endosperm which is the source of carob seed gum. The carob tree is cultivated in the Mediterranean area: in Syria, Cyprus, Greece, Italy and Spain and to a smaller extent in Portugal, Turkey, Morocco and Algeria. Today the carob is put to little use and it is only the gum that gives it some economic importance, but this does not stand up to competition from other gums, particularly the newly introduced guar gum.

Carob seed gum consists of D-mannose and D-galactose and has a molecular weight of about 310,000. The gum is used in the food industry as a stabilizer for ice creams and as a thickening agent for soups, salad dressings and pie fillings. In cheeses it is used to modify the texture.

212. Ghatti, Gum

Gum ghatti is the exudate of a large tree, *Anogeissus latifolia*, a member of the family Combretaceae native to India and Ceylon. Gum ghatti is a calcium salt of ghattic acid, a polysaccharide with molecular weight about 12,000 which yields on hydrolysis L-arabinose, D-galactose, D-mannose, D-xylose, D-glucuronic acid and traces of 6-deoxyhexose. The exudate is used in the

food industry mainly as an emulsifier and is more viscous and less adhesive than gum arabic.



212. GHATTI GUM, Sources of (*Anogeissus latifolia*)

213. Guar Gum

Guar or cluster bean, *Cyamopsis tetragonolobus* (family Leguminosae), has for a long time been cultivated in India as a fodder and green manure, while the green, immature pods were used by man as a vegetable. It is native to India and has also been introduced to the U.S.A., but more as a fodder

plant than for human consumption. Although guar has been known in the U.S.A. since 1903, the discovery of its useful seed gum is of a very recent date. Guar first began to be cultivated for its gum-yielding seeds in North America in 1953 and now a sufficient quantity is produced to replace carob seed gum almost completely.

As a substitute for locust bean mucilage, guar gum is used as a stabilizer in ice creams, as an emulsifier in salad dressings, a thickening agent in beverages, etc. It is sold in the form of a powder called guar flour.

Guar gum is a straight chain of D-mannose with a side chain of D-galactose at approximately every other mannose unit; its molecular weight may be up to 250,000.

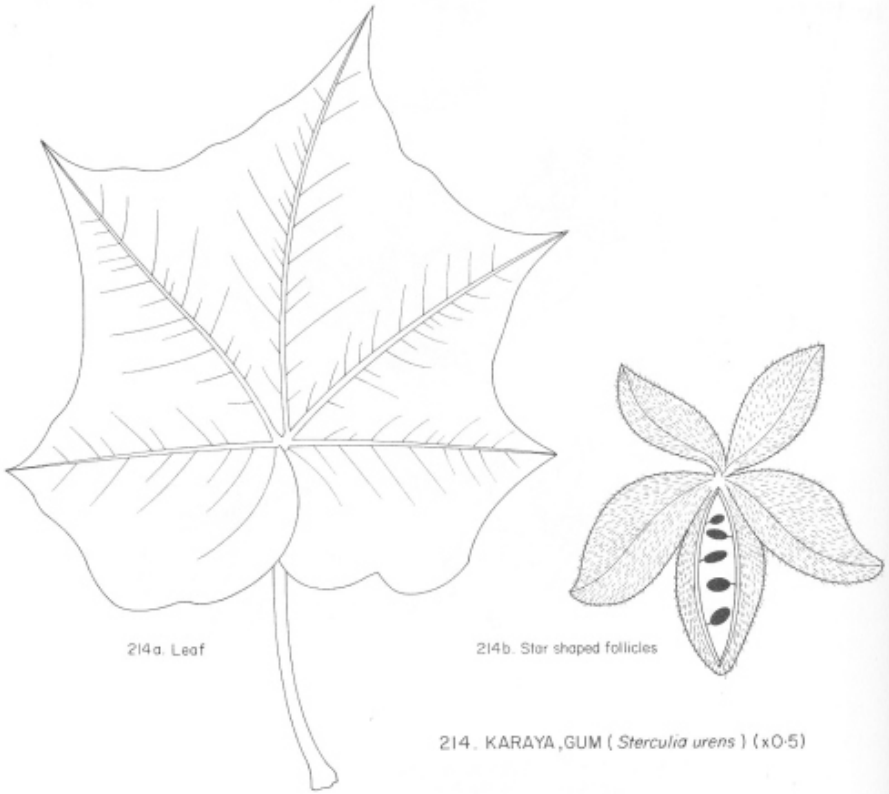
213. GUAR or CLUSTER BEAN (x 0·5)
(*Cyamopsis tetragonoloba*)
A. Pods
B. Groove

214. Karaya, Gum

Gum karaya is yielded as a stem exudate by the tree *Sterculia urens* (family Sterculiaceae), a native of central India, which reaches up to 30 m in height. They are tapped five times in their lifetime and an average tree is estimated to

produce a total of 5–25 kg of gum. Like almost every edible gum, gum karaya is used in the production of ice creams but it has a special use, to prevent the formation of large crystals. Otherwise, gum karaya is used as a stabilizer in sherbets and salad dressings, as a binder in sausages and other meat products, and it is also a useful material in the pharmaceutical, cosmetic, paper and textile industries. During the First World War this gum was adopted as a cheap substitute for tragacanth in the U.S.A.

Chemically, gum karaya consists of L-rhamnose, D-galactose and D-galacturonic acid. Its molecular weight is estimated to be enormous, around 9,500,000.

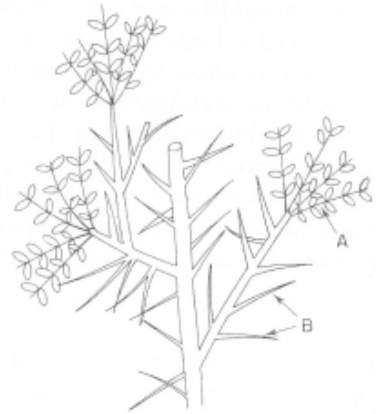


214. KARAYA, GUM (*Sterculia urens*) (x0·5)

215. Tragacanth, Gum

Gum tragacanth is derived from a shrub, *Astragalus gummifer*, a member of the family Leguminosae. It grows in western Asia, Asia Minor and the eastern part of southern Europe, in Iran, Turkey and Syria. The gum is obtained by puncture or excision of the bark; the exuded gum is left to dry on the stem and is then collected.

Chemically, gum tragacanth is a complex polysaccharide containing D-galacturonic acid, D-galactose, D-xylose and L-arabinose in association with calcium, magnesium and potassium cations. Its molecular weight may be up to about 310,000. It is used in the food industry as a stabilizer and thickening agent for salad dressings, ice creams, sweets and sauces.



215. TRAGACANTH, GUM (*Astragalus gummifer*) (x0·5)
Twigs
A. Leaves
B. Spines

216. VEGETABLE FOOD DYES

Another category of edible materials extracted from plants is that of the dyes used in the processing of food. Dyes derived from plants are nowadays seldom used in foods and it would therefore be superfluous to deal with them in a special chapter. Since the discovery of methods for preparing aniline dyes from coal tar, artificial colours have been preferentially used for dying foods because the natural colourings cannot compete with them for fastness and brightness.

