Chicha is produced from maize or corn by a process of salivation, which transforms the starch sugar, and after which the 'spit' is subjected to fermentation. The process, although seems is still practised by the tribals.

Non-Alcoholic Beverages

The refreshing and stimulating properties of non-alcoholic beverages are due to the pre caffeine or related alkaloids. Caffeine, when taken in small quantities, imparts mental animation wakefulness (increased mental activity and reduction in fatigue). It also stimulates increased of digestive juices and has a marked diuretic action, that is, increasing the excretion of

The three major non-alcoholic beverages are tea, coffee and cocoa (all are strictly tro The first two have a little nutritive value, while cocoa is a good source of energy. Other beverages are maté or Paraguay tea, derived mainly from the leaves of *Ilex paraguari* A. St (family Aquifoliaceae); guarana from the seeds of an Amazonian climber, *Paullinia* (Sapindaceae); cola, extracted by powdering the seeds of *Cola nitida* (Vent) Schott and (Sterculiaceae); khat, a tea-like drink obtained from a north-eastern African plant, *Ca* (Celastraceae) and yoco, obtained from the bark of a South American tree, *Pau* and Killi. (Sapindaceae). Their use has become an integral part of the daily life and it is di imagine the world without them.

In this chapter, we will discuss the three main non-alcoholic beverages–tea, coffee a the three are true stimulants to heart, nervous system and kidney. Coffee is more stimulating brain and cocoa to the kidney, while tea occupies an intermediate position between the two, a mild stimulant to most bodily functions. Historical records of beverage plants reveal that civilisations that arose in different regions of the world developed their own characteristic bever Thus, tea was the beverage of South-East Asia, cocoa of the tropical America and coffee of eastern Africa and Arabia.

Tea

***Camellia sinensis* (L.) Kuntze (n = 15)**
Syn. *Thea sinensis* L.
Family: Theaceae (Ternstroemiaceae)

Tea has acquired prominence as an agricultural commodity in the world during the last century a half. It is enjoyed by over half of the world's population, chiefly in the Far East. Tea is also popular in Britain, Northern Ireland and Australia, the first two together consume more than 50 per cent of the exports from the producing countries.

HISTORY AND ORIGIN

Tea has a very long history. The legendary Chinese emperor Shen Nung is said to have discovered the stimulatory properties of tea leaf extract around 2700 BC, and that at first it was used mainly as a medicine. The exact geographical centre of the origin of tea has not been settled. It is believed to have originated either in India or China or even both. Although there is no doubt that tea was being

MORPHOLOGY

The tea of commerce consists of the processed tender leaves and the leaf buds of *Camellia sinensis* (L.) O. Kuntze, which was once designated as a species of the genus *Thea* (*T. sinensis* L.) but was later shifted to *Camellia* as *C. thea* Link (now known as *C. sinensis*.)

Under natural conditions, the tea plant is an evergreen or semi-evergreen woody shrub, attaining a height of 9.1-15.2 m, but under cultivation, it is never allowed to grow beyond the plucking height. The bushes are often pruned back to encourage maximum leaf production. The leaves are alternate, generally elliptic to lanceolate with toothed margins. The older leaves are leathery, bright green in colour and 5-30 cm long (Figure 11.2). The under surface of young tender leaves is densely covered with soft hairs that vanish as they age (Figure 11.3). The characteristic fragrance and aroma of the leaves is due to the presence of numerous oil glands. Yellow-centred white or pinkish fragrant flowers are borne in leaf axils either singly or in groups of two to four. At maturity, they produce three-celled woody capsules, each compartment of which contains a brown seed, about 1.25 cm in diameter.

Figure 11.2 A flowering and fruiting branch of the tea plant with a seed at the bottom left.

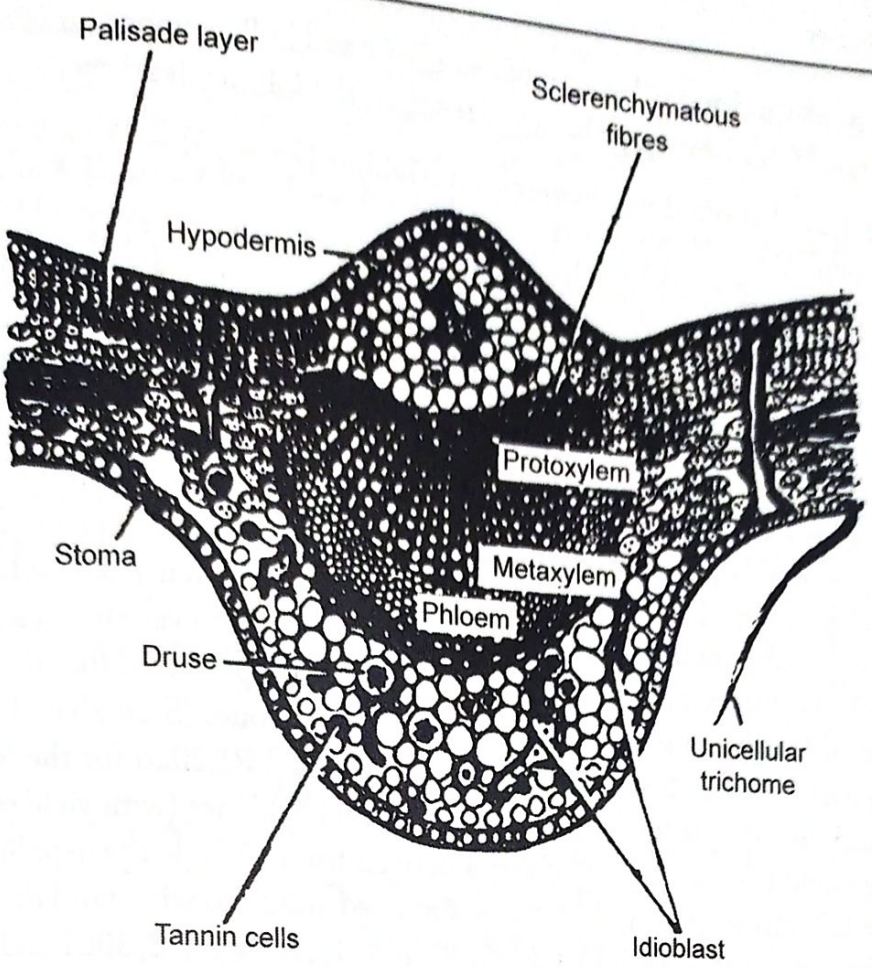

Figure 11.3 A V.S. through tea leaf. Note an arc of xylem with phloem below, the whole tissue being surrounded by a slightly lignified band of fibres. Stomata and unicellular, thick-walled conical hairs occur only on the lower surface. Druses are scattered throughout the mesophyll tissues. Idioblasts occur at intervals, sometimes stretching across the lower epidermis to the upper epidermis of the wing portion. Tannin cells are well-distributed throughout. The marginal serrations of each leaf terminate into a small conical gland that readily breaks off and is often absent in the mature leaf.

