

Utilization of tropical foods: fruits and leaves

Compendium on technological and nutritional aspects of processing and utilization of tropical foods, both animal and plant, for purposes of training and field reference

FAO
FOOD AND
NUTRITION
PAPER

47/7



FOOD
AND
AGRICULTURE
ORGANIZATION
OF THE
UNITED NATIONS
Rome, 1990

The designations employed and the presentation of material in this publication do not imply the expression of any opinion whatsoever on the part of the Food and Agriculture Organization of the United Nations concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

M-80
ISBN 92-5-102874-5

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying or otherwise, without the prior permission of the copyright owner. Applications for such permission, with a statement of the purpose and extent of the reproduction, should be addressed to the Director, Publications Division, Food and Agriculture Organization of the United Nations, Via delle Terme di Caracalla, 00100 Rome, Italy.

© FAO 1990

Contents

TROPICAL FRUITS	1
Variety and importance	1
Avocado	1
Occurrence and characteristics	1
Nutritional aspects	2
Utilization of avocado pears	2
Mango	3
Occurrence and characteristics	3
Nutritional aspects	3
Vitamin A deficiency	4
Utilization of mangoes	6
Processing of green mangoes	6
Processing of ripe mangoes	6
Papaya	6
Occurrence and characteristics	6
Nutritional aspects	8
Utilization of papaya	8
Extraction and use of papain	9
Pineapple	10
Occurrence and characteristics	10
Utilization and nutritional aspects	10
Custard apples	11
“Bullock’s heart”	11

Sweetsop or sugar apple	12
Soursop and hybrid custard apples	12
Cherimoya	14
<i>Abo</i>	14
Nutritional aspects	14
Utilization of custard apples	14
Rose apples	14
Jambolan	15
Malay rose apple	15
Watery rose apple	15
Java rose apple	16
<i>Pitanga</i> or Suriname cherry	16
<i>Carambola</i> and <i>bilimbi</i>	16
Cape gooseberry	17
Indian gooseberry	17
Star apples	18
Akee apple	18
Occurrence and characteristics	18
Utilization of akee apple	19
Rambutan, pulasan, litchi and longan	19
Rambutan	19
Pulasan	19
Litchi	19
Longan	20
Guavas	20
The common guava	20
Other species of guava	21
Utilization of guavas	21

Durian	22
Occurrence and characteristics	22
Utilization and nutritional aspects	22
Sapodilla	22
Mangosteen and <i>goraka</i>	23
Passion fruit and granadilla	25
Loquat	27
Prickly pear	27
Indian jujube or <i>ber</i>	27
Occurrence and characteristics	27
Utilization and nutritional aspects	28
Acerola	28
Occurrence and characteristics	28
Utilization and nutritional aspects	28
Citrus fruit in the tropics	29
Sweet orange	29
Lemon and lime	30
Preparation of lime pickle	30
Pomelo	30
Grapefruit	30
Tangerine, mandarin and citrus hybrids	31
Wild citrus species	31
Preparation of citron peel	31
Use of gathered wild fruits	32

African wild loquat	32
Snot apple, ebony apple and wild orange	33
Snot apple	33
Ebony apple	33
Wild orange	33
Mobola plum	33
<i>Mongongo, marula and uvilla</i>	34
<i>Mongongo</i>	34
<i>Marula</i>	34
<i>Uvilla</i>	34
Roselle	35
Nightshade and other <i>Solanum</i> species	35
LEAVES AND FLOWERS	37
Leafy vegetables in tropical diets	37
Importance of edible green leaves in tropical Africa	37
Leaves of herbaceous plants	38
Edible leaves from shrubs and trees	38
Knowledge of traditional food plants	40
Vegetable amaranths	41
Distribution and characteristics	41
Nutritional aspects	41

Utilization of amaranth in Africa and Asia	42
Preparation of <i>efo</i> soup	42
Preparation of <i>efo</i> relish	42
Preparation of amaranth <i>koottu</i>	42
Domestic use of leafy vegetables in eastern Africa	42
Cooking techniques	42
Preservation of leafy vegetables by sun-drying	43
Vegetables in Asia and the South Pacific	43
Cultivated vegetables	44
Semi-domesticated and gathered vegetables	46
Use of leaves in cooking and packaging foods	46
Flowers as vegetables	46
Seaweeds and freshwater algae	47
Mushrooms and edible fungi	47
Cultivation of mushrooms	48
Domestic use of leafy vegetables in Southeast Asia	48
Acid preservation techniques	49
Preparation of chutneys and pickles	49
Preservation of vegetables by brine fermentation	51
Preparation of <i>kimchi</i>	51
Preparation of "cat's whiskers" as <i>pak-sian-dong</i>	52
Preparation of green mustard leaves as <i>gundruk</i>	53
INDEX OF SCIENTIFIC NAMES	57

Tables

Table 1 Nutrient content of some tropical fruits (values per 100 g edible portion)	2
Table 2 Countries with significant mango production (estimates for 1979)	4
Table 3 Nutrient composition of mango (values per 100 g edible portion)	5
Table 4 Nutrient composition of papaya (Solo variety) and of guava (values per 100 g edible portion)	8
Table 5 Nutrient content of pineapple and orange (values per 100 g edible portion)	12
Table 6 Composition of mangosteen and durian fruits (values per 100 g edible portion)	23
Table 7 Nutrient composition of ripe sapote fruits (values per 100 g as purchased)	24

Table 8 Composition of passion fruit and granadilla (values per 100 g edible portion)	26
Table 9 Composition of acerola (values per 100 g edible portion)	29
Table 10 Nutritional content of some green leafy vegetables (values per 100 g edible portion)	39
Table 11 Wild and semi-wild leafy vegetables and flowers utilized as food in tropical Asia	40
Table 12 Per capita energy and protein contribution from rice, pulses, vegetables and dairy products in Asia	44
Table 13 Average food energy levels of diets in selected Asian countries (1971-1975)	45
Table 14 Composition of several types of <i>kimchi</i> (values per 100 g edible portion)	52

Figures

Figure 1 Traditional production of Philippine <i>nata de piña</i>	13
Figure 2 Production of <i>Pleurotus</i> mushroom on oil palm waste	50
Figure 3 Flow chart of <i>kimchi</i> processing	54
Figure 4 Flow chart for the fermentation of “cat’s whiskers”	55
Figure 5 Flow chart for the fermentation of bamboo shoot	56

Tropical fruits

VARIETY AND IMPORTANCE

In tropical countries, rural communities recognize and consume a wide variety of different species of edible fruits; most of these fruits are gathered and eaten within the locality. Many tropical fruits are not formally cultivated but may be protected and preserved in areas where they occur naturally. Local fruits in season are sought and eaten by children; in some societies, fruit eating is associated with childhood food habits and only the most favoured wild fruits are gathered and eaten by adults.

In contrast to this wide variety of gathered fruits, a limited number of tropical fruits are deliberately cultivated, both in home gardens and in commercial plantations. Some of these fruits have become important market and export crops, and considerable effort has been devoted to research on their cultivation and improvement. Such export crops include banana, pineapple, citrus, avocado and mango.

AVOCADO

Occurrence and characteristics

The avocado (*Persea americana*) is a medium-sized tree which is native to Mexico and Central America. Avocados are now cultivated in many African and tropical American countries for home use and for export. Producing areas include Brazil, Cameroon, Central America, Colombia, Mexico, Trinidad and Zaire.