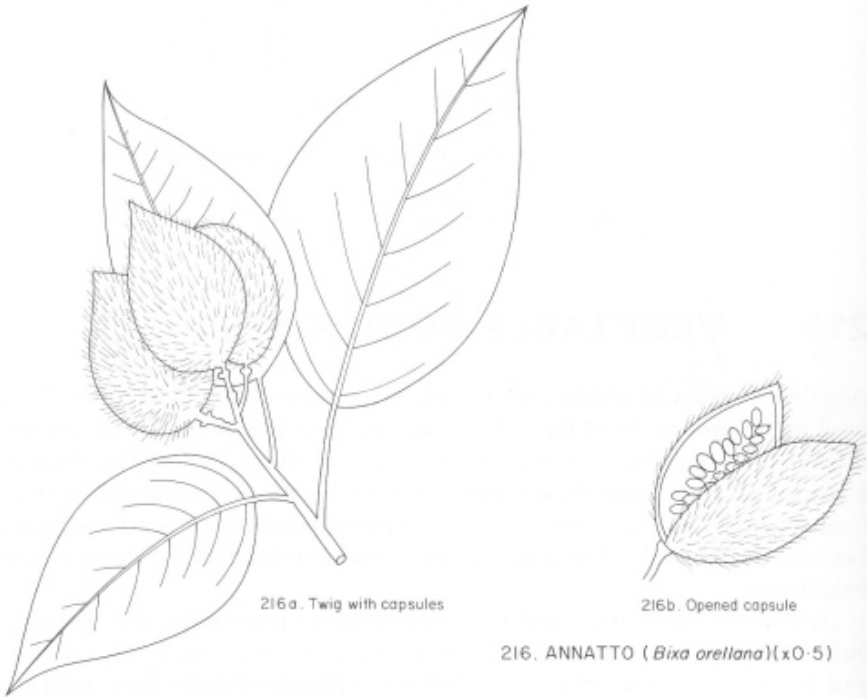
Despite the wide variety and vivid colourings of fruits in nature, there are only two fruit colours that are still commonly used for dyeing food: APRICOT and ELDERBERRY. The apricot fruit colour is prepared from dried apricots mixed with water and vacuum distilled, to produce a concentrated extract which is further distilled at atmospheric pressure and caramelized. The caramelized concentrate is then diluted with water and alcohol.

Elderberries are often used for colouring purposes in Europe and also in North America, in which case they have to be imported from Europe. Elderberries are used for colouring blackberries, raspberries, currants, cherries

and other red fruit. For ease of importation elderberries used in America are generally in the dried form, but in Europe they are often used fresh.

SPICES, e.g. saffron and turmeric, are sometimes used as dyestuffs, both of these having an orange colour. Saffron, the stigmata and tips of the styles of *Crocus sativa*, is used in bakeries for cakes and buns, and as a colouring in rice dishes, while turmeric, the rhizome of *Curcuma longa*, is used for colouring curries and pastas, e.g. macaroni.

The yellow dye for butter, margarine and cheese is supplied in the dairy industry by ANNATTO (*Bixa orellana*, family Bixaceae), a small tree about 5 m tall and native to tropical America. Its fruits are two-valved capsules, usually red when fresh and brown when dry. The capsule contains numerous (30–50) small seeds, each about 5 mm in diameter, and the seeds produce a scarlet aril yielding a bright yellow dye. Either the seeds are exported or the aril is scraped off and shipped abroad in the form of a paste. This dye was originally used by South American Indians for painting the body and given the name *urucú*.



216a. Twig with capsules

216b. Opened capsule

216. ANNATTO (*Bixa orellana*) (x0·5)

The natural colour used as a green dye is CHLOROPHYLL extracted from foliage leaves of various plants, e.g. nettles and spinach. LIQUORICE is sometimes used as a black dye to colour stout, and INDIGO derived from the leaves of *Indigofera tinctoria* (family Leguminosae) was once an important deep blue plant dye but is now produced synthetically; it is sometimes used to counteract the slightly yellow colour of icing sugar.

The most popular vegetable food dye is CARAMEL, produced by heating sugar. Caramel is used in confectionery and puddings, and also in the manufacture of spirits—for colouring brandies, whiskies, calvados, slivovitz, etc. Brandies acquire the required yellow-brownish colour which used to be achieved by absorption from the wooden casks in which their long maturation was carried out.

More or less as a curiosity, one should mention a lichen (a symbiont of an alga and fungus) which is used for colouring purposes. This is a blue or purple material called ARCHIL, ORSEILLE or CUDBEAR obtained by treating the macerated lichens, chiefly the species *Rocella tinctoria*, with ammonia. The dye was formerly used for colouring wines and is now used in sauces and bitters.

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217. WOOD SMOKE

This final section on plant extracts will consider smoking as a method of processing food. The smoke is derived from wood and is used to preserve meat, fish, poultry and cheese. There are two alternative methods: slow processing at a low temperature (about 20°C) or rapid processing at higher temperatures (about 40°C in Great Britain and about 70°C in the U.S.A. and continental Europe). The former process is called cold smoking, the latter hot smoking. Formerly the smoking of meat was merely an art but in recent times the procedure has begun to be understood and controlled by science. Over 200 chemical substances have been isolated from wood smoke. These include formic acid, acetic acid, propionic acid, butyric acid, valerianic acid, caproic acid, corton acid, angelica acid, methylacetate, diethylacetate, methyl alcohol, allyl alcohol, formaldehyde, acetaldehyde, butaldehyde, vanillin, acetone, phenol and cresol. The bactericidal function can mainly be attributed to formaldehyde which has small molecules that can easily penetrate into the interior of the meat, while formic acid and acetic acid can hardly have such a function since they are present in such small quantities. The average concentration of formaldehyde in smoked meat is 1·0 mg per 100 g, but in sausages this is reduced to 0·014–0·031 mg per 100 g, while at the periphery of special smoked lard the concentration reaches 12·11 mg per 100 g. However, formaldehyde does not become evenly distributed and is more concentrated at the periphery than at the centre.

Tar is responsible for the surface coloration of smoked meat and phenol for its taste. Carbon monoxide developing from the combustion of the wood combines with the pigment of the meat and produces the typical bright red colour. Carcinogenic substances from wood smoke have been found on the walls of the smoking chambers but not on the smoked goods. Experiments with mice that have been fed solely on strongly smoked meat have shown that

they develop no harmful effects, but the presence of carcinogenic compounds such as 3,4 benzpyrene and 1,2,5,6 phenanthracene in wood smoke is indisputable. These carcinogens are derived from lignin at temperatures above 350°C, while the temperature of smoking wood in the combustion zone normally reaches 1000°C.

The chemical nature of the smoke depends on many factors, e.g. the type of wood, the percentage of water in the wood, the heat evolved during smoking, the access of air to the materials being smoked, etc. During smoking, meat loses water (6–20% in sausages) and the main chemical change is the rancidity of fats.

The woods used are beech, oak, maple, plane and birch. Other dicotyledonous woods, e.g. alder and poplar, have been tried, but with little success, in common with conifers which have too strong an aroma. The best wood for smoking is beech, and this is also preferred to oak because its smoke has a lower acidity. Cones from fir and spruce, branches bearing needles of conifers, and especially branches of juniper together with the "berries" are often added for aroma during smoking. In some countries (e.g. Germany) the use of peat as an additive is prohibited because it produces carcinogenic substances. Wood for smoking is very seldom used in the form of logs but usually as sawdust or chips.

Morphological Survey of Plants used for their Extracts

(DYE—GUM—OIL—SMO (Smoke)—STA (Starch)—SUG (Sugar))

ALGAE

Leaf-like part of the thallus, extracted from

205. Agar-agar, *Gelidium* spp. (GUM)
206. Algin, Knotted Wrack and Oarweed (GUM)
207. Carrageenan, *Chondrus crispus* and *Gigartina* spp. (GUM)
208. Furcellaran, *Furcellaria fastigiata* (GUM)

ALGAE–FUNGI (LICHENS)

216. Archil or Orseille (DYE)

GYMNOSPERMAE

Rhizome

189. *Zamia floridana* (STA)

Seed

190. *Dioon edule* (PCER)

Seed (contd.)

190. Kaffir bread (PCER)

ANGIOSPERMAE

Root

Swollen taproot

200. Sugar beet (SUG)

Fleshy adventitious root

216. Liquorice (DYE)

Root tuber

[69.] Cassava (STA)

Stem

Stem

[11.] *Sorghum* spp. (SUG)
201. Sugar cane (SUG)

Stolon

216. Liquorice (DYE)

Rhizome

189. *Maranta arundinacea*—Arrowroot (STA)

Rhizome (contd.)