VARIETIES

Bailey (1949) recognised four principal varieties, var. *bohea* Pierre (*T. bohea* L.), var. *cantoniensis* Pierre (*T. cantoniensis* Lour.), var. *viridis* Pierre (*T. viridis* L.) and var. *assamica* Pierre (*T. assamica* Mast.).

For practical purposes, the cultivated forms are generally grouped into two types, namely the Chinese teas (*C. sinensis* var. *sinensis*) and Assam teas (*C. sinensis* var. *assamica* Mast.), to which *sinensis* × *assamica* hybrid teas may be added as the third. In fact, most of the tea cultivated outside China, Japan and Assam is the hybrid tea. A brief detail of the two cultivated form is as follows:

- ***China teas:***

China tea is a slow growing, multi-stemmed bush, 1.22-2.74 m tall, with relatively narrow, short, dark green leaves, 4-7 cm long, with a dull, flat surface, pointing upward. It is a hardy variety, capable of withstanding cold winters, and has an economic life of at least 100 years. The flowers are borne singly.

- ***Assam teas:***

This is a quick growing, less hardier, single stemmed tree, ranging in height from 6.1-18.3 m, which has an economic life of 40 years. The leaves are much larger (15-30 cm long), held horizontally or

back of the plucker. The leaves must not be compressed in the basket nor should they be gathered in one hand while plucking with the other. Both of these practices crush the leaf and rupture its surface, thereby initiating fermentation.

A worker can pluck 18 to 34 kg of tea leaves each day. Picking stimulates the development of lateral buds that will be ready for picking after seven to ten days. After a number of flushes, the bush is pruned back to maintain a convenient plucking height. After about ten years, the bushes are often cut back to ground level, allowing suckers to replace the old bush.

The finer grades of tea are obtained only from the terminal bud and the first two leaves of the young shoots (Figure 11.4). The terminal buds are rich in tannin (28 per cent) and are most valued in the trade; commonly referred to as 'golden tips'. The terminal buds also have a high caffeine content (4.0-4.5 per cent of the dry matter). Several other tea designations that have been given are 'orange pekoe', the smallest leaf (28 per cent tannin); 'pekoe', the second leaf (21 per cent tannin); 'pekoe-souchong', the third leaf (18 per cent tannin) and 'souchong', the fourth leaf (14 per cent tannin). Sometimes even the fifth leaves are used for a tea known as 'congou'.

Figure 11.4 Tea of commerce consists of processed tender leaves, that is, the terminal bud and the first two leaves of the young shoot.

PROCESSING OF TEA

The four main types of commercial tea, generally recognised in the trade are black tea, green tea, oolong tea and brick tea. Green tea is mainly produced in Japan, China and Taiwan, while India and Sri Lanka produce mostly black. China also produces a considerable amount of black tea. Oolong tea, a partially fermented product, comes almost exclusively from Taiwan and the bulk of it is exported to the US. Brick tea is mainly made in China to be exported to Central Asia. Ninety-eight per cent of the international trade is in black tea.

Black tea

The fresh tea leaves, after picking are lightly packed in baskets to prevent bruising and heating and are immediately sent to processing units. Four main operations are involved during the manufacture of black tea, withering, rolling, fermenting and drying or firing.

The freshly picked shoots as they arrive in factory are spread out evenly on trays, jute hessian, or nylon nets or fine-meshed screen wire trays, racks or shelves to permit wilting, rendering them soft and flaccid. Care is to be taken not to bruise or injure the leaves otherwise premature fermentation will set in. Wilting is accomplished either in open sheds where it is affected by the natural breeze or

in special sheds equipped with controlled heating and ventilating facilities. The entire process lasts for 10-12 hours at 30 °C. During withering, the moisture content of the leaf is reduced to 50-60 per cent from 75-80 per cent.

The withered leaves are then passed through rollers under pressure to rupture the cells, liberating the sap and the enzymes that participate in the fermentation later on. If necessary, the coarse fraction is subjected to heavy rolling to obtain a more homogeneous mass.

The process of fermentation is carried out in specially designed fermentation houses where temperature, humidity and air circulation can be regulated. A temperature between 24 and 27 °C with a humidity of about 90 per cent is considered essential. The partially fermented rolled mass of leaves is piled into special trays to a thickness of 2.5-10 cm, and subsequently covered to keep it warm. During fermentation, the colour turns bright red and the leaves develop a characteristic aroma and flavour.*

During drying or firing the fermented leaves are exposed to a current of hot air (90-100 °C) for 20-25 minutes in specially constructed ovens. The dried product contains three to four per cent moisture. It is cleaned and sorted with the help of rotating or vibrating screens. After sorting, the various grades of tea are traditionally packed in plywood chests lined with tin or aluminium foil and shipped for export.

The waste left after sorting and grading is sold as 'fluff' (caffeine content 3.5 per cent), which is used for the extraction of caffeine.

Any leaf distortion that occurs in the conventional rolling process is so gentle that as much as one quarter of the oxidisable phenols may remain unchanged and are not converted to theaflavins (responsible for the brightness of the liquor) and thearubigins (responsible for the body and strength). The stages in the conversion are shown below:

Epigallocatechin, its gallate(EGCG), and probably epicatechin gallate

↓

ortho-quinones

↓

bis-flavanols

↓

theaflavins

↓

thearubigins

The modern leaf distortion systems, such as CTC (crushing, tearing and curling), Legg-cut, Rotorvane and Triturator cause thorough mechanical disruption of cells, resulting in complete mixing of the enzyme (polyphenol oxidase or catechol oxidase, associated with the plastids) and the substrate (polyphenols, located in the cell sap of the vacuole).

An ultrasonic generator, which effectively ruptures the tea leaf cell membranes, has been tested in Georgia, CIS (Commonwealth of Independent States, erstwhile USSR). However, whether or not the technique can be used commercially in the production of quality tea remains to be investigated.**

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* Sometimes adulterated with spent tea leaves, husk of beans such as green gram or black gram, leaves of leguminous plants such as *Sesbania bispinosa* (Jacq.) W.F. Wight, *Cassia auriculata* L., bark of the trunk and even grits and sand.

** Heat sealed 'tea bags' are manufactured from leaf fibres of Abaća or Manila hemp (Musa textilis Nee) or from 'soilon'–a fine mesh made from corn starch

Green tea

During the plucking operation, the tea pickers often wear shade hats to prevent premature withering of the leaves. Green tea is made by briefly heating the freshly picked leaves in an iron pan (pan firing) in China or by steam (in Japan) to inactivate the enzymes, thereby skipping the fermentation process. The leaves are then rolled and dried just like black tea and polished with soapstone or French chalk to improve the colour. The final product is dull green with an even texture and quality. The tea obtained as a result of pan firing is of better quality. The tannin and caffeine content of the green tea is higher than the black tea. At times, green tea is scented with the blossoms of *Jasminum sambac* (L.) Ait. (Family Oleaceae) or other aromatic plants, the flowers being mixed in with the dried tea leaves.