The avocado bears large, usually pear-shaped, fruits which may each weigh up to one kilogram. Avocado pears have thick skins, pale yellow, reddish-green or purple in colour. Under this thick outer skin, the yellowish-green flesh of a ripe fruit is soft, smooth and buttery, with a distinctive flavour. Each fruit contains a large round seed; both seed and fruit flesh are rich in oil.

TABLE 1. Nutrient content of some tropical fruits
(values per 100 g edible portion)

	Avocado	Banana	Mango	Papaya
Energy (kcal)	165	116	63	39
Protein (g)	1.5	1.0	0.5	0.6
Retinol equivalent (mcg)	60	30	180	160
Vitamin C (mg)	15	10	30	50
Iron (mg)	1.0	0.5	0.5	0.5

Source: Platt, B.S. 1962. *Tables of representative values of foods commonly used in tropical countries*. MRC Special Report Series No. 302. London, HMSO.

Nutritional aspects

Fresh avocados have a higher energy content than bananas because they contain from 5 to 25 percent of an edible oil; they provide 1-5 percent of protein, together with niacin and other B-complex vitamins. Selected varieties also contain significant quantities of beta-carotene and vitamin C. The average nutrient composition of avocado is included in Table 1.

In areas with sufficient rainfall, preferably more than 800 mm, an orchard of avocado trees will provide a valuable supplement to the local diet. A good tree can bear 400-600 fruits each season and, as the crop does not all ripen at the same time, the harvest often extends over several months.

Utilization of avocado pears

In Central America, the avocado is sliced and eaten as a vegetable salad; alternatively, the flesh is pulped and seasoned with spices in the preparation of an avocado purée called *guacamol*. In several countries of eastern Africa, the avocado is eaten as a savoury, spread on bread or as a sandwich-filling in place of butter. In the Caribbean, chopped avocado, mixed with cassava meal and coconut milk, is the basis of a highly spiced appetizer called *féroce d'avocar*; this dish is often flavoured with lime, garlic, hot pepper and salted dried fish.

Most avocados are eaten fresh; thermal processing is not satisfactory as the pulp develops a bitter after-taste on heating. There is a commercial

market for avocado oil, for use in the cosmetic industry. Other components of the pulp and of the seed may have medical applications in the fields of bacteriology and dermatology.

MANGO

Occurrence and characteristics

The mango (*Mangifera indica*) belongs to the same family, Anacardiaceae, as the cashew nut (*Anacardium occidentale*) and the pistachio nut (*Pistacia vera*). The mango is believed to have originated in the border areas of India and Myanmar. It has been cultivated in India for over four thousand years, and is probably one of the oldest cultivated fruits. There are now hundreds of different mango varieties grown throughout the tropical and semi-tropical regions, but the quality of individual cultivars varies considerably. A list of countries with significant mango production is shown in Table 2.

Unimproved wild seedlings often bear small, dry, fibrous fruit with a marked turpentine flavour; the best selected cultivars produce magnificent juicy, fibre-free fruits with a delightful fresh flavour and a smooth rosy-yellow skin. Some of the wild fibrous mangoes contain higher levels of ascorbic acid and of carotene than those of the improved varieties, but their flavour and texture characteristics are usually less desirable.

Mangoes are large, spreading, evergreen trees; they are often planted in a prominent place in the village where they provide a deep and welcome shade. The mango will grow and fruit in areas with scanty rainfall as it has a deep tap-root and is well adapted to withstand prolonged periods of drought. It can be planted on poorer, sandy types of soils provided they are not waterlogged, shallow or too acidic.

Nutritional aspects

Representative figures for the nutrient content of mango are shown in Table 3. Composition varies considerably between cultivars, and the vitamin content is greatly affected by conditions of cultivation and by maturity at harvest. Mangoes can provide a rich source of provitamin A, which is of particular importance for young children in some developing countries, where vitamin A deficiency can contribute to serious nutritional disorders.

TABLE 2. Countries with significant mango production (estimates for 1979)

Countries	1 000 MT production	Countries	1 000 MT production
Africa		North/Central America	
Benin	12	Cuba	54
Chad	29	Dominican Republic	168
Egypt	90	Haiti	285
Côte d'Ivoire	13	Honduras	13
Madagascar	143	Mexico	570
Malawi	26	Panama	26
Mozambique	30	Saint Lucia	43
Senegal	33	Asia	
South Africa*	13	Bangladesh	214
Sudan	61	China	240
Tanzania	172	India	9 300
South America		Indonesia	300
Brazil	680	Malaysia	11
Columbia	18	Pakistan	600
Ecuador	26	Philippines	338
Paraguay	30	Sri Lanka	57
Peru	72		
Venezuela	138		

Source: FAO. 1980. *Production yearbook*, Vol. 33. Rome.

Vitamin A deficiency

Vitamin A deficiency is often associated with protein-calorie malnutrition; most commonly, the eyes of afflicted children are affected creating a condition called xerophthalmia. In the early stages of xerophthalmia, children may avoid bright light, and find difficulty in distinguishing obstacles in restricted light at dusk, or at night. As the disease advances, the cornea becomes opaque and soft, the eyeball is destroyed and the child becomes permanently blind.

TABLE 3. Nutrient composition of mango
(values per 100 g edible portion)

Water (%)	81.7
Food energy (kcal)	66
Protein (g)	0.7
Fat (g)	0.4
Total carbohydrate (g)	16.8
Fibre (g)	0.9
Ash (g)	0.4
Calcium (mg)	10
Phosphorus (mg)	13
Iron (mg)	0.4
Sodium (mg)	7
Potassium (mg)	189
Vitamin A value (I.U.)	4 800
Thiamine (mg)	0.05
Riboflavin (mg)	0.05
Niacin (mg)	1.1
Ascorbic acid (mg)	35

Source: Watt, B.K. & Merrill, A.L. 1963. *Composition of foods*. Agriculture Handbook No. 8, Washington, D.C., United States Department of Agriculture.

Nutritional blindness can be prevented as it arises when the diet is deficient in animal foods and in fats and contains insufficient amounts of fresh vegetables and fruit. Such a diet lacks both the vitamin A form, retinol, and its precursors, the carotenes. Treatment of vitamin A deficiency reduces mortality and morbidity in affected communities; interventions may include short-term activities, such as the distribution of high-dose vitamin A capsules every six months. On a long-term basis, the most effective strategy is to promote the production and consumption of locally produced fruits, vegetables and animal products.

Utilization of mangoes

In village communities, mangoes are eaten locally as fresh fruit throughout the fruiting season, but many are wasted through spoilage and early harvesting in conditions where adequate marketing and processing facilities are not available.

Processing of green mangoes

Mangoes are processed at two stages of maturity; green fruits are often brined for storage and then pickled as chutneys and curries. Immature fruits may also be peeled and dried as slices, as pulp or as a green mango powder, called *amchoo* in India. This powder is used to prepare drinks or to thicken other mango preparations such as chutneys. In Thailand, crisp slices of green mango are included in a mixed fruit and vegetable salad. This may contain sliced bamboo shoot, green ginger, lily root, green mango, papaya, cucumber and pineapple; it is often served with a hot, spicy fish sauce.