189. *Canna edulis*, Arrowroot (STA)
189. *Tacca* spp.—Arrowroot (STA)
216. Turmeric (DYE)

Leaf

Leafy shoot

216. *Indigofera tinctoria* (DYE)
216. Nettle, etc. (DYE)

Flower

Stigma and the tip of style

216. Saffron (DYE)

Fruit

Berry

216. Elderberry (DYE)

Drupe

216. Apricot (DYE)
194. Oil palm (OIL)

Seed

of an achene

193. Niger seed (OIL)
197. Safflower (OIL)
186. Sunflower (OIL)

of a caryopsis

[1.] Barley (ALC)

of a capsule

192. Cotton (OIL)
198. Sesame (OIL)

of a legume

[57.] Bean, Soya (OIL)
[130.] Carob (OIL)
[183.] Peanut (OIL)

of a siliqua

196. Rape

of a berry

191. Cocoa (OIL)
199. Shea Butter

of a drupe

[179.] Coconut (OIL)
195. Oil palms of Brazil
Babassu palm (OIL)

Seed of a drupe (contd.)

Cohun palm (OIL)
Licuri palm (OIL)
Murumuru palm (OIL)
Tucum palm (OIL)

Embryo

[2.] Maize (OIL)

Aril

216. Annatto (DYE)

Sap

202. Sugar maple (SUG)
203. Sugar palms (SUG)
203. Sugar palms
Coconut palm (SUG)
Gomuti palm (SUG)
Palmyra palm (SUG)
Toddy palm (SUG)
Wild Date palm (SUG)

Gum

[121.] Apple (Pectin) (GUM)
209. Larch gum (GUM)
210. CMC (GUM)
211. Arabic, Gum (GUM)
212. Ghatti, Gum (GUM)
213. Guar gum (GUM)
214. Karaya, Gum (GUM)

Resin

Alhagi spp. (SUG)—Introduction to Sugar plants
Fraxinus ornus (SUG)—Introduction to Sugar plants
Tamarix gallica (SUG)—Introduction to Sugar plants

Nectar

204. Nectar plants (SUG)

Smoke

217. Smoke of wood (SMO)

VII. FLAVOURING PLANTS

All vegetable materials that are added in small quantities to give taste to foods, beverages and even to fumitories and masticatories may be considered as flavourings and the plants supplying them as flavouring plants. All the spices belong in this category, but not all the flavourings are spices. Spices are often defined by the specialists who deal with them as dried plant materials containing essential oils. In this case spices include the dried leaves of parsley, chives, mint, rosemary, etc., as well as pulverized garlic and onion, while the fresh leaves of these plants, the cloves of garlic and bulbs of onions are excluded by the definition although they are used for the same purpose. No suggestion is given as to another group in which they might be classified, and for this reason it is preferable to avoid the term spice, and to consider instead the broader group of flavourings which, in addition to spices, includes all other kinds of condiments.

Before leaving the subject of spices, one should not omit to mention their enormous historical importance; here one is considering mainly the imported, dried aromatic plant materials that do not grow in Europe or the Mediterranean region. The ancient Egyptians used spices, but for purposes other than cooking: they used the cinnamon and cassia that they obtained from the Arabs, who in turn obtained them from the Indians, for embalming and for cosmetic purposes. The ancient Greeks and Romans were already using pepper (black and white), ginger and other spices in cooking. During the Middle Ages, despite the fact that spices were still in use in perfumery and medicine, their culinary use reached its culmination, and during the thirteenth century there was an abundant supply of cassia, cinnamon, ginger, pepper, nutmeg and mace in all European markets. However, the trade was still in the hands of the Arabs, and Europeans were unable to achieve direct contact with the "islands" where the spices grew. Their efforts to reach them by sea caused them to become navigators, and the Portuguese navigator Vasco de Gama was the first to reach India in 1498. Before this, in 1492, Columbus discovered America, believing that he had reached the spice islands of the Indian archipelago. The desire for spices was so strong that the Europeans sent ships into all the unknown parts of the world in the attempt to discover the countries where the spices grew. The occupation of these spice countries started the epoch of colonial power which was only ended with the Second World War.

Many of the flavouring plants have already been described in other chap-

ters in the context of their use as vegetables, fruits and nuts, and it would be superfluous to list them again as flavouring plants. Therefore this chapter will be restricted to the description of those flavouring plants that have not yet been mentioned, or those in which condiments are supplied by another structure or developmental stage from those already described.

However, it is useful to make general mention of food plants that can also be used as flavourings. The algae, which were the first group of plants considered in the chapter on vegetables, can all be used as flavourings, and the same applies to the second group, the fungi. There are in addition two fungi that are not used as food plants but are eaten as condiments; these are truffles and *Penicillium*. Although *Penicillium* is always eaten as a mere condiment, as a constituent of special cheeses, truffles can in fact be used for the preparation of special dishes and they appear in this way in old recipes; however, in view of the enormous price that has to be paid for truffles, they are nowadays regarded as a luxury, even as a condiment. Many angiosperm vegetables are used as flavourings in the fresh or dried state, but the primary use of most of them is for food. On the other hand, virtually all fruit may be used as flavourings, either entire or sliced, as well as in the form of juices and extracts. The flavouring extracts are mainly prepared from avocados, apples, apricots, bananas, blackberries, blackcurrants, grapes, grapefruits, guavas, mangoes, pawpaws, passion fruit, peaches, pineapples, pomegranates, prunes, raisins, raspberries and strawberries. The expressed juice is mixed with alcohol and the mixture vacuum distilled, and the extracts mainly used in the production of ice cream and soft drinks. Citron, lemon and lime are fruits that belong only to the category of flavouring plants. Nuts can also be considered as flavourings in some instances, being mixed into dough, creams, sauces, etc.

The flavourings include dried and fresh plant materials, and also candied materials such as angelica. They are used solely to make food more palatable and it is irrelevant whether or not they contain nutritious substances. Spices mostly stimulate the digestion, and the especially hot spices are consumed largely by nations living on a monotonous and dull diet, e.g. those eating only rice for much of the time—the widespread use of curry in India is a good example. The consumption of spices in Europe during the Middle Ages can be similarly explained: many food materials eaten at that time had a poor or actively unpleasant flavour resulting from primitive storage methods and preservation by salting and drying, and spices were needed to mask their bad taste. Apart from this use, it was found in the past by rich people that the use of spices enabled them to eat much more food than their stomachs would normally allow.

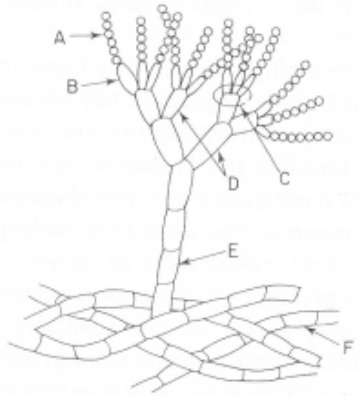
The characteristic flavours of condiments are chiefly due to essential oils present in spices, herbs and the rind of hesperidia. These oils were extracted by the ancient Egyptians who used them for the production of perfumes.

Essential oils also acquired medicinal value, which, however, they have largely lost in modern times, and only a very few survive as officially approved medicaments. But they are used in the preparation of liqueurs and in food manufacture; strictly speaking the oils themselves could therefore be classified among plant extracts, but it is convenient to consider them under the heading of flavourings.