Oolong tea

This is a partially fermented product prepared almost entirely in Taiwan from a special form of China teas, 'chesima'. It is consumed mainly in America. It is an intermediate between the green and black tea, having the flavour of the former but the colour of the latter. The characteristic flavour of oolong tea is due to the special variety of tea grown in Taiwan and also due to the climatic and soil conditions.

Brick tea

This is prepared from the waste left after the preparation of black and green teas. It may consist of leaf, stalks, and even twigs, or mainly coarse tea dust. The bulk is softened with steam and then compressed into blocks or bricks. It is mostly consumed in Tibet but is also exported by China.

The tea industry is now producing instant or powdered black tea. In Myanmar, Thailand and China, the tea leaves may be pickled and the product 'leppet-so' or 'miang' is eaten as a vegetable. Most tea brands are mixtures that combine the characteristics of different varieties, from different growing areas, which are professionally blended to satisfy the consumer taste.

CHEMISTRY OF TEA LEAVES

A freshly plucked tender tea shoot, consisting of the terminal bud and the two leaves just below it, contains about 77 per cent moisture and 23 per cent solid matter. Nearly 50 per cent of the solid matter is insoluble in water and is composed of crude fibres, cellulose, starches, proteins, etc. The remaining soluble half includes over 20 amino acids, about 30 polyphenolic compounds, 12 sugars and 6 organic acids. The Assam variety is richer in caffeine and polyphenolic compounds than the China variety. In the fresh leaf, the stimulating theine (an alkaloid identical to caffeine) occurs in combination with tannins and is only released by fermentation. A very small amount of the allied alkaloid theophylline is also present .

The distinctive character of the beverage is mainly due to three principal constituents, the essential oils, the alkaloidal fraction and polyphenols (the so-called tannins). The aroma and flavour of tea is due to the presence of the ethereal oil, theol. Theine is responsible for the stimulating and refreshing qualities of the tea, whereas the bitterness and astringency of the leaves are due to tannins.

The tannins undergo a major change during the preparation of black tea and their concentration is reduced to 12 per cent from the original 28. The caffeine content of finished tea leaves varies from 2.5-4.5 per cent, twice as much of that of roasted coffee beans (1.0-2.0 per cent).

The stimulating properties of black tea are mainly due to an alkaloid–theine, which together with another alkaloid theophylline helps to speed up the heart rate and make a person feel mentally alert. However, the tea contains a few carbohydrates, fats and proteins. Although tea is rich in polyphenols and tannins, it lacks tannic acid. Black tea contains two types of flavonoids, theaflavins and thearubigens.

Black tea is rich in antioxidants, such as polyphenols and catechins (their concentration is more in green tea) that give it many health benefits, including protection against oxidative damage to the cellular membranes and the cellular DNA, thus preventing some forms of cancers. These antioxidants are also known to prevent artery-blocking blood clots, control blood pressure by promoting blood flow, reduce the risk of arteriosclerosis (clogged arteries), thereby lowering the risk of cardiovascular diseases and Type 2 diabetes.

Catechins and polyphenols, present in green and black teas, promote oral health, killing and suppressing cavity-causing bacteria as well as hinder the growth of bacterial enzymes, thus, reducing plaque formation that is responsible for dental caries or cavities and tooth decay. Tea leaves contain fluoride which makes tooth enamel stronger and more resistant to acids.

Regular consumption of tea, especially green tea lowers harmful or bad cholesterol, increases good cholesterol in the blood stream and further improves the ratio of good cholesterol to bad cholesterol. Further, the polyphenols in the tea increase the level of fat oxidation.

Tea can be consumed hot and cold to get its benefits. Overconsumption (taking more than three to four cups a day) should be avoided as the oxalates present in tea infusion can cause kidney stones as well as may bind with free calcium in the body. Intake of green tea increases mental alertness and improves memory.

Although tea is primarily consumed for its theine content, a cup of tea provides four calories without any added ingredients. With the addition of a tablespoon of milk and a lump of sugar, it gives 40 calories. In addition, it contains several of the B complex vitamins and nicotinic acid. Indian teas are peculiar in having a relatively larger tannin content than Chinese varieties, which are known for their delicacy. Chinese teas are favourite drinks of persons with delicate digestive systems.

The per capita consumption of tea in the UK is nearly 4.5 kg per year compared to 0.3 kg per head in the US. It is of interest to note that coffee consumption, on the other hand, is about 0.9 kg per head in the UK compared to 7.25 per head in the US.

Coffee

***Coffea* spp. (x = 11)**
Family: Rubiaceae

Domestication of coffee began relatively recently (nearly 500 years ago) and has become popular as a beverage only since the eighteenth century. It is now a general breakfast drink in Europe and North America. At present, it is consumed hot or cold by about one-third of the world's population, in larger quantities than any other drink. The beverage is made by brewing the roasted and pulverised coffee beans with water. The refreshing and invigorating properties are because of the alkaloid caffeine.

The genus *Coffea* includes a large number of species, of which only two are commercially important, Arabian or Arabica coffee (*C. arabica* L.) and Robusta coffee (*C. canephora* Pierre ex Froehner). The former contributes nearly 90 per cent of the world's coffee crop, while the latter a little less than nine per cent.

HISTORY AND ORIGIN

C. arabica is indigenous to the tropical rainforests of Ethiopia where the leaves and dried coffee berries have been used as a masticatory since ancient times. According to an old Ethiopian legend, a shepherd named Kaldi (around AD 800) noticed that his flock of sheep, instead of being drowsy in the evening, became elated and sleepless whenever they nibbled berries from a certain shrub on the hillside. He tried some of these berries himself and experienced a sense of exhilaration and wakefulness. This habit of chewing dried berries and leaves was carried to Arabia by the Arab invaders during the fifteenth century. They were also the first to discover the practice of making a brew of coffee beans. However, the priesthood pronounced coffee intoxicating, and the Koran prohibited its use. At one time in the Near East, coffee drinkers were put to death. Despite scorn and ridicule, taxes and penalties, prohibition and punishment, the new beverage outlived all imposed restrictions. The Arabs themselves became so fond of coffee drinking that the first public coffee houses were opened in Mecca and Medina in 1470. Its popularity spread rapidly during the fifteenth and sixteenth centuries throughout the Moslem World of North Africa and the Middle East. It has since been used as stimulant for inducing wakefulness during the long religious services or rituals.

Coffee did not reach Europe until the beginning of the seventeenth century (Venice in 1615, Paris in 1645 and London in 1650). It reached only the affluent class and was considered a luxury. Until the close of the seventeenth century, the world's limited supply of coffee came almost entirely from plantations in the province of Yemen in southern Arabia.