Processing of ripe mangoes

In many tropical countries, there is a considerable food processing industry for ripe mangoes which may be converted to nectar, juice or pulp, squash, jams and jellies.

Hand peeling is now being replaced by treatment with steam, or with sodium hydroxide together with a wetting agent. Pasteurized mango pulp may be acidified to pH 3.5 with citric acid and subsequently stored in sterilized wooden barrels, or polythene containers, for up to six months before processing.

Ripe mangoes may be sun-dried in the open, or in solar driers, as slices, flakes or powder. Commercially a number of dried mango products are obtained by using tunnel, drum or spray-drying techniques.

PAPAYA

Occurrence and characteristics

The papaya or papaw (*Carica papaya*) probably originated in tropical America, together with other closely related species, including the mountain papaws of Central America (*C. candamarcensis* and *C. peltata*) which occur

in Costa Rica and southern Mexico. Papayas are now cultivated throughout the tropics; they are grown mainly for their edible fruits, but also as a source of the proteolytic enzyme, papain, which is obtained from the latex of unripe papaya.

Although papaya production is widespread, there is little commercialization of this fruit in the tropics. Papayas are usually planted in home gardens for domestic consumption. Like mangoes, the papaya fruit of different cultivars may vary considerably in size, shape and quality.

The fruit shape can be round or long and pendulous. Papayas are thin-skinned with a soft, juicy flesh, varying in colour from pale yellow to red. They contain shiny, black seeds in the hollow centre of the fruit. Fruit from different varieties may weigh from 0.5 to over 2 kilograms; it may contain more than a thousand small round seeds, or only a small number in selected cultivars; flavour is also very variable. Good papaya varieties are delicious and, as they will flower and fruit within nine months in the tropics, their cultivation and selection should be encouraged.

1. Papaya trees



TABLE 4. Nutrient composition of papaya (Solo variety) and of guava (values per 100 g edible portion)

Component	Papaya	Guava
Water (%)	86.80	84.35
Food energy (kcal)	46	55
Protein (g)	0.36	0.28
Fat (g)	0.06	0.1
Total carbohydrate (g)	12.18	14.79
Fibre (g)	0.58	2.38
Ash (g)	0.57	0.48
Calcium (mg)	29.9	14.6
Phosphorus (mg)	11.6	15.5
Iron (mg)	0.19	0.29
Vitamin A (mcg)	10.93	0.09
Thiamine (mg)	0.027	0.056
Riboflavin (mg)	0.043	0.060
Niacin (mg)	0.33	1.28
Ascorbic acid (mg)	84.00	100

Source: Wenkam, N.S. & Miller, C.D. 1965. *Composition of Hawaiian fruits*. Bulletin 135. Honolulu, Hawaii Agric. Exp. Station.

Nutritional aspects

The edible portion of papaya is mainly water and free sugars with little or no starch; many varieties are excellent sources of provitamin A and of ascorbic acid. The fruit is of low acidity and is remarkably free from fibre. These factors enhance the value of papaya as a supplementary food for young children, especially in areas where xerophthalmia is prevalent. Data on the nutrient composition of a hermaphrodite flower form of papaya, called "Solo", are given in Table 4.

Utilization of papaya

In addition to its consumption as the fresh, ripe fruit, papaya is used in many countries in the immature, green stage as a vegetable. For this purpose, the

fruit is peeled and the seeds are discarded; it may then be chopped into pieces and steamed or boiled; alternatively, the immature fruit is grated and added to curries.

In Sri Lanka, unripe papaya is prepared as *pawpaw mallum*; the green fruit is peeled, grated, and washed several times to reduce the papain content. The shredded papaya is then cooked with turmeric, salt, peppercorns and green chilies; finally, grated coconut is added. This preparation is served as a side dish or condiment. In Malawi, a vegetable stew of boiled green papaya is flavoured with tomatoes and chilies; this dish is traditionally thickened with groundnut paste or flour. Unripe papaya may also be baked like vegetable marrow, with a filling of boiled, spiced rice and accompanied by a tomato sauce.

Green papaya is used in pickles and chutneys; it may also be preserved as a jam or as a conserve, flavoured with lemon and ginger. Jam is also prepared from a mixture of ripe papaya and the sieved pulp of guavas. Commercially, papaya may be processed as a purée, as a nectar base, or as canned slices. Good-quality papaya may be canned in syrup at the half-ripe stage to give a product resembling canned peaches.

Papaya contains a high proportion of enzymes, especially invertase, pectin esterase and papain. When the fruit is pulped, the purée tends to gel very rapidly; this may be prevented by inactivation of the pectin esterase by heat and acidification.

Extraction and use of papain

Papaya latex contains up to 2 percent of papain, a proteolytic enzyme with wide applications in the food, cosmetic, leather and pharmaceutical industries. Concentration of papain is greatest just before the fruit ripens.

Latex is tapped from the green fruit early in the morning by making thin cuts vertically down the surface with a sharp knife. The milky latex oozes out and is scraped off after it hardens; it is then sun-dried to give a crude form of the enzyme. This extract also contains another proteolytic enzyme called chymopapain; as these enzymes are proteins, they can be purified by standard methods including fractional precipitation and recrystallization.

The value of papaya as a meat tenderizer is well known in the tropics. In Africa, it is an accepted practice to wrap raw meat in papaya leaves for some hours before cooking. In Sri Lanka, raw beef is seasoned, coated with oil and then wrapped in crushed papaya leaves before it is grilled. Alternatively, slices of the green fruit are layered with the raw meat for several hours and removed before cooking, or some finely chopped slices of green papaya are cooked and served with the meat.

In the preparation of curries, two or three pieces of papaya tree bark may be crushed and added to meat during cooking. These are usually removed before serving.

Papaya seeds are a major by-product from the papaya purée industry. These seeds have a spicy pungent flavour and have been used as an adulterant or a substitute for black pepper. They have a high protein value and are reported to contain an edible oil, but fresh seeds contain about 70 percent of water.

Papaya is widely used throughout the tropics in traditional medicine. Its application as a digestive aid is probably based on the papain content; however, it also contains a number of pharmacologically active compounds including several carpine alkaloids.

PINEAPPLE

Occurrence and characteristics

The pineapple (*Ananas comosus*) originated in tropical America. It is now cultivated extensively as an important commercial crop, and for domestic consumption. It is relatively drought-resistant and can be grown in subtropical and drier regions as well as in the humid tropics.

Utilization and nutritional aspects

The ripe, whole fruit is rather perishable; a major change occurred in the economic importance of pineapple when suitable canning techniques were developed for the peeled, sliced fruit and for pineapple juice. Pineapple industries were rapidly established in Latin America, the Far East and Africa. Major exporting countries include Brazil, India, Kenya, Malaysia, the Philippines and Thailand.

By far the greater part of the world's pineapple production is canned. Slices are the most valuable product, then juice, chunks and dice. Other products prepared from pineapple include fruit salad, sugar syrup, alcohol and citric acid.

Fresh pineapple is a good source of vitamin C; it also contains appreciable quantities of thiamin. The nutritional content of pineapple is shown in Table 5. Fresh pineapple is greatly appreciated as a refreshing snack or as a dessert. The juice is prepared as a delicious drink, often mixed with coconut cream or coconut milk.