FUNGI

218. *Penicillium*

The genus *Penicillium* of the family Aspergillaceae (Fungi Imperfecti) consists of moulds, certain species of which are used in cheese processing, adding a special flavour to cheeses. *Penicillium* is thus a condiment but flavours the cheese not only by its presence but also by its metabolic processes. The species *P. camemberti* and *P. caseicolum* are used in the production of Camembert and Brie cheeses, respectively. *P. caseicolum* has white conidia, while those of *P. camemberti* are pale green. The dark green veins in Roquefort cheeses are formed by the conidia of *P. roqueforti*, which is also used in making Gorgonzola cheese. The species *P. gorgonzolae* has no special affinity to Gorgonzola cheese, in spite of its name and taxonomic closeness to *P. roqueforti*. The blue-veined cheeses such as *dolce verde* are processed by the species *P. expansum*. *Penicillium* spp. used in cheeses are the only fungi that are consumed entire.



218. PENICILLIUM (*Penicillium* spp.) (highly magnified)
A. Chain of conidia
B. Sterigma
C. Penicillus
D. Metulae
E. Conidiophore
F. Mycelium

219. Truffles (Macrofructifications)

Truffles are subterranean fungal fructifications used almost solely as condiments. Other fungal fructifications that have already been listed are also used for flavouring, but they are often eaten in large quantities as vegetables. Truffles, because they are so excessively expensive, are not used in this way. True truffles are Ascomycetes belonging to the family Tuberaceae (order Tuberales) and form mycorrhiza in association with the roots of certain trees, chiefly oaks. Their fructifications remain in the soil about 10 cm beneath the surface, but they have also been reported to occur as much as 0·5 m deep. They are located by specially trained dogs or pigs which are able to distinguish them by smell. In Sardinia goats are used for this purpose and in Russia bear cubs were used for searching out underground fungal fructifications of the genus *Choiromyces* which was formerly included in the family Tuberaceae. The smell of truffles and similar fructifications may be discerned by trained animals at a distance of 110 m.

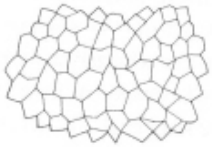
The best species of truffle, *Tuber melanosporum*, is found in France, Italy and Spain. In France these truffles grow mainly in the region of Périgord, around Périgeux, the capital of the département of Dordogne; this is the marketing centre for *T. melanosporum* which are otherwise known as Périgord truffles. Périgeux is also the centre of production of the famous pâté de foie gras au truffes, liver pâté containing small blackish pieces of truffle.

T. melanosporum, which is also known as winter truffle (*truffe d'hiver*), is variable in size, from that of a walnut to that of a human fist. Its warty surface is blackish and the inside is purplish-black at maturity. It is symbiotic with the roots of oaks and therefore planting oaks that are already infected with the fungus may increase the crop of truffles. In this way a farmer called Joseph Talon of the hameau des Talons in Vaucluse successfully attempted in 1810 to "cultivate" truffles, although their dependence on oaks was not previously known.

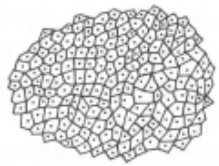
Another important centre of the truffle industry is the Italian town of Alba, near Turin, near to which various kinds of truffles occur naturally in relative abundance. The edible truffles belong not only to the species *T. melanosporum* but also to other species: *T. aestivum* (summer truffle), *T. nitidum* and *T. magnatum*. *T. magnatum*, known as the white truffle of Piedmont, is highly prized mainly in Italy, while *T. aestivum* is the only truffle to be gathered commercially in Britain—until 1928 it was collected from the area of Winterslow in Hampshire. *T. aestivum*, however, is inferior in flavour to the other species; it reaches 2–9 cm in length and is dark brown and warty, the warts being much larger than those of *T. melanosporum*. The gleba, the inner mass of sporogenous tissue, is grey or putty-like and shows white veins. All truffles are solid underground structures and have marbled flesh because the hymenium permeates the gleba to line the small cavities and passages within it. Truffles have an agreeable spicy flavour and a few small pieces can flavour an entire dish. They are the most expensive edible plant material and in 1969 fetched £35 per lb.

Truffles were eaten by the Romans and other ancient nations of the Mediterranean region, but these were different from the truffles described above, being derived from the hot, desert areas of the Mediterranean. They belong to the family Terfeziaceae (order Tuberales) which comprises two genera, *Terfezea* and *Tirmania*. These genera produce underground fructifications which appear above the ground when ripe; in former times they were described as plants without roots, leaves, flowers or seeds. Today *Terfezia* is still an important fungus in the diet of Greeks and Arabs in North Africa and it also appears in the markets of Izmir, Damascus, Jerusalem, Baghdad, Baku and Tiflis. *Choiromyces*, as mentioned above, is another genus of truffle-like fungus related to *Terfezia*; the species *C. meandriformis* or WHITE TRUFFLE is known in upper Silesia as KAISERPILZ and it is often used in France to adulterate true truffles. White truffle was previously considered as a member of the family Tuberaceae, despite the fact that it often grows above ground or only partly buried in the soil.

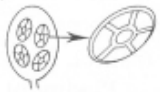
In Australia the underground fungus *Mylitta australis* (or *Polyporus mylittae*), known as BLACKFELLOW'S BREAD, is eaten by the Aborigines. It belongs to the basidiomycete family Polyporaceae, while the truffles are ascomycetes. It grows just below the surface of the sandhills and is easily found because the growing mushroom breaks the surface of the sand.



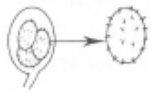
219a. *Tuber aestivum* (x0·5)



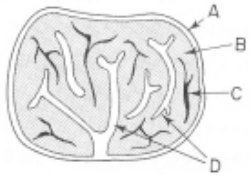
219b. *T. melanosporum* (x0·5)



219c. Spores of *T. aestivum* (20–40 × 15–30 μm)



219d. Spores of *T. melanosporum* (32–40 × 23–30 μm, 2–4 in capsule)



219e. *Tuber rufus*, L.S. Inside of the tuber (x0·5)
A. Cortex
B. Ascogenous tissue
C. Tramal plate (compact hyphae)
D. Air-containing tissue

219. TRUFFLE (*Tuber* spp.)
Entire truffles life size, spores highly magnified

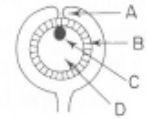
GYMNOSPERMAE

220. Juniper

Juniper, *Juniperus communis* (family Cupressaceae) is a shrubby conifer native to the cooler regions of the northern hemisphere. The seeds are completely surrounded by a fleshy, dark blue "cupule", correctly called the aril, which develops from the uppermost scales of the female strobilus. The cupule gives the seed the appearance of a berry 0·8–1·0 cm in diameter. It takes 3 years before the "fruit" is completely developed and it is mainly used in the production of gin, genever and Steinhaeger. However, juniper is also used as a spice for roast meat and sauces. In this case it is generally used in the form of whole "berries", while ground juniper may be used as a constituent of mixed spices.

220a. Twig bearing fruit (x0·5)

220b. Seed covered with aril (x1·25)



220c. Seed L.S. (x1·25)
A. Aril
B. Testa
C. Embryo
D. Endosperm

220. JUNIPER (*Juniperus communis*)

Apart from juniper, the only conifer used as a flavouring material is the resinous wood of PINE which is used in Greece to flavour wine. The wine is either stored in pine casks or is directly mixed with the pine resin. This wine is known as *retsina*.

ANGIOSPERMAE

221. Allspice (Pimento)

Allspice or pimento is the name given to the berries of *Pimenta dioica*, an evergreen tropical tree of the family Myrtaceae, up to 9 m in height. The plant is native to the West Indies and Central America and this gives it the name "new spice" in some European countries. The English name "allspice", however, gives a good description of its flavour which resembles a combination of the odour and taste of cinnamon, nutmeg and cloves.