The Dutch introduced coffee to Ceylon in 1658 and Java, Sumatra and other island of Malaya Archipelago in 1699. Coffee was planted in India by the British around 1700, but the Indian tradition credits Baba Budan, a Moslem pilgrim to Mecca for having introduced coffee in about 1600 into southern India (Baba Budan Hills), which is still an important coffee producing area.

In 1706, a few plants were taken from Java to the Botanical Garden in Amsterdam, of which only one tree fruited. The descendants of this plant formed the basis of plantations in tropical America and the West Indies. Even Hawaiian and Philippine coffee is of Javanese origin being derived from the lonely tree in Amsterdam. The development of coffee cultivation in the tropical America has indeed been very impressive, supplying today about two-thirds of the world's production.

At one time, Sri Lanka was the leading producer of coffee in the Indian Ocean and its economy depended heavily on the crop. However, the entire plantations were devastated within a few years in the nineteenth century when one of the great plant plagues of history, 'leaf spot' or 'coffee rust', caused by the fungus *Hemileia vastatrix* Berk. and Br., swept through the island. Dependence of a country on a single crop is very dangerous, but fortunately for Sri Lanka, the establishment of tea plantations saved its shattered economy. It is feared that the cocoa industry in Africa, particularly Ghana, may suffer in a similar manner as 'swollen shoot virus disease' is posing a serious threat.

PRODUCTION

The total world's production of coffee in 2012 was 8 826 903 tonnes. Brazil was the largest producer, accounting for approximately 3 million tonnes of green coffee beans, followed by Vietnam (1 292 389 t), Indonesia (657 200 t), Colombia (464 640 t), India (314 000 t), Peru (303 264 t), Honduras (300 000 t), Ethiopia (275 530 t), Guatemala (248 000 t) and Mexico (246 121 t). The other small producers were Uganda, Costa Rica, Nicaragua, El Salvador, Laos, Papua New Guinea, Madagascar, China and Venezuela. Brazil is the leading coffee exporting country of the world, followed by Vietnam, Indonesia, Colombia and Ethiopia. Other small exporters are Peru, India, Honduras, Mexico and Guatemala.

The United States is the largest coffee importing country in the world, followed by Germany, Japan, Italy, France, Belgium, Canada, Spain, the UK and Austria. Finland has the highest per capita consumption of 12 kg a year, followed by Norway (9.2 kg) and Denmark (8.7 kg). Americans consume nearly 4 kg per year while Britons' consumption is around 2.7 kg a year.

The major coffee producing Indian states are Karnataka, Tamil Nadu, Kerala and Odisha.

ECONOMIC SPECIES

C. arabica L. Arabica or Arabian coffee (n = 22)

The bulk of the world's production of coffee (approximately 90 per cent), and incidentally the best, is derived from the Arabian coffee plant (*C. arabica*, n = 22)–a highland species preferring a cooler and less humid climate. Plantations in Latin America and the West Indies consist almost entirely of the forms of *C. arabica*. It is also grown in India, Indonesia and other Asian countries. There are a large number of botanical varieties, but the two most important are *C. arabica* L. var. *arabica* (= var. *typica* Cramer) and *C. arabica* var. *bourbon* (B. Rodr.) Choussy. The Arabian coffee plant is an evergreen shrub or small tree, 4.5-9.0 m high, but is kept low under cultivation by careful pruning. Pruning further helps in building a robust and well-balanced framework to support and promote the periodic rejuvenation of fruiting branches, which otherwise become senescent and non-productive. It also protects the crop from wind and excessive sunlight.

The shoot morphology of *C. arabica* has two distinctive structural features–the presence of a series of five or sometimes six buds in leaf axils and a dimorphic pattern of branching. Provided that the main stem remains intact, the uppermost buds of the series on either side develop into plagiotropic (horizontal) branches, usually called 'laterals' or 'primaries', while the lower buds (most or all of which are invisible) remain dormant. The latter produce upright orthotropic shoots whenever the main axis is topped or damaged. When small, these orthotropic shoots are known as suckers or water shoots (Figure 11.5). The leaves on the laterals, like those on the main axis, are opposite and bear a 'series of buds' in their axils. Each of the bud is capable of developing into a plagiotropic shoot (never a vertical shoot) or an inflorescence. The inflorescence, more commonly, arises from the first three or four buds. It bears four shortly stalked flowers, each being subtended at the base by a pair of bracts with axillary buds that usually remain dormant. Leaves are ovate or elliptic with margins, sometimes undulate, opposite, glabrous and glossy with prominent acuminate tips, and are characteristic in having inter-petiolar stipules. Snow-white, star-like flowers which smell delicately of jasmine are borne in dense axillary clusters and are produced in 'flushes' three or four times a year (Figure 11.6 A). The flowers are short-lived, remaining open in the morning and fading by the midday. The young fruits are green, turning crimson red at maturity, six to nine months after blossoming (Figure 11.6 B).

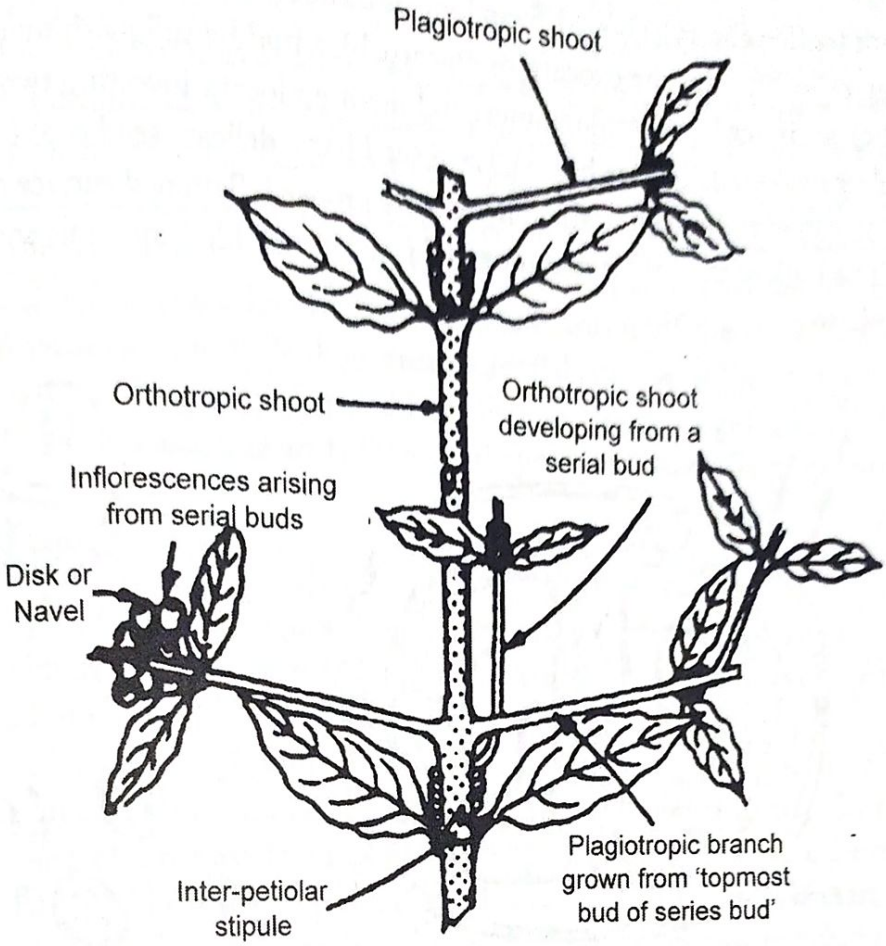


Figure 11.5 Shoot morphology of arabica coffee (*Coffea arabica*) showing the dimorphic pattern of branching as well as the arrangement of the serial buds.