In the Philippines, the juice from pineapple or from pineapple trimmings is used to produce a delicacy called *nata de piña*. Its preparation closely resembles that of *nata de coco*, which is made from coconut. *Nata* is a thick cream-coloured gelatinous film, produced by growing *Acetobacter aceti* subsp. *xylinum* on an acidified medium, containing sugars and other nutrients. *Nata* is eaten as a dessert, with fruit, or candied as a sweetmeat. Details of its preparation are shown in Figure 1. Pineapple can be preserved as a jam or as a chutney, and also makes an excellent fruit wine.

Pineapple leaves yield a strong, white fibre which provides the raw material for the production of *piña*, a silky cloth made in Taiwan and in the Philippines. Special cultivars are used for this purpose; the fruit is removed to facilitate leaf production.

CUSTARD APPLES

The general term, custard apple, has been applied to a number of different species of the *Annona* genus. These include *Annona cherimola*, the cherimoya of Peru and Ecuador; *A. reticulata*, the "bullock's heart", a reddish, heart-shaped fruit from the West Indies; *A. muricata*, the soursop, which is grown commercially in Puerto Rico and Venezuela, and the Indian custard apple or sweetsop (*A. squamosa*), also known as the sugar apple.

These are all tree fruits of the American tropics which are now widely grown and appreciated in many tropical and subtropical regions.

"Bullock's heart"

The bullock's heart (*A. reticulata*) bears reddish or yellow-brown fruit with faint angular markings. The fruit is 10-12 cm across with pulpy, white flesh

TABLE 5. Nutrient content of pineapple and orange
(values per 100 g edible portion)

	Pineapple	Orange
Calories (kcal)	57	53
Protein (g)	0.4	0.8
Calcium (mg)	20	30
Iron (mg)	0.5	0.5
Vitamin A (I.U.)	100	30
Thiamine (mg)	0.08	0.08
Riboflavin (mg)	0.03	0.08
Niacin (mg)	0.1	0.2
Ascorbic acid (mg)	30	45

Source: Latham, M.C. 1966. *Human nutrition in tropical Africa*. Rome, FAO.

in which numerous dark-brown seeds are embedded. The fruit is more solid and granular in texture than that of the Indian custard apple, or sweetsop.

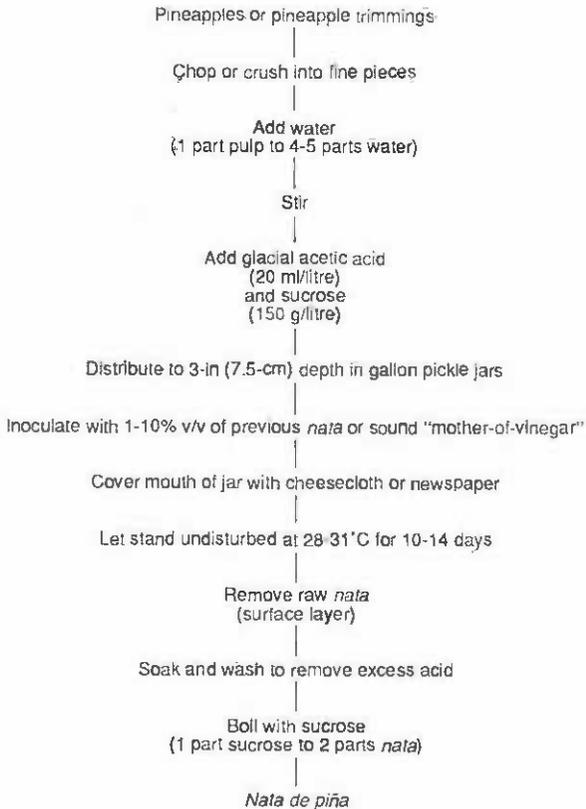
Sweetsop or sugar apple

The sweetsop (*A. squamosa*) is the sweetest and most widely distributed of the custard apples. The heart-shaped fruits are 7-10 cm long and are covered with round fleshy knobs; the white, granular pulp is sweet and tender with a slightly acidic flavour. The fruit is usually picked before it is completely ripe, and is then stored in straw, or dried grass, until it is ready for eating. Extracts from the roots and leaves of the tree are used in India as components of purgatives and tonics.

Soursop and hybrid custard apples

The soursop (*A. muricata*) bears large, ovoid fruit which are covered with soft, green spines. It has an aromatic, juicy flesh with a rather woolly texture, and contains numerous large, black seeds. Soursops are widely distributed throughout the humid tropics and are particularly popular in Cuba, the West Indies and Malaysia. Hybrid custard apples include a sweetsop and soursop cross, and a cross between the soursop and the cherimoya. The latter hybrid,

Figure 1
Traditional production of Philippine *nata de piña*



Source: Mendoza, J.M. *Philippine foods, their processing and manufacture*.
Published in the Philippines by the author.

called the *atemoya*, is commercially grown in southern Africa and in tropical Australia. Other fruit-bearing *Annona* species found in Central America include the *ilama* (*A. diversifolia*), which can be grown in the lowland tropics, the mountain soursop (*A. montana*) and the *soncoya* (*A. purpurea*).

In the Philippines, a gelatinous dessert called *nata de guayabano* is based on soursop extract. Its method of preparation and use resembles that of *nata de piña*.

Cherimoya

The cherimoya (*A. cherimola*) grows naturally in the Colombian and Peruvian Andes where the climate is relatively cool and dry; it is produced commercially in southern Africa, Latin America and in southern Australia. Its fruit is considered to be the best of all the custard apples but it does not thrive in the hot, lowland tropics.

Abo

The *abo* (*A. senegalensis*) is indigenous to Africa. It is a savannah shrub found from Senegal to the Sudan. In Nigeria, the variety *deltoides* is most common; it bears small fruit with firm, orange flesh containing many seeds.

Nutritional aspects

The fruit pulp of *A. reticulata*, the bullock's heart, is reported to supply 92 calories, 22 g of total carbohydrate and 2.1 g of protein per 100 g edible portion.

Utilization of custard apples

The pulp is usually eaten raw after removal of the seeds but it may also be prepared as a refreshing drink. In Latin America, the concentrate and juice of soursops are preserved by canning.

ROSE APPLES

There are many species of rose apple growing wild or cultivated throughout the tropics and some produce very pleasant fruit. Little attention has been given to their development as fruit trees although most species are valued as ornamentals.

Most tropical rose apples are species of the genus *Eugenia*; this is now accepted as also including species previously classified as *Syzygium*. Most *Eugenia* species are grown for their fragrant, decorative flowers as well as for their edible fruits. The flower-buds of *E. caryophyllus* are marketed in their dried form as cloves.

Jambolan

The jambolan (*Eugenia cuminii*, syn. *E. jabolana*) is also known as *Syzygium cuminii* or the Java plum. It is native to India, Myanmar and Sri Lanka but has now become naturalized throughout many countries in the Far East. It has also been introduced to the West Indies, and to East and West Africa.

The quality of the fruit varies considerably between seedlings; inferior cultivars bear small astringent fruit with large seeds but selected varieties produce larger, relatively sweet, juicy fruit that are small-seeded or even seedless. The ripe fruit is usually eaten raw; green fruit may be pickled for use as a condiment. It is reported to be a good source of vitamin C, comparable to citrus fruits such as lime, lemon and orange.