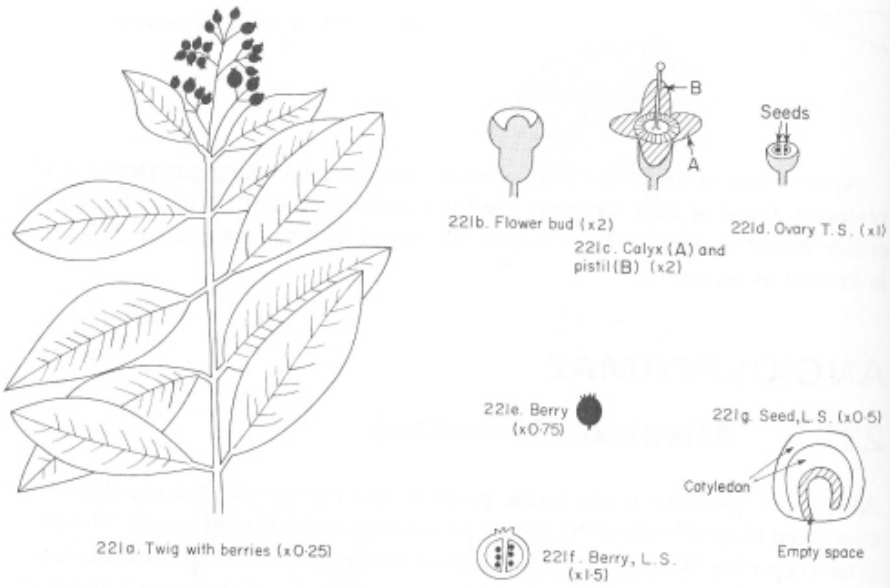
The berries develop in a cymose inflorescence and are small spheres, 4–7 mm in diameter, containing two single-seeded loculi. The seeds are ex-

albuminous and the coiled embryo consists of two small cotyledons and a large radicle. The berries are harvested unripe, when they are still green, and are then dried. The small dried brown berries, with a piece of pedicel adhering to them, are used either entire or ground.

The largest producer of allspice is Jamaica where the trees need little attention owing to the equable climate. Apart from Jamaica, allspice is cultivated in Mexico, Guatemala, Honduras, Brazil and the Leeward Islands, but all attempts to cultivate it in the palaeotropics have been unsuccessful because the plant has always failed to produce fruit. Allspice is thus exclusively a crop of the western hemisphere.

Francisco Hernandez, an early explorer travelling through Mexico, discovered the allspice tree first in the region of Tabasco and named it PIPER TABASCI because its fruits resemble the pepper. The Spanish name, also, is PIMIENTA (pepper) and this was later anglicized to PIMENTO. In most European languages allspice is called "pepper of Jamaica": e.g. PEPE DI GIAMAICA (Italian); PIMENTA DA JAMAICA (Portuguese); YAMAYSKI PYERETS (Russian). Allspice reached London for the first time in 1601.

The ripe berries of pimento are used in Jamaica for flavouring a special drink based on rum and known as pimento dram.



221. ALLSPICE (*Pimenta dioica*)

222. Angelica

Angelica archangelica or *A. officinalis* (family Umbelliferae) is a stout, perennial herb about 180 cm tall, native to northern parts of Europe and western Asia. It was cultivated in Great Britain as early as 1568 but nowadays it is grown almost exclusively in Germany. All parts of the plant are aromatic and may be used for flavouring, but the broad hollow stem is the part most generally used as a condiment and is normally sold candied. It is also appreciated for its attractive green colour and is used in cakes, pastries and sweets simultaneously as a flavouring and as a decorative material. In addition, angelica is added with many other flavouring herbs to vermouths and liqueurs. It received its name because it was believed to be an effective antidote for poison.

Angelica used to be held in great esteem for all kinds of magical powers: e.g. the leaves steeped in hot water were used against inflammation and chewing its root was supposed to save people from the plague.

222. ANGELICA
(*Angelica archangelica*) (x0·5)
Part of the stem

There are about 50 species of *Angelica*, among them some that are indigenous to North America and New Zealand. The North American species have acquired the common name ALEXANDERS OR BLACK LOVAGE and are used as vegetables or pot herbs. *Angelica archangelica* was also, in the past, used in Britain as a pot herb and it is still eaten as a vegetable in the Faroe Islands and Iceland, where it grows with great vigour and abundance.

223. Angostura

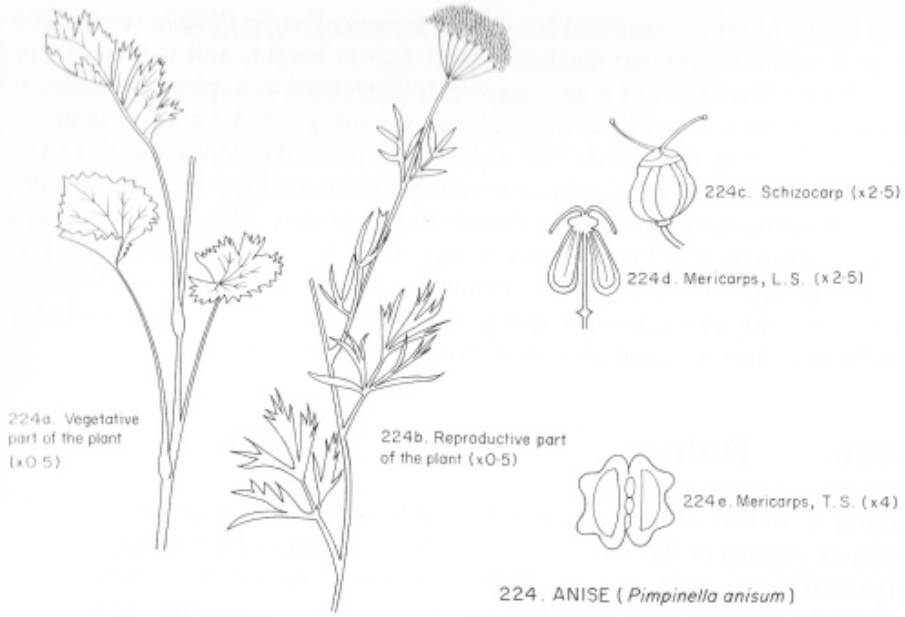
Angostura is the bark of *Cusparia febrifuga* (family Rutaceae), a small tree native to tropical America. Its common name is derived from the town Angostura on the Orinoco (nowadays called Ciudad Bolivar) from where this flavouring was first exported to Europe at the end of the sixteenth century. The native Indians used the bark of *Cusparia* as a remedy for malaria (hence the specific epithet) but in Europe it has mainly become a condiment

for use in aperitifs (angostura bitters). The first angostura drink was prepared in Angostura by a doctor named Siegert in 1824.

223. ANGOSTURA (*Cusparia febrifuga*) (x0·25)
Leaf and inflorescence

224. Anise

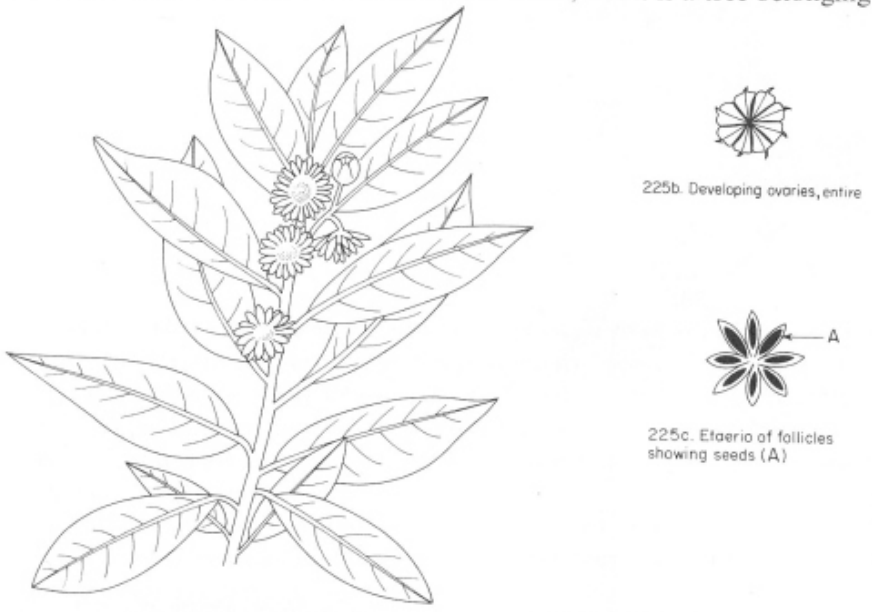
Pimpinella anisum, a member of the family Umbelliferae, is an annual native to the eastern part of the Mediterranean region and yields fruit known as aniseed. The fruit is schizocarpic, a cremocarp, and when ripe it separates into two single-seeded carpels suspended on the split carpophore to which they are joined by means of the stylopods. The split, one-seeded parts of the fruit are called mericarps, and these are 3–5 mm long by about 2 mm wide with 5 longitudinal ridges. They are used as a spice in cakes, pastries and sweets. The volatile oil expressed from them is a popular flavouring for alcoholic beverages such as anisette, ouzo, raki, Pernod, etc. The mericarps of anise, in common with all kinds of mericarps and cremocarps, contain endospermous seeds with a tiny embryo at the apex. Anise is a herb about 60–90 cm tall with feathery leaves and was known as a condiment to the ancient Greeks, Romans and Hebrews. Today the main producers of anise in Europe are Spain, Italy, Germany and Turkey but the largest producer in the world is Mexico, where anise was introduced from the Old World.