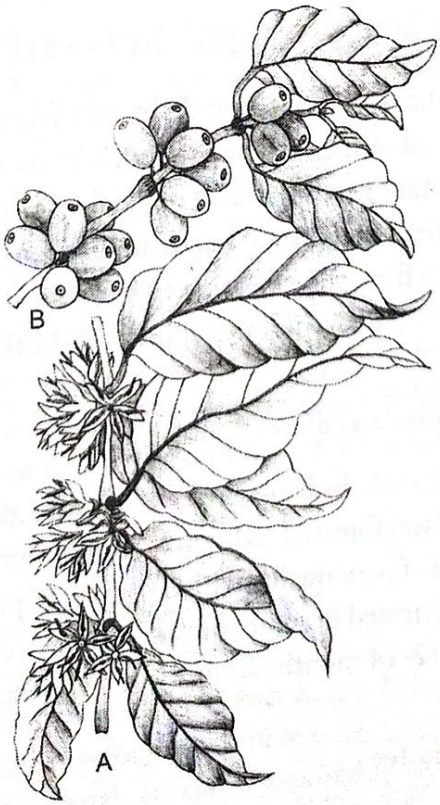


Figure 11.6 (A) *Coffea* sp. in blossom. The snow-white flowers smell delicately of jasmine and are produced in 'flushes', that is, three or four times a year, and (B) fruiting branches with disk or navel at the tip of fruits.

The flavour of coffee depends upon several factors such as; the location, varietal type, the degree of ripeness of the seed, the method of curing and drying, the practice of roasting and also the extent and type of substitutes used. Professional coffee tasters blend together, in appropriate proportion, coffee from different locations to produce a flavour to suit consumer taste.

Instant coffee powder is obtained by vaporising a strong infusion of coffee in vacuum or by the freeze drying technique. The use of robusta coffee for the manufacture of instant coffee is rapidly increasing, the bulk of which is produced in Africa, particularly the Côte d'Ivore, Angola, Uganda, Congo and Madagascar and in Indonesia.

Coffee is a general breakfast drink in Europe and North America. At present, it is consumed hot or cold by about one-third of the world's population in larger quantities than any other drink. Its stimulating properties are due to the presence of caffeine which can stimulate the nervous system, thus fight fatigue and keeps us alert and awake.

Coffee contains a complex array of disease-fighting antioxidants, some 1000 compounds have been identified in unprocessed coffee beans, and hundred more develop during roasting. Coffee contains as much as four times the antioxidants present in tea. Thus, coffee is a super-concentrated source of polyphenol antioxidants, such as bioflavonoid with a punch of anthocyanins and proanthocyanidins. Among the other antioxidants are chlorogenic acid, caffeic acid, quinic acid and ferulic acid, diterpenes (caféstol and kahweol with anti-carcinogenic properties), eugenol, isoeugenol, gamma tocopherol, p-coumaric acid, scopotitin and tannic acid. In addition, trigonelline, an anti-bacterial compound that not only gives it a wonderful aroma but may be a factor for preventing dental caries is also present. Besides antioxidants, coffee is a rich source of amino acids, vitamins (such as riboflavin, pantothenic acid and niacin) and minerals like manganese, potassium and magnesium.

Consumption of coffee in moderation provides the following health benefits:

- Can lower the incidence of fatty liver diseases, cirrhosis and cancer
- Associated with a much lower neurodegenerative disorders of Alzheimer's (leading cause of dementia) and Parkinson's (caused by the death of dopamine–generating neurons in the brain)
- May reduce the risk of type 2 diabetes which has been attributed to caffeic acid and chlorogenic acid
- May help to protect against cardiovascular diseases by lowering cholesterol and blood platelet clumping, thereby optimising blood flow to the heart and brain
- Defend against cancer causing DNA damage, especially of breast, liver, prostrate and colon, etc.

Therefore, there is a possible correlation found in coffee and overall good health. Caffeinated and decaffeinated types of coffee provide nearly the same level of antioxidants.

Drinking coffee in moderation is very safe. Studies have shown that people who drink a modest amount of coffee (two to three cups per day) have longer life expectancies. Coffee is the biggest source of antioxidants in the western diet, outranking both fruits and vegetables combined. A cup of black coffee (without milk and cream) only contains around two calories. However, if we add sugar and milk, the calorie count can shoot up.

Caffeine free (decaffeinised) coffee is obtained by removing the caffeine from unroasted coffee beans with an organic solvent.

The leaves also contain caffeine and an infusion from the dried leaves is made in Indonesia and Malaysia. In Arabia, an alcoholic drink is prepared from the dried coffee pulp. Waste products such as coffee pulp and parchment are used as manures and mulches and in India they are occasionally fed to cattle. Coffelite, a type of plastic material with good insulting properties, can be made from coffee beans.

The popularity of coffee as non-alcoholic beverage remains unchallenged, particularly in the Western World. The coffee houses have become an integral part of the daily life of the educated classes. They are centres of refreshment, relaxation and intellectual discussion. In 1675, King Charles II tried to suppress coffee houses, because they were considered the centres of political agitation, but the public outrage was so great that within 11 days the king had to revoke his proclamation.

Cocoa

***Theobroma cacao* L. (n = 10)**
Family: Sterculiaceae

Cocoa* and chocolate are two major products that are obtained from the roasted kernels of ripe seeds of the cacao tree, a native of low-lying areas of the tropical Central and South America. Like coffee, its centre of production is far removed from the centre of genetic diversity. At present, nearly two-thirds of the world production comes from Africa. The cacao plant should not be confused with coca (*Erythroxylum coca* Lam.) to which it has nothing in common, the latter being a source of cocaine. Cocoa now ranks third amongst the most popular non-alcoholic beverages consumed largely in Europe and North America. The average consumption is the highest in Holland with 6.94 kg per head per annum.