Malay rose apple

This species, *E. malaccensis*, is indigenous to Malaysia but is also grown in India, Indonesia, Java and Sabah. There are many cultivars differing in fruit shape, colour and flavour. In some varieties, the white fruit pulp around the single seed is pithy and flavourless but seedless fruits of high quality have been developed. A dark-red striped cultivar is grown and marketed in Indonesia.

Watery rose apple

The watery rose apple (*E. aquea* or *Syzygium aqueum*) is native to southern India; it is cultivated commercially in Indonesia under humid tropical conditions, where it frequently bears two crops annually. There are red, pink and white fruited varieties; each pear-shaped fruit normally contains one or two brown seeds but seedless varieties have been developed. The fruit is usually eaten fresh; selected varieties are very juicy and are good thirst

quenchers. Ripe fruits may be prepared as a syrup or as a fruit drink.

A related species, *Syzygium guineense* or *S. cordatum*, the African water berry, is also called *musomba*. It grows wild and widespread in Zambia, especially along river banks. The fruits are white or reddish-purple with a single stone. They are not cultivated but are gathered and eaten as snacks, mainly by children. In the Philippines, another species (*S. calubcob*) is popular locally; it bears small, 3-4 cm, creamy-white fruit with a pleasant sweet-sour flavour. The lipote (*E. curranii*) is also cultivated in the Philippines; the fruit has a high pectin content, which makes it suitable for processing as jams and jellies, but cultivars are very variable in flavour and quality.

Java rose apple

The Java rose apple (*E. javanica* or *S. javanicum*) is also called the *samarang* rose apple or the wax *jambu*. It is native to Java and is widely cultivated in West Bengal, southern India and Indonesia. The waxy fruit may be white, pink or red; some varieties are very fragrant and rather pithy in texture.

Pitanga or Suriname cherry

The Suriname cherry (*E. uniflora*, syn. *E. michelii*) is also called the *pitanga* or *goraka jambu*. The fruits are small and round, with a deeply ribbed and flattened waxy surface. In flavour, they are sweetish-acid and aromatic, and are widely used in jams and jellies. The *pitanga* is native to Brazil but is also grown in many other tropical and subtropical locations as an orchard crop, as an ornamental and as a hedge plant. Other Brazilian species of rose apple are the *cabelluda* (*E. tomentosa*), the *pitomba* (*E. luschnathiana*), the *grumichama* (*E. dombeyi*), the *pero do campo* (*E. klotzschiana*) and the *uvalha* (*E. uvalha*), but these fruits are not extensively cultivated outside their native habitat.

CARAMBOLA AND BILIMBI

These fruits are both species of *Averrhoa*; they are believed to have originated in Southeast Asia, in Indonesia or in Malaysia, but are now

extensively distributed in other countries including tropical and subtropical America.

The *carambola* or "starfruit" (*A. carambola*) is cultivated as an orchard crop for use in preserves and beverages. The fruit is ovoid and angular, 10-12 cm long, with a deeply-ribbed, five-angled surface and a golden, semi-transparent, waxy skin. It is very juicy and has a sweet-acid flavour; some Brazilian cultivars have a very high content of vitamin C as well as an appreciable amount of provitamin A.

An excellent drink is prepared by grating the pulp of starfruit into sugared water or by soaking thin slices of the fruit in sugared water overnight. The pulp of acidic varieties is reported to contain oxalic acid; oxalates can inhibit the absorption of calcium from the diet, but the amounts consumed are seldom significant in practical terms.

The *bilimbi* (*A. bilimbi*) is more acidic than the *carambola* and is credited with various medicinal qualities. The fruit resembles a gherkin in appearance; it is produced in clusters on the tree trunk and oldest branches, hence the tree is sometimes known as the "cucumber tree". The *bilimbi* is used locally as a component of jams and pickles, and in curries.

Cape gooseberry

The Cape gooseberry, or Peruvian cherry (*Physalis peruviana*) is native to Peru, but is naturalized throughout Latin America. It is also cultivated in southern Africa and in tropical Australia. In form, it is a straggling herbaceous perennial; the fruit, which resembles a small cherry, is surrounded by a dry, bladder-like calyx which conceals it completely. The ripe fruit has a refreshing flavour and is used to make jam.

Indian gooseberry

The Indian gooseberry or *amla* (*Phyllanthus emblica* or *Emblica officinalis*) is domesticated in India, together with the star gooseberry (*Phyllanthus acidus*). The *amla* is a rich source of vitamin C, containing 747 mg per 100 g of pulp. It is preserved by pickling in a salt solution after boiling the fruit in water for a few minutes. Alternatively, the fresh fruit may be sliced and dried in the sun; it is then ground and stored as a fine powder which contains 10-16 mg of ascorbic acid per gram.

STAR APPLES

There are two races or types of star apple which are distinguished by the colour of the ripe fruit which has either a purple or a pale-green skin. Both types are classified as *Chrysophyllum cainito*. Mature star-apple trees are very attractive and are often grown as ornamentals. The star apple is indigenous to Central America and the West Indies, but is also grown in tropical Africa, southern India, the Philippines and Sri Lanka. The fruit is smooth-skinned and shaped like an apple and measures 6-10 cm in diameter. When unripe, the star apple contains a sticky, astringent latex, but on ripening, a white translucent pulp with a sweet and pleasant flavour is formed around the dark seeds.

Other species are believed to be indigenous to Africa; in West Africa, *C. alba* is a high forest tree which is also valued for its edible fruit. A related species, *C. magalimontanum*, is collected and used in Zambia to prepare jams, fruit syrup and wine. The flavour is said to resemble that of plums, and this fruit is reported to contain 40 mg per 100 g of vitamin C. In eastern Africa, the bark of *C. magalimontanum*, together with that of *Azelia quanzensis*, is used in ceremonies to placate ancestral spirits.

AKEE APPLE

Occurrence and characteristics

This is the fruit of a West African tree, *Blighia sapida*, so named in honour of Captain Bligh who introduced it to Jamaica. The fruit is bright scarlet with one to three shiny, black seeds. The edible part is the aril around the base of each seed; this is sometimes called "vegetable brains" as it has a firm, fat-like appearance.

When fully ripe, the fruit splits open and should then be immediately picked as the quality of the aril deteriorates on long exposure to the air. Underripe and overripe fruit are unsafe to eat; they contain a water-soluble toxin which can cause uncontrollable vomiting, convulsions and unconsciousness in young children. Water used for cooking akee should always be discarded.

Utilization of akee apple

Between the lobes of the aril in the fully ripe fruit, there is a pink integument which must be removed. The aril may then be fried in butter or boiled and flavoured with salt and pepper. Akee is particularly appreciated in the West Indies. In Jamaica, it is cooked with salt-fish and peppers, and used as a stuffing for bread-fruit. It may also be cooked as a breakfast dish like scrambled eggs, or used in a vegetable soup. Akee apple is canned for domestic consumption in the West Indies and is also exported in this form.