224. ANISE (*Pimpinella anisum*)

225. Anise, Star

Star anise, despite its name, is an entirely different plant from anise. Its fruit has a similar flavour and odour to that of anise, but it is a tree belonging to

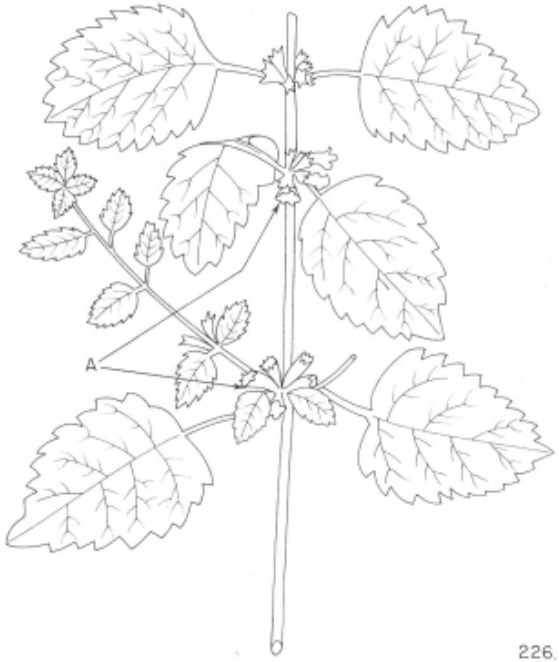


225. ANISE, STAR (*Illicium verum*) (x0·5)

the family Magnoliaceae and having the botanical name *Illicium verum*. The tree is small, evergreen, reaching about 6 m in height, and it is native to southern China. Its fruit is an etaerio of follicles used as a spice. Six to eleven follicles form a star-like configuration measuring 2·5–4·5 cm in diameter. The pericarp of the follicle has a pleasant, anise-like odour owing to the presence of a volatile oil, while the endospermous seed is poorer in the volatile oil and therefore has a less marked odour and taste. Star anise is used as a spice only in the Far East, its fruit being collected unripe and then dried. It is also used as a masticatory for freshening the breath. It is exported to Western countries only in the form of extracted volatile oil which is used chiefly for industrial purposes, and also for flavouring liqueurs and aperitifs.

226. Balm

Balm or *Melissa officinalis* (family Labiatae) is a perennial herb native to the eastern regions of the Mediterranean area. Its dried or fresh leaves are used for flavouring soups, sauces, salads and various other dishes, while the expressed volatile oil which has a distinct lemon aroma is used for the preparation of beverages. Balm was a popular spice of the ancient Greeks and Romans.



226. BALM (*Melissa officinalis*) (x0·5)
A. Inflorescences

227. Basil, Sweet

Sweet basil, *Ocimum basilicum*, is a stout tropical perennial herb or shrub belonging to the family Labiatae. It appears to be native to tropical Asia and Africa, but it was also introduced into temperate regions and it is now commercially cultivated mainly in France, Hungary and the U.S.A. There is an ancient superstition that basil produces scorpions in the human body, even in the brain.

227. BASIL, SWEET (*Ocimum basilicum*) (x0·5)
Entire flowering plant

The dried leaves and flowering shoots of sweet basil are used as a spice for soups, sauces and other foods. It is particularly popular among the Italians and French; a special sauce of garlic and basil known as *pistou* is prepared in Provence, southern France, and originates from an Italian invention called *pesto*. Balm is also added to pizzas and to the dish called *pollo cacciatore*, an Italian chicken speciality.

Another species of *Ocimum*, *O. canum*, is used in a similar manner, while the species *O. sanctum* is sacred in the Hindu religion. From time immemorial *O. sanctum* has been cultivated in India as *tulsi*, a plant sacred to Vishnu. The specific epithet of *O. basilicum* appears to be derived from the Greek name for

king, *basileus*, or from its diminutive form *basilius*, meaning a dragon-like creature with flaming breath.

228. Bay

Bay, SWEET BAY OR BAY LAUREL, known botanically as *Laurus nobilis*, is a small tree native to Asia Minor and a member of the family Lauraceae. Dried leaves up to 10 cm long and 5 cm wide are added as a spice to soups, sauces and meat dishes. Bay laurel is mainly cultivated in Europe. From ancient times laurel leaves have been used as a symbol of victory and laurel wreaths were worn by victorious generals, emperors and also the winners at the Olympic games. The term "baccalaureate" is also derived from this plant but in fact refers to the berries of bay (*bacca lauri*). The "berries" of laurel, which are actually drupes, are sometimes also used as a spice.

228a. Leafy shoot (x0·25)

228b. Bay in the marketed form (separated leaves) (x0·5)

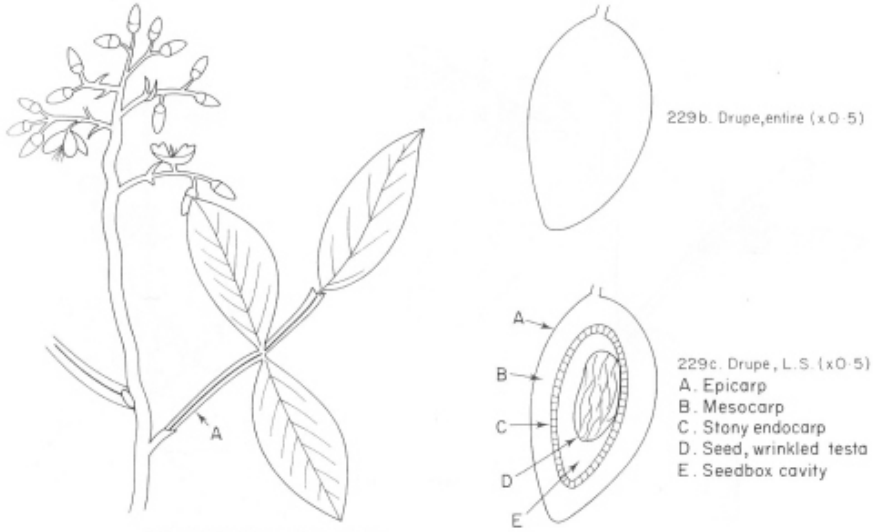
228. BAY, SWEET (*Laurus nobilis*)

229. Bean, Tonka

The tonka bean is obtained from a leguminous tree, *Dipteryx odorata*, a native of tropical South America. The tree may be up to 12 m tall and its trunk may reach 1 m in diameter. The fruit is commercially known as a pod and the seeds as beans; however, botanically the fruit is a drupe. The epicarp is hard, but the mesocarp is fleshy while the hard endocarp encloses a single seed which is the useful part, containing 2–3% coumarin and about 25% solid fat—tonka butter. Tonka fruits are mostly obtained from wild trees in Venezuela, and Colombia and Brazil also contribute to a smaller extent to the export of tonka beans. After collection the drupes are first opened and then the stone is removed and dried. The dried stone is cracked and the exalbuminous seed cured in barrels of strong rum (45–65%). These cured seeds are the commercial tonka beans.