HISTORY AND ORIGIN

Long before the discovery of America, the Aztecs, Mayans and other tribes of Central and South America and the West Indies, had cultivated the tree. Because of the Aztecs' legends of the divine origin of cacao, Linnaeus named it *Theobroma cacao* L. (from the Greek theos means God and broma means food, hence food of God). The early civilisations in the Western Hemisphere used to prepare a drink called 'chocolatl' by pounding cacao seeds with maize grains and then boiling the powder with water. Only the royal classes consumed chocolatl. It was unsweetened, cold and flavoured with vanilla and green pepper. At one time in South America cacao beans were used as a currency. Tribute to the Aztecs emperor was made in cacao beans rather than gold. Hernando Cortés, after conquering present-day Mexico in 1519, unearthed a vast horde of cacao beans in the royal palace of the Mexican ruler Montezuma II, who is known to have honoured his guests by serving a chocolate drink in goblets of beaten gold. The Spaniards, who found cocoa more palatable when it was sweetened, brought the habit of drinking cocoa to Europe. They closely guarded the secret of 'chocolatl' or 'xocoatl' for almost 100 years. In 1525, the Spaniards planted cacao trees in Trinidad and later established plantations in Venezuela. By the end of the sixteenth century, cocoa and chocolate had become their favourite food and drink. It was only in 1606 that the beverage reached Italy.

* The term Cacao is often employed for the tree and its parts, and 'Cocoa' for the manufactured products.

The Spaniards introduced the cacao tree into the Philippines in 1670 and later the Dutch carried it to Ceylon and Indonesia. The Germans took it to New Guinea and other islands in the Pacific, reaching as far as Samoa. The Dutch also introduced the cacao tree to the island of Sâo Tome in the gulf of Guinea, off the west coast of Africa. It was from here that in 1878 or 1879, a native labourer carried it to West Africa, which is now the world's leading producer of cacao beans.

C.J. van Houten, in 1828, discovered that the defatting cacao kernels made the drink more palatable and digestible. Hence, the subsequent use of the expressed fat (cocoa butter) in the manufacture of eating chocolate and the idea of adding dried powdered milk to eating chocolate (milk chocolate) (M.D. Peter in 1876), were instrumental in increasing the demand of cacao seeds in the latter part of the nineteenth century.

PRODUCTION

Of the world's production of cocoa of five million tonnes in 2012, Côte d'Ivoire (earlier known as Ivory Coast) accounted for 1 650 000 metric tonnes, around 33 per cent of the total. Other chief producers were Indonesia, 936 300 t; Ghana, 879 348 t; Nigeria, 383 000 t; and Cameroon, 256 000 t. Other producers were Brazil, Ecuador, Mexico, Dominican Republic, Peru, Colombia, Papua New Guinea, Togo, Venezuela, Sierra Leone, Uganda and India. About 73 per cent of the global cocoa production comes from West African countries, which are also the major exporters in the world market. The Americas contributed nearly 13 per cent, and Asia and Oceania together 14 per cent of the total. The chief consuming countries, in the order of importance, are the Netherlands, Malaysia, the US, Germany, Belgium, France, Spain, Singapore, Italy, Brazil, Canada, China, the Russian Federation, Switzerland, Turkey, Indonesia, the Ukraine and Thailand.

In India, the crop is of minor importance chiefly grown in Kerala and Karnataka–the former accounting for about 80 per cent of India's production.

MORPHOLOGY

A fully grown cacao tree seldom exceeds a height of 7.6 m under cultivation but may go up to 12.2 m or more when growing wild (Figure 11.8).

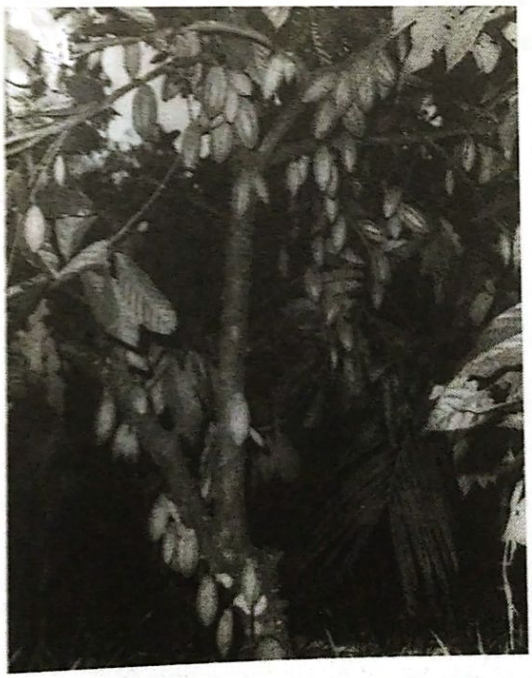


Figure 11.8 Cacao tree with pods.

The branching pattern of the cacao plant is characteristic and unusual. Branching is profuse, starting when the plants are only 0.9–1.5 m tall. The main stem divides into four to six lateral branches that arise at the same point. This group of plagiotropic branches is called a 'jorquette' or 'fan' (Figure 11.9). Shortly after, an axillary bud just below the jorquette develops into a vertical orthotropic shoot, the 'chupon', which will again form a jorquette, a few feet higher up. Another chupon will again arise just beneath the second jorquette. This process may be repeated, a third or even a fourth time, producing a leafy canopy. Jorquette branches normally only produce 'fans', but may occasionally produce a chupon. The leaves are spirally-arranged on the main stem and subsequent chupons, but are alternately placed on the jorquette branches. The mature leaves are dark green, about 37 cm long and 7.5 cm broad, oblong-oval or elliptic-oblong with prominent veins and veinlets. The short petiole is provided with two articulations (Figure 11.10).

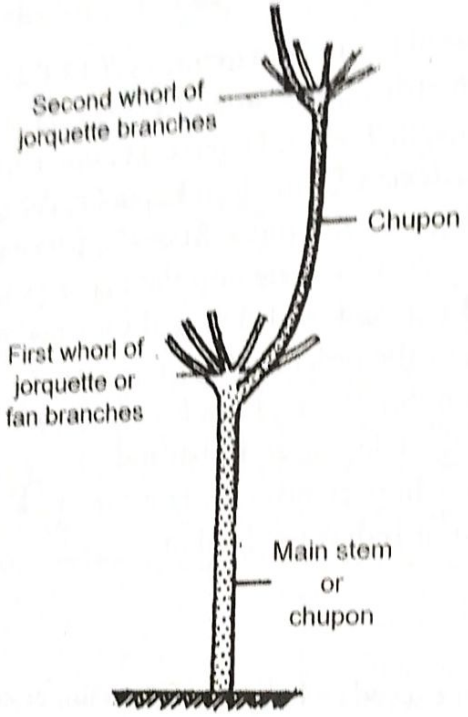


Figure 11.9 Diagrammatic representation of the branching pattern of the cacao plant. Successive chupons are produced sympodially, each bearing a group of jorquette branches that arise at the same point.