RAMBUTAN, PULASAN, LITCHI AND LONGAN

Rambutan

The rambutan (*Nephelium lappaceum*) is believed to originate in Malaysia. Its name in Malay means hairy and it is sometimes called the "hairy litchi" as its fruits are covered with yellowish-red, soft, spiny outgrowths. Beneath the skin, the large seed is surrounded by a white, juicy aril with a delicious flavour. Birds and bats are particularly fond of this fruit; it is extensively cultivated in Malaysia at the village level for domestic use, and as a plantation crop. It is also grown in the Philippines, Sri Lanka and Thailand, and on a trial basis in regions of Central America.

The rambutan is regarded as one of the most delectable fruits of Southeast Asia and is usually eaten as the fresh fruit. Its export potential as canned fruit has not been developed. The nut-like seed is also edible when cooked and it has a high oil content.

Pulasan

The fruit of the pulasan (*N. chryseum*, syn. *N. mutabile*) is larger than that of the rambutan with short, blunt spines and a soft jelly-like flesh. Another species, *N. malaiense*, also bears edible fruit, called *mata kuching*, but these species are less important than the rambutan.

Litchi

The litchi (*Litchi chinensis* or *Nephelium litchi*) is a medium-sized tree, native to China, but grown in Mauritius, Sri Lanka, Thailand and parts of India. The pinkish-brown fruit, borne in large clusters, resembles a plum but

has a rough, thin, warty rind. Within this outer cover is a single seed covered with a pearly white gel which has a delicate, acidic sweetness. Litchis are eaten fresh or peeled, stoned and canned for local marketing and for export. Litchis may also be preserved by drying; they are sometimes fermented for Chinese medicine or used to make wine. They contain ascorbic acid, 8-9 mg per 100 g of edible portion, and are a good source of niacin.

Longan

The longan (*Nephelium longana* or *Euphoria longana*) bears a brown fruit, about 3 cm in diameter, which is similar to that of the litchi; it is generally considered to be comparable in quality, although less acidic and less astringent in flavour. It may be eaten fresh or preserved by drying. The longan has a much higher content of vitamin C than the litchi, with 33 mg of ascorbic acid per 100 g of fruit pulp.

GUAVAS

The common guava

The common guava (*Psidium guajava*) originated in tropical America, but is now a familiar compound tree in most tropical countries. The fruit may be round, ovoid or pear-shaped; pear guava bears a large succulent fruit with a smooth yellow rind and pale-green aromatic pulp. In other varieties, the

2. Longan fruit



flesh may be white, yellow, pink or red. In most cultivated guavas, the outer pulp layer is granular in texture; inside is a softer pulp layer which usually contains many small seeds. Several varieties of seedless guava have been developed in India and Malaysia.

Fruits from different cultivars may show great variation in flavour and quality, but all have a characteristic musky aroma. Guavas contain two to five times the vitamin C content of fresh oranges. The average nutrient composition of guava is shown in Table 4.

Other species of guava

The strawberry or cherry guava (*P. cattleianum*), which originated in Brazil, has small, yellow, mild-flavoured fruits. A cultivar which is grown in Sri Lanka has wine-coloured fruit resembling small plums, and a juicy, purple-red pulp of excellent flavour.

Apple guava (*P. pomiferum*) has round, apple-like fruit with a reddish pulp. Guinea guava (*P. guineense*) is believed to be native to West Africa; it is a small, reddish-yellow guava, similar to the cherry guava, cultivated in Sri Lanka. Another cherry guava called *cattley* is grown in Malawi. A rather sour-tasting yellow-fruited guava, locally called *embul-pera*, is common in Sri Lanka, where it is used for making guava jelly.

The Costa Rican guava (*P. friedrichsthalianum*) grows wild in forests and high savannahs from Honduras to Panama. Its fruit is very acidic and is used mainly to make drinks, jams and jellies.

Utilization of guavas

The fruit of selected guavas is eaten fresh or stewed as a dessert but, as most unimproved varieties contain many seeds, these are processed before use. Guavas are cooked as jams or jellies, or pulped and sieved to prepare a stiff paste called "guava cheese". Commercially, selected guavas are canned as guava halves, with the seeds, or as guava shells or slices with the seeds removed. They are also processed as guava juice and nectar.

DURIAN

Occurrence and characteristics

The durian (*Durio zibethinus*) is characterized by its extraordinary smell; this has been variously described as "stale cheese and onions flavoured with turpentine", "custard and almonds mixed with sherry" or, worst of all, as "a mixture of condensed milk and rotting fish".

The durian is indigenous to Malaysia and is cultivated throughout Southeast Asia, where good quality durian commands high prices. It is not grown in Africa, nor is it commercially cultivated in tropical America, although it has been experimentally introduced in Honduras. The appearance of the fruit is as characteristic as its smell. It is a large round or ovoid fruit which may reach a weight of 5 kg; its green skin is covered with an armour of thickly-set, sharp-pointed spikes about 1.5 cm long. The fall of a ripe durian from a mature tree poses a very real risk to the harvesters.

Utilization and nutritional aspects

Within the thick skin, the durian is divided into about five sections, each containing several large brown seeds surrounded by a yellowish-white, creamy, aromatic pulp. The fresh, ripe pulp is usually eaten shortly after harvest as it soon becomes sour and rancid. Durian is sometimes gathered before it is completely ripe to increase its useful shelf-life. The fruit may also be preserved by brining.

In Southeast Asia durian pulp is preserved with sugar and prawn paste. The pulp may also be preserved by fermentation. In addition to its attractions as a fresh fruit, durian is used as a flavouring component in many commercial sweetmeats ranging from biscuits to icecream. In Malaysia, a milk drink is flavoured with durian pulp. Durian seeds may be roasted and eaten as a snack; they are said to resemble chestnuts. The nutritional composition of durian is shown in Table 6.

SAPODILLA

The sapodilla or sapote (*Manilkara achras*, syn. *Achras zapota*) is native to Central America, but is widely cultivated in the humid tropics. Sapodilla bark secretes a milky latex which contains 20-40 percent of chicle gum. The

TABLE 6. Composition of mangosteen and durian fruits
(values per 100 g edible portion)

Component	Mangosteen	Durian
Energy (kcal)	76.0	147.0
Water (%)	79.9	59.9
Protein (g)	0.7	2.0
Fat (g)	0.8	1.2
Total carbohydrate (g)	18.6	36.1
Fibre (g)	1.3	1.9
Ash (g)	0.2	0.8
Calcium (mg)	18.0	18.0
Phosphorus (mg)	11.0	56.0
Iron (mg)	0.3	1.1
Vitamin A	0	Trace
Thiamine (mg)	0.06	0.32
Riboflavin (mg)	0.01	0.28
Niacin (mg)	0.04	1.1
Ascorbic acid (mg)	2.0	44.0

Source: Food composition table. 1968. Manila, Philippines, Food and Nutrition Centre.

Jatex was formerly extracted by tapping the bark and was used as a basis for chewing gum. Commercial manufacturers now utilize a high proportion of synthetic substitutes for chicle, so the trees are mainly grown for their fruit.

The fruits are round, or oval, 5-10 cm long, with thin, yellowish-brown skin; when fully ripe, they contain several hard black seeds embedded in juicy, sweet, rather granular pulp. Unripe fruits are gummy in consistency and almost inedible. The nutrient content of ripe sapote fruit is given in Table 7.