The extracted fat containing coumarin, or an alcoholic extract of coumarin, is used as a flavouring, having an aroma similar to that of new-mown hay and vanillin. Coumarin from tonka beans is used mainly for flavouring tobacco but also for liqueurs and confectionery. Because of its similarity with vanillin, coumarin is often used as a substitute for it, e.g. in the production of ice creams.

Tonka beans are also obtained from another species of *Dipteryx, D. oppositifolia*. Since the Second World War the production of tonka beans has decreased as a result of competition from synthetic coumarin and vanillin.



229a. Twig with terminal panicles of buds and flowers (x0·25)
A. Winged petiole

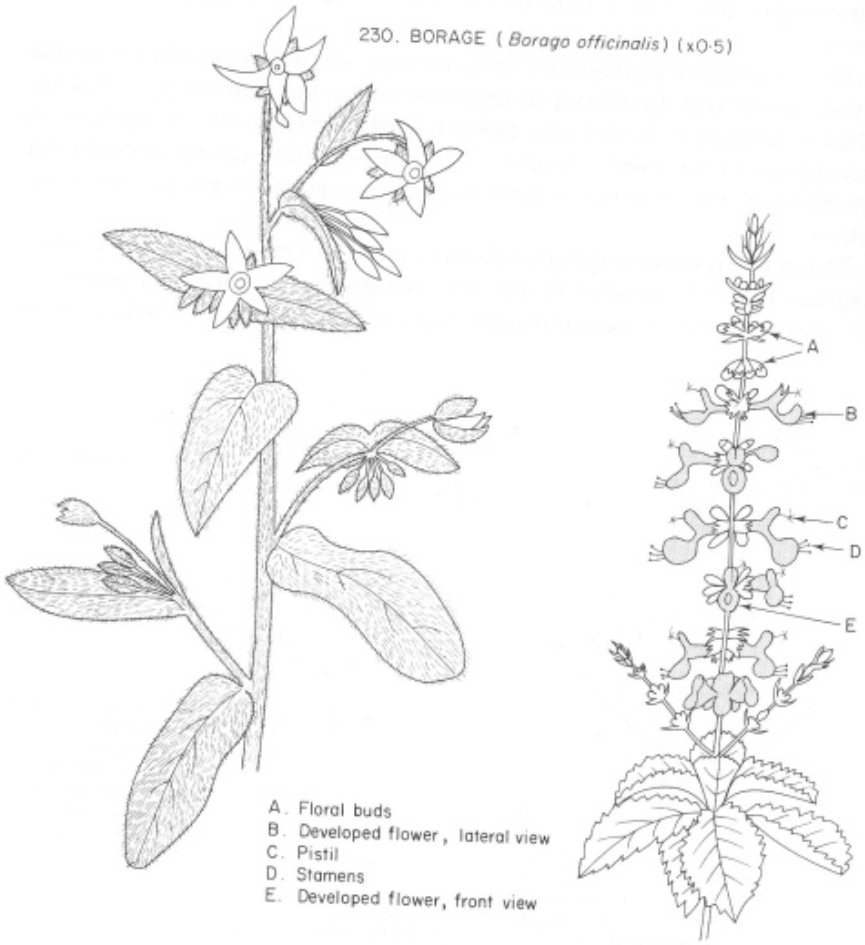
229. BEAN, TONKA (*Dipteryx odorata*)

230. Borage

Borage, *Borago officinalis*, belongs to the family Boraginaceae and has bright blue flowers and white hairs on the leaves and stems. It is an annual, native to eastern parts of the Mediterranean region but is now distributed throughout Europe and North America. It is cultivated in Britain and was formerly very

common there. Its young leaves are mainly used for salads and the fresh herb is also used for the preparation of a drink, while the flowers were added to wines.

230. BORAGE (*Borago officinalis*) (x0·5)



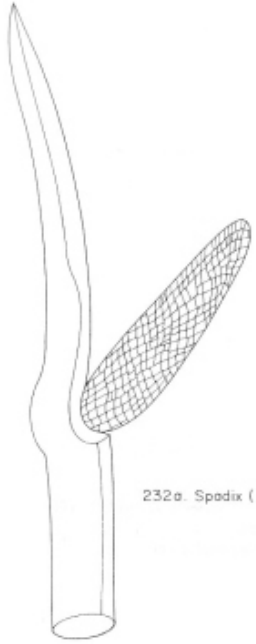
231. BORAGE, INDIAN (*Coleus amboinicus* or *aromaticus*) (x0·5)

231. Borage, Indian

Indian borage or *Coleus amboinicus* (*C. aromaticus*) is a rather succulent herb of the family Labiatae, about 50 cm tall. It is native to Indonesia but is now cultivated in south-east Asia and in the West Indies. Its leaves are mainly used in stuffings and for flavouring meat and it is also used as a substitute for sage (*Salvia officinalis*) and borage (*Borago officinalis*).

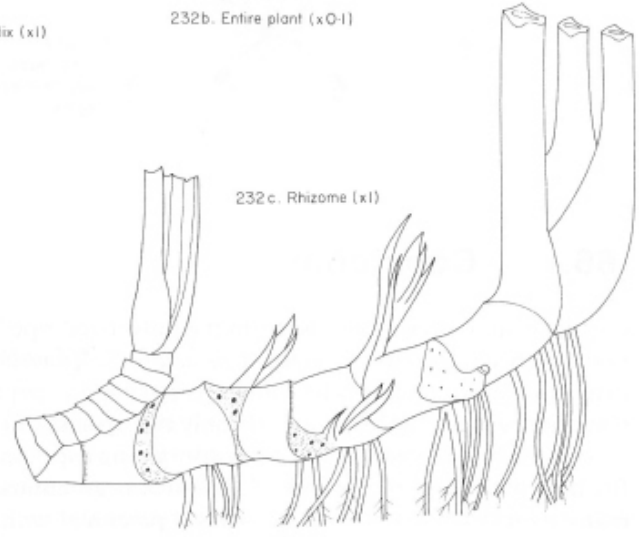
232. Calamus

Calamus or sweet flag, botanically *Acorus calamus*, is a member of the monocotyledonous family Araceae and is a native of south-east Asia, mainly India and Ceylon. It is a hardy perennial plant and its useful part is the much-branched rhizome which is rich in oil glands. The rhizome is sometimes used as an ingredient in mixtures of spices, or it may be candied and coated with sugar, but more usually it is used as the source of calamus oil. The rhizome also contains a glucoside (acorin) which is used in native medicine.



232a. Spadix (x1)

232b. Entire plant (x0·1)

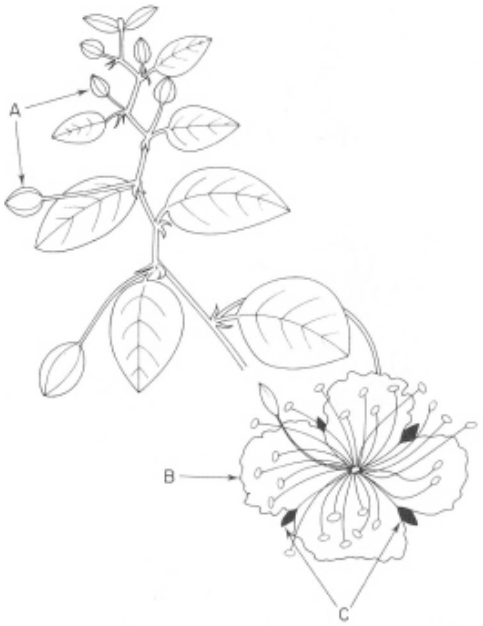


232c. Rhizome (x1)

232. CALAMUS or SWEET FLAG (*Acorus calamus*)

233. Caper

Capers are the floral buds of *Capparis spinosa* (family Capparidaceae), a spiny shrub native to the Mediterranean region. The unopened floral buds are pickled in vinegar and salt. The main producers are Italy, Spain and Algeria. Capers, which are about 7 mm in diameter, are added as a condiment to sauces (e.g. tartare sauce), meat, pizzas, etc. Sometimes true capers are adulterated by substitutes such as the floral buds of marsh marigold, *Caltha palustris* (Ranunculaceae) or of *Tropaeolum majus* (Tropaeolaceae).