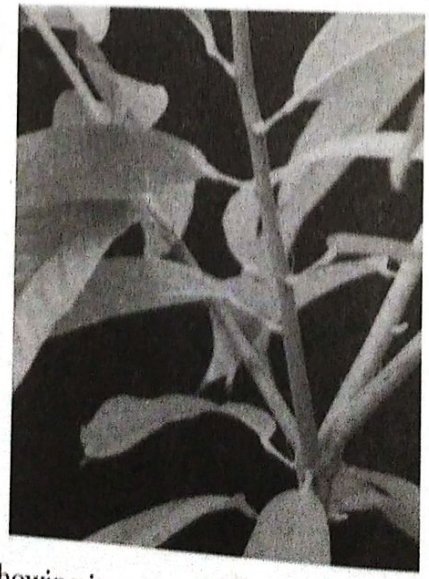


Figure 11.10 A photograph showing jorquette formation. Note the presence of two articulations in the petiolar region.

Tiny white, yellow or rose coloured pedicellate flowers are borne in small clusters on cushions on the bark of the trunk and older branches, never on young shoots–a type of formation known as cauliflory (Figure 11.11 A). Only a few of the many thousand flowers develop into fruits. Flowering and fruiting continues throughout the year.

The flowers are bisexual, regular and pentamerous. The sepals are prominent, leathery and fused at the base. The corolla consists of five petals, smaller than the sepals, each having a broad, curved, saccate basal part and a much-narrower terminal portion, expanding terminally into a cup-shaped pouch. Ten stamens are arranged in two whorls of five, the outer being represented by infertile, narrow, ciliate, erect pointed structures forming a fence around the style. On the other hand, the stamens of the inner whorl have curved filaments, the anthers developing inside the saccate portion of the petal (Figure 11.11 B). Stamens and staminodes are fused in the basal region forming a short tube. The gynoecium consists of five fused carpels surmounted by a single short, hollow style, terminating in five stigmas.

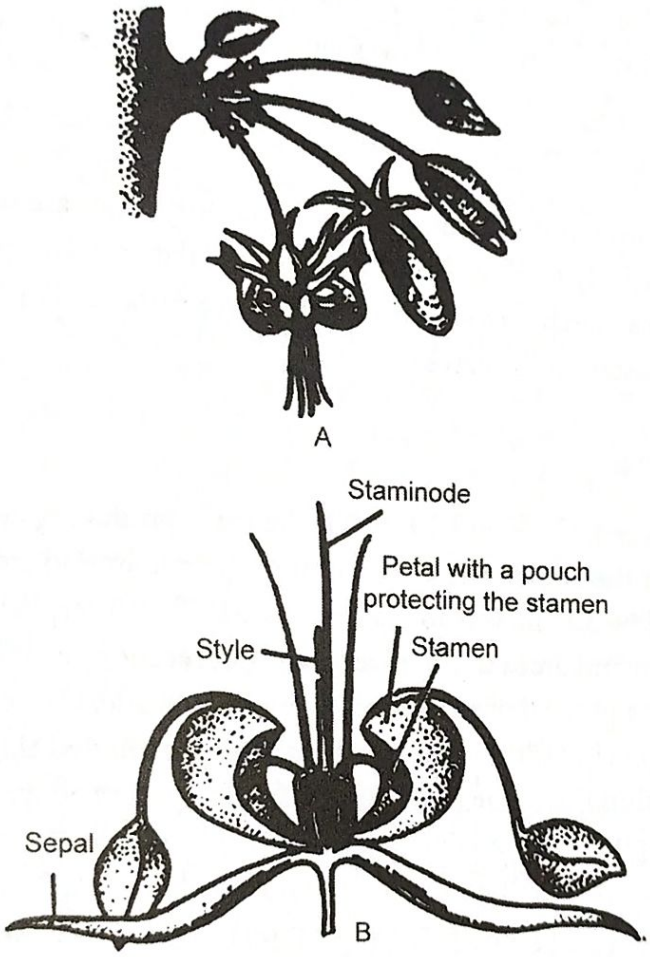


Figure 11.11 (A) Buds and flowers arising in clusters on cushions present on the bark of the trunk and older branches, (B) longitudinal section of a flower.

The mature fruit, a berry but commonly called a pod, is composed of a fairly thick, leathery, smooth or corrugated pericarp or husk. The fruits are somewhat cucumber shaped, elliptic-ovoid, about 10 cm in diameter and 22.5-30 cm or even more in length, and the colour ranges from green, yellow, red to purple. Inside the pod are 20 to 40 flat or round seeds, or 'cacao beans' embedded in a white, pink or brown, aromatic, mucilaginous, sweet or faintly acidic pulp. The seeds are arranged in five rows. Seed colour varies from white to violet in different varieties. Each cacao tree produces only one or two pounds of beans every year.

to prevent the possible transfer of disease producing organisms by a contaminated knife blade. To ensure the production of quality beans, only mature and ripe pods are collected and are processed promptly (Figure 11.12).

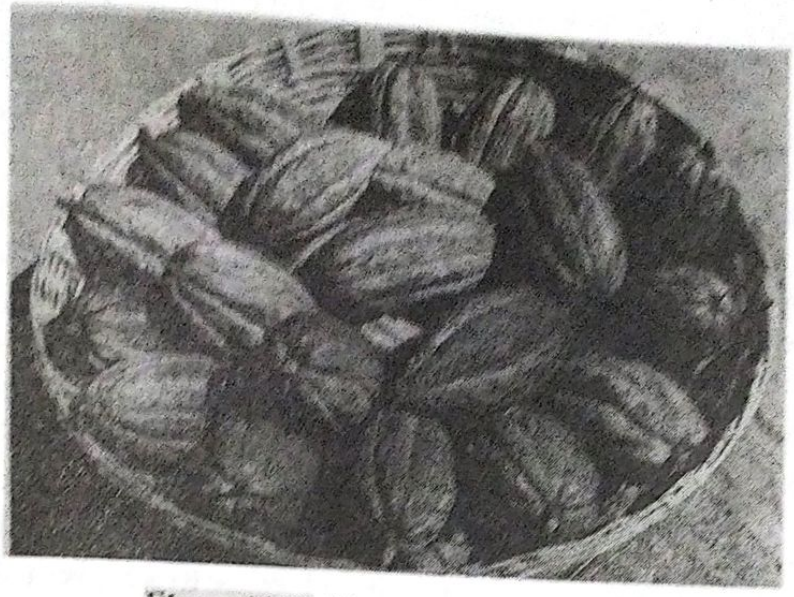


Figure 11.12 Harvested fruit in basket

PROCESSING

The fruits are split open by slashing the husk with a cutlass or machete, or by striking the two pods together (Figure 11.13). The seeds and pulp are then scooped out and fermented. In small-scattered plantations in West Africa or elsewhere, cacao is fermented in heaps or in medium-sized baskets, usually covered with banana leaves to retain the heat. The beans are left for four to seven days depending upon the prevailing climatic conditions. They may be left undisturbed or turned upside down to allow good aeration and prevent the temperature from rising too high. During fermentation, the sugars contained in the pulp are first converted to alcohol by the activity of yeast (*Saccharomyces* spp.) and finally into acetic acid by *Acetobacter* spp. The beans are killed by the penetration of alcohol and acetic acid and develop a chocolate brown colour. The cotyledons shrink from seed coat and separate. The characteristic aroma is due to the presence of an essential oil, 'cacool.