MANGOSTEEN AND GORAKA

In Southeast Asia, the mangosteen (*Garcinia mangostana*) is regarded as one of the most delicious fruits of the tropics. The small round fruit, about 8 cm across, has a thick reddish-purple rind, which contains tannic acid and

TABLE 7. Nutrient composition of ripe sapote fruits
(values per 100 g as purchased)

Constituents	Gopalan <i>et al.</i>	Hernandez <i>et al.</i>
Energy (kcal)	98	38
Water (%)	73.7	—
Fat (g)	1.1	1.1
Protein (g)	0.7	0.7
Carbohydrate (g)	21.4	18.0
Fibre (g)	2.6	—
Minerals (g)	0.5	—
Carotene (mcg)	97	—
Vitamin C (mg)	6	12
Thiamine (mg)	0.02	0.02
Riboflavin (mg)	0.03	0.0
Niacin (mg)	0.2	0.3
Calcium (mg)	28	31
Phosphorus (mg)	27	9
Iron (mg)	2.0	1.5
Edible portion (g)	83	86

Sources: Gopalan, C., Sastri, B.V.R. & Baisubramanian, S.C. 1977. *Nutritive value of Indian foods*. Hyderabad, India, Nat. Inst. Nutrition, Indian Council of Medical Research.
Hernandez, M. *et al.* 1974. *Nutritive value of foods*. Mexico, Nat. Inst. Nutrition.

a very persistent, dark-staining dye. Within this rind are five or more segments of delicate, translucent white pulp, with a flavour compared to a blend of grapes and strawberries. Some of these segments contain hard vegetable structures which are not true seeds. New trees can be grown from this nucellar tissue but every seedling is genetically identical and possibilities for selection and breeding are severely restricted. The nutritional content of mangosteen is shown in Table 6.

Mangosteens are usually eaten as the fresh fruit; in India, they are also prepared as a preserve called *manggis* but this does not retain the delicate flavour of the fresh fruit. Mangosteens are native to Malaysia; they are

cultivated throughout tropical Asia and have been introduced to Cuba, Honduras and the West Indies. Other edible *Garcinia* species which are cultivated locally in Malaysia include the "egg-fruit" (*G. xanthochymus*) which produces large numbers of egg-shaped, yellow, juicy fruit with a sharp, refreshing flavour.

In India, the *goraka* (*G. cambogia*) is found growing wild in most low-lying areas of the Western Ghats and in Kerala. The fruit of *goraka* is rather larger than the mangosteen and is not so renowned. It has a smooth, deeply-indented skin, red or orange-yellow in colour. The large seeds are surrounded by an acidic pulp which may be preserved by drying on mats in the sun. The dried fruit is used in the same way as tamarind, as an additive to brine during fish preservation, and as an acid adjunct in the preparation of curries. The leaves of *goraka* are used in laxatives.

Goraka seeds are also utilized; they contain up to 30 percent of edible fat known as "kodapuli butter", which is extracted and marketed locally. The yellow dye, gamboge, is obtained from the bark resin of *goraka* and other *Garcinia* species.

In Africa, there are also several wild species of *Garcinia* with edible fruit. *Garcinia livingstonei* is sometimes called the African mangosteen; it occurs in Zambia and Zimbabwe. The fruit is an orange-red, fleshy berry with one to five seeds; it can be eaten raw or cooked with porridge, to which it imparts a pleasant acid flavour.

PASSION FRUIT AND GRANADILLA

The passion fruit (*Passiflora edulis*) is a woody, perennial climber, native to Brazil; it bears large numbers of purple, or yellow, oval fruits about 7 cm long. There are two forms: *P. edulis* has sweet, purple fruit and thrives best at higher elevations; *P. edulis* f. *flavicarpa*, also called the "yellow granadilla", will grow and yield heavily in humid, lowland tropics. There is also a yellow passion fruit (*P. ligularis*) which has a particularly high content of provitamin A.

Passion fruit comprises a firm shell enclosing a cavity containing large, soft seeds, embedded in a juicy acid pulp. The pulp may be eaten directly from the shell or strained from the seeds for preparation as a fruit drink,

TABLE 8. Composition of passion fruit and granadilla
(values per 100 g edible portion)

Constituents	Passion fruit		Granadilla
	<i>Passiflora edulis</i>	<i>P. edulis</i> <i>f. flavicarpa</i>	<i>P. quadrangularis</i>
Water (%)	85.6	84.9	88.0
Energy (cal)	51	53	41
Protein (g)	0.4	0.7	0.9
Fat (g)	0.1	0.2	0.2
Total carbohydrate (g)	13.6	13.7	10.1
Fibre (g)	0	0.2	0
Ash (g)	0.3	0.5	0.9
Calcium (mg)	3.6	3.8	10.0
Phosphorus (mg)	12.5	24.6	22.0
Iron (mg)	0.2	0.4	0.6
Vitamin A (I.U.)	717	2 410	70
Thiamine (mg)	Trace	Trace	0
Riboflavin (mg)	0.1	0.1	—
Niacin (mg)	1.5	2.2	2.7
Ascorbic acid (mg)	30	20	20

Source: Wenkam, N.S. & Miller, C.D. 1965. *Composition of Hawaiian fruits*. Bulletin 135. Honolulu, Hawaii Agric. Exp. Station.

squash or nectar. In very acid varieties, the juice is partially neutralized with sodium bicarbonate. Kenya is a major producer of passion-fruit juice, based on the purple variety, *P. edulis* f. *flavicarpa*. The yellow granadilla fetches higher prices on the fresh fruit market as it is larger and does not shrivel as badly as the purple passion fruit. However, it is not as good for juice extraction as it is less aromatic.

The granadilla (*P. quadrangularis*) resembles the passion fruit in general appearance but the fruits are larger and are fleshy instead of hollow. The flesh as well as the pulp of the granadilla is edible. The green, unripe fruit may be cooked as a vegetable in the same way as green papaya. The composition of passion fruit and of granadilla is shown in Table 8.

LOQUAT

The loquat (*Eriobotrya japonica* or *Photinia japonica*) grows well at medium elevations in the tropics; it is indigenous to southern China and to Japan. It bears slightly pear-shaped, oval fruit, 4-6 cm long, which vary in colour from light yellow to orange. The fruit has a thick, tough peel surrounding firm flesh, with a flavour reminiscent of a peach. It is rich in provitamin A, having a carotene content of more than 1 600 I.U. per 100 g of edible portion. Loquats are usually eaten fresh but may also be cooked and preserved as a jelly.

PRICKLY PEAR

Prickly pear is the fruit of the cactus, *Opuntia* spp., which is commonly called *tuna* in Latin America. It is cultivated in Central America, Mexico and Peru. In Mexico, there is an annual production of 2.7 million metric tons. There are at least six species of edible *Opuntia*, which produce fruits of various shapes, colours and sizes. The most commonly cultivated variety is *O. amyoclaea*, known as *tuna blanca*. The fruit is oval, or pear-shaped, and weighs 100-150 g; clumps of small prickles are distributed over its surface but these are easily rubbed off.

Prickly pears are sweet, luscious fruit which are low in acidity and high in sugars; they contain appreciable quantities of calcium and phosphorus, and a small amount of vitamin C. The fruit is normally eaten in the fresh condition or processed as *tuna* "cheese", *tuna* syrup and dried *tuna*. It may also be glazed or crystallized.

In eastern Africa, the fruits of another prickly pear are collected from wild plants. This species is classified as *O. ficus-indica*, also known as *tuna castilla*.