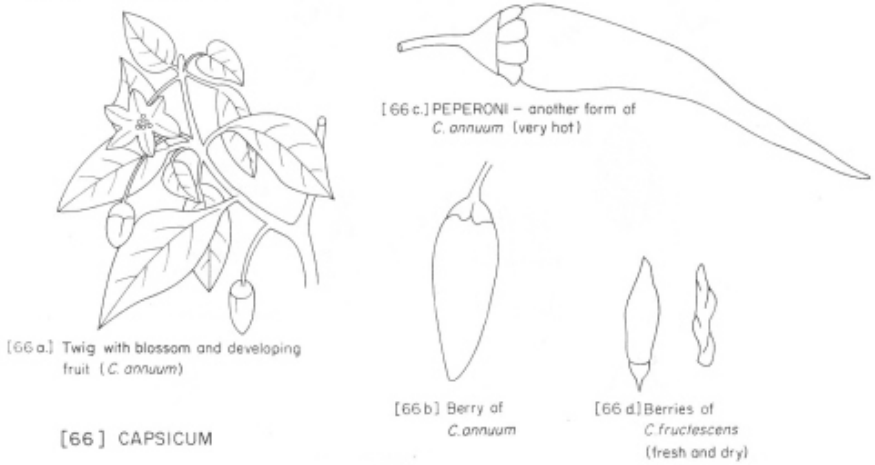
233. CAPER (*Capparis spinosa*) (x0·5)
A. Floral buds
B. Fully developed flower
C. Sepals

[66.] Capsicum

Capsicum as a spice is derived from the pulverized ripe berries of species and varieties belonging to the genus *Capsicum* (Solanaceae). This spice, which originated in America, is also known as red pepper, paprika, chilli powder or Cayenne pepper. There are usually only two species of *Capsicum* recognized, *C. annuum* and *C. fructescens*, both containing capsicin which is responsible for the "hot" taste of the fruit. *C. annuum* is an annual herb that occurs in many varieties, while *C. fructescens* is a perennial with only one variety, *C. fructescens* var. *baccatum*. The perennial plant has small, erect and comparatively narrow berries, about 0·7–2·5 cm long, and is short-lived (3–4

years). It is used for the preparation of Cayenne pepper although it does not grow in Cayenne—it is grown on a large scale in India, Thailand, Mexico, Japan, Turkey, Uganda, Nigeria, Ethiopia, etc. All other red peppers are spices derived from varieties of *C. annuum*. CHILLI, a Mexican name for the special pepper ground from capsicum berries, is said to be *C. annuum* var. *acuminatum*, while PAPRIKA (a Hungarian name derived from the Greek *piper*) is attributed to *C. annuum* var. *grossum*.

For the production of spice, the ripe berries of both species are dried either entire or after removal of the seeds and placentas. In Hungary, where paprika is particularly popular, almost every dish is flavoured with it; goulash (or more correctly *gulyash*, meaning "herdsman" and *gulyás hús* "herdsman's meat") is the best known of these dishes. In Hungary and neighbouring countries paprika is also consumed as an appetizer, being eaten whole in the pickled form. The berries used for this purpose are conical, about 10 cm long. They are known as *peperoni* (an Italian name) and are very hot and pungent. In Spain the sweet paprika called PIMIENTO (derived from pepper) is also used for flavouring cheeses and for stuffing olives. Finally, it should be added that the mild, sweet paprikas are often used more as a food dye than as a spice.



[66] CAPSICUM

234. Caraway

Caraway "seeds" are actually fruits—mericarps of the plant *Carum carvi* which belongs to the family Umbelliferae. The cremocarp splits into two mericarps which are normally 4–5 mm long by 1–1·5 mm wide with 5 light-coloured ribs. The plant is a biennial but under cultivation it behaves as an annual. It is native to Europe, Asia and North Africa and caraway seeds were excavated from the Swiss Lake Dwellings. Today caraway is cultivated in

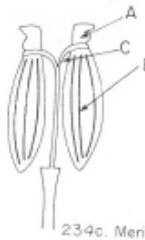
northern Europe, Russia and the U.S.A., but for many years the biggest exporter was the Netherlands. The name is derived from the Arabic KARAUYA but many nations inappropriately call it CUMIN, which is in fact a spice supplied by another umbellifer. In German it is called KUEMMEL, in Spanish COMINO, in Swedish KUMMIN, in Czech KMIN and in Russian TMIN, while in the Orient caraway is known as ROMAN CUMIN, FOREIGN CUMIN, PERSIAN CUMIN, etc.

In Central Europe the mericarps of caraway are one of the most commonly used spices, being added to dough in bread-making, boiled with potatoes, added as a flavouring to cheeses, used in the preparation of cabbage, goulash, soups, sauces and even as a liqueur flavouring (Kuemmel).

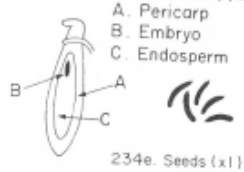
Another species of *Carum* that is utilized is *C. bulbocastanum*, an Indian species which is not cultivated but which grows wild in manured soil in the northern parts of India. The fruits are collected and marketed as a substitute for *C. carvi*.

234a. Infructescence (x0·5)

234b. Schizocarp (x5)



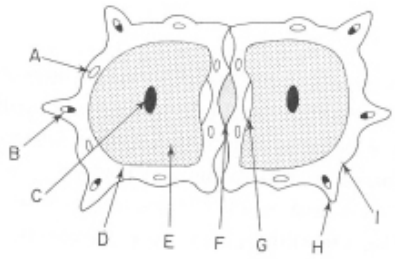
234c. Mericarps (x5)
A. Stylopod
B. Mericarp
C. Splitting carpophore



234d. Mericarp, L.S. (x5)
A. Pericarp
B. Embryo
C. Endosperm

234e. Seeds (x1)

234. CARAWAY (*Carum carvi*)



234f. Mericarps, T.S. (x50)
A. Vitta
B. Vascular bundles
C. Embryo
D. Testa
E. Endosperm
F. Carpophore
G. Raphe
H. Ridge
I. Pericarp

235. Cardamom

Cardamom is a perennial herb, *Elettaria cardamomum*, with a branching rhizome, belonging to the family Zingiberaceae. The leafy shoots may be from 2 to 6 m tall while the flowering stems reach only about 60–120 cm in height. The inflorescence is racemose and the flowers develop into capsules which are harvested before they are fully ripe and dried. The entire capsules, or the seeds alone (there are 15–20 per capsule), are then ground into a powder which forms the spice. Cardamom is used as a culinary spice and as a constituent of curry is a very important spice in India. The whole seeds are also utilized as a masticatory.

Cardamom is native to South India and Ceylon and these countries are also its largest producers. There are two distinct varieties—the Ceylon and Malabar cardamom. The Ceylon type has 3-sided oblong capsules with dark brown seeds, while Malabar cardamom has spherical capsules with black

235a. Reproductive shoot (x0·5)

235b. Capsule, entire (x1)

235c. Capsule, T.S. (x1)

235. CARDAMOM (*Elettaria cardamomum*)