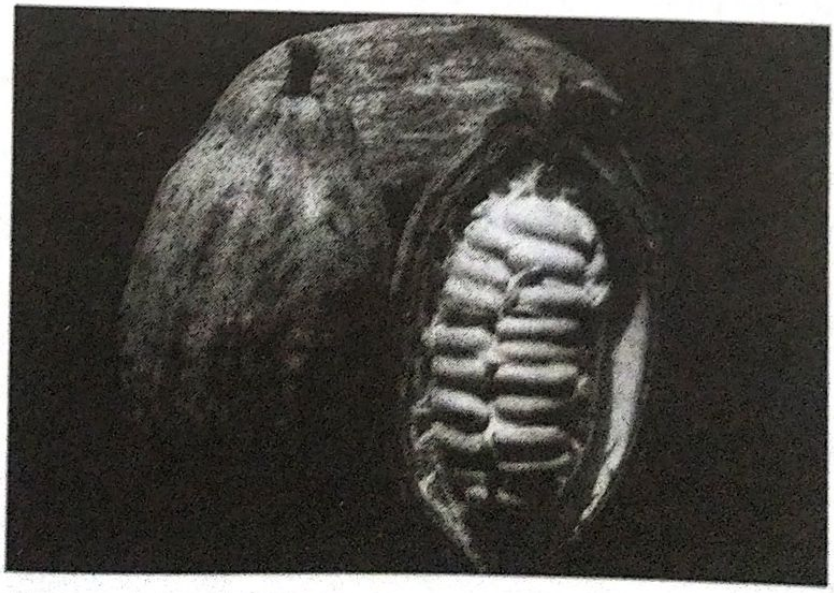
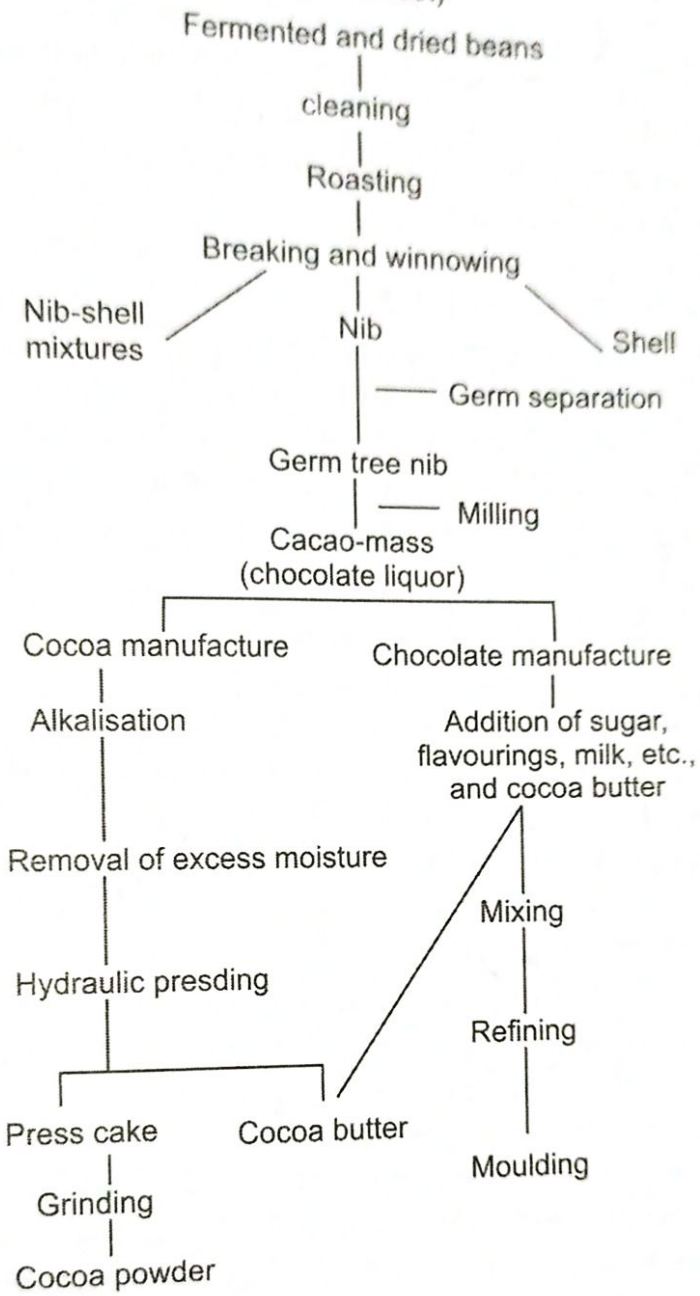


Figure 11.13 Opened out cacao pod

Cocoa and chocolate manufacture
(flow sheet)



Cocoa is a highly concentrated energy food, containing fat (30-56 per cent), starch (15 per cent) and albuminoids (15 per cent). Its stimulating qualities are due to the presence of theobromine (3 per cent) and small quantities of caffeine. Cocoa products are rich in fibres, minerals, such as iron, magnesium, manganese, copper, zinc, potassium, and calcium and vitamins of B group and E. Additionally, cocoa powder and chocolates are rich in antioxidants–beneficial phytonutrients that help the body to fight against free radicals, thus preventing cancer, cardiovascular diseases, age-related macular degeneration and premature ageing.

Of all the foods known (such as blueberries, pomegranate, red wine, apple, onions and tea), cocoa has the highest level of polyphenol antioxidant (which include anthocyanins, isoflavones, flavanones, flavonols, flavanols and flavones). The flavonols in dark chocolates can stimulate endothelium (the lining of arteries) to produce nitric oxide. Nitric oxide is a gaseous molecule that relaxes and dilates blood vessels, prevents hardening of arteries, inhibit blood platelets from

clumping together and forming clots, help in preventing the build-up of plaque in the arteries, thus producing a surge in blood flow to the heart and brain. A type of flavonoids called 'flavanols' boosts cognitive skills, concentration and focus. Since dementia is caused by a reduced flow of blood and oxygen to the brain, it could thus be treated with cocoa. Cocoa consumption is also associated with reduced inflammation, decreased blood pressure, decreased LDL or 'bad cholesterol' and increased HDL or 'good cholesterol'.

The health benefits of cocoa products can be maximised by consuming 100 per cent pure cocoa powder as a beverage–a tablespoon of cocoa powder is mixed with hot skimmed milk, and a little raw sugar is added for sweetness. More antioxidants are released while drinking hot milk mixed with cocoa powder. The dark chocolate with 70 per cent or higher cocoa content is a healthier choice than milk chocolate because it is a powerful source of antioxidants, containing more than double the amounts of flavonoids. Cocoa in a raw or roasted form has four times more concentration of antioxidants than the processed cocoa, but will taste bitter and to overcome this sugar or honey is added.