INDIAN JUJUBE OR BER

Occurrence and characteristics

The jujube (*Ziziphus mauritiana*, syn. *Z. jujuba*) is an important fruit crop in India where it has been cultivated for centuries. It is believed to be of African origin; in East Africa, the jujube is protected where it appears spontaneously, and is retained during land clearance for agriculture. It is widely cultivated in Mozambique.

It can tolerate salinity, waterlogging and drought better than either citrus or mango. The fruit is up to 2 cm in diameter, yellow or reddish-brown in colour, with a single stone like a cherry; the edible pulp is soft and slightly sweet. The fresh fruits are eaten raw; in East Africa, they may be added as a flavouring to maize porridge. They remain fresh for some weeks after picking; this extended shelf-life enables them to be marketed locally.

Utilization and nutritional aspects

In India, the jujube may be dried or candied. The dried pulp is fermented to make a drink, or prepared as a mealy, brown fruit paste, which provides a convenient snack for travellers. In Myanmar, the jujube is dried, powdered and mixed with jaggery as a sweetmeat. A related species, *Z. abyssinica*, has been called the "gingerbread tree" as a reference to this use of its dried fruit. Unripe jujube fruits can be used in jams, jellies, chutneys and pickles; they are reported to have a high content of vitamin C, of the order of 76 mg per 100 g of edible portion.

In India, the jujube is a preferred species for the preparation of lac, a resinous crust formed by a species of scale insect (*Tachardia lacca*) with which the young branches and twigs are inoculated. The dried resin is heated and formed into thin sheets of "shellac" which is used as a varnish, or as a substitute for true lacquer, which is prepared from the natural sap of the Japanese lacquer-tree (*Rhus vernicifera*).

ACEROLA

Occurrence and characteristics

The acerola or West Indian cherry (*Malpighia puniceifolia* or *M. glabra*) is native to Puerto Rico. Related species are found in Central America, Jamaica and Mexico. This tree is very high yielding; under warm humid conditions, four or five harvests may be gathered annually to give a total production of about 60 tons per hectare.

Utilization and nutritional aspects

The fruit generally resembles the European cherry but has shallow ridges on the skin and contains three triangular seeds. It has an exceptionally high

TABLE 9. **Composition of acerola**
(values per 100 g edible portion)

Water (%)	91.1
Protein (N × 6.25) (g)	0.7
Ash (g)	0.5
Fat (g)	0.2
Crude fibre (g)	0.6
Carbohydrate (g)	7.0
Ascorbic acid (mg)	2 329

Source: Miller, C.D., Weakam, N.S. & Fitting, K.O. 1961. *Acerola: nutritive value and home use*. University of Hawaii Circular, 59. Honolulu, Hawaii Agric. Exp. Station.

content of ascorbic acid; one cherry of about 20 g, half of which is pulp, contains 200-300 mg of ascorbic acid, which represents over five times the recommended dietary allowance of vitamin C. The nutrient content of acerola is shown in Table 9.

The fruit is very perishable and is usually eaten fresh. It may be processed as a juice or as a palatable pinkish-red jelly. The jelly is prepared from equal parts of green and ripe fruit with some added lime juice, as acerola is low in pectin. Acerola jelly has an ascorbic acid content of over 1 000 mg per 100 g, but over 50 percent of this is lost over a storage period of six months. Acerola pulp may also be prepared as a powder by solar or drum-drying; some loss of vitamins occurs during this process.

CITRUS FRUIT IN THE TROPICS

Sweet orange

The most commonly cultivated citrus fruit is the sweet orange (*Citrus sinensis*). This species is not well adapted to tropical conditions although it is extensively cultivated. In order to produce orange-coloured fruit, night temperatures below 14°C are required, together with a low humidity. In most tropical countries, ripe oranges remain partially or completely green. The nutrient content of the sweet orange is shown in Table 5.

The semi-sweet orange (*C. aurantium*) is more adapted to the tropics, but tends to be coarse and thick-skinned if grown at low elevations.

Lemon and lime

Similar considerations apply to the lemon (*C. limon*), which will grow readily in the tropics but tends to produce inferior fruit which is coarse and pithy with thick, warty rind. Research on citrus fruit for the lowland, humid tropics has so far been very limited; the largest citrus orchards are found in the subtropics and temperate regions of the world. The lime (*C. aurantifolia*, syn. *C. acida*) takes the place of the lemon in the tropics. It is native to southern Asia and is cultivated in most tropical countries. Limes are grown commercially in the West Indies where the preparation and export of raw or concentrated lime juice is a major industry. Lime oil is an important by-product of the juice-extraction process; lime marmalade is also produced. Much of the citrus juice prepared in developing countries is preserved with sulphur dioxide, particularly in Central America.

Preparation of lime pickle

In India, a traditional pickle is prepared from ripe limes and finely ground salt. The limes are quartered and completely coated in powdered salt. They are then placed on perforated trays to ferment and drain for three days. The pickled limes are transferred to an absorbent cloth and finally dried in the sun before storage.

Pomelo

The pomelo or shaddock (*C. grandis*) is native to Southeast Asia where it is most highly cultivated, especially in Thailand. It tolerates the climatic conditions of the lowland tropics, and will grow in marshy, brackish conditions which are unsuitable for other citrus species. The green or yellow fruit is larger than the grapefruit; it has a thick rind and a rather fibrous structure in the internal segments. The flavour of selected varieties is acid-sweet without bitterness. A pink-fleshed pomelo which has been developed in Java is one of the most delicious cultivars.

Grapefruit

Pink-fleshed grapefruit have also been produced although most common cultivars have a pale flesh with an acidic, sometimes bitter flavour. The

grapefruit (*C. grandis* var. *acemosa*, syn. *C. paradisi*) is not considered a separate species as it is believed to have originated from the pomelo in Jamaica some centuries ago. It often grows well in the tropics, but its promotion and improvement have been overshadowed by the emphasis on the cultivation of sweet oranges, which remain the most popular of the citrus fruit, cultivated in Africa.

Tangerine, mandarin and citrus hybrids

Tangerines and mandarins (*C. reticulata*, syn. *C. nobilis*) are grown in both tropical and subtropical regions to provide an additional variety to oranges and grapefruits. Various hybrids are also grown, such as the tangelo, which is a cross between a grapefruit and a tangerine, as well as the *ortanique* from Jamaica, which is believed to be a cross between a sweet orange and a mandarin. The *chironja* is a natural hybrid of the orange and the grapefruit which grows wild in the mountains of Puerto Rico. It is cultivated in home gardens in the area and has been experimentally canned as segments and as juice.

Wild citrus species

There are many lesser-known tropical citrus species, most of which grow wild or semi-wild. They are not often used as a table fruit but rather as a condiment, as a leaf spice, or in traditional medicine. The wild lime (*C. hystrix*) comes into this category. About the size of a lemon, with a rough coarse skin, the fruit is used in herbal mixtures in Sri Lanka, and the leaves are used in curries.

Preparation of citron peel

Another species of citrus fruit is the citron (*C. medica*). This is a large fruit with a rough, adhesive rind, which is the main edible portion as the pulp is acidic and bitter. Citron peel is fermented in a 3-3.5 percent salt solution; during fermentation the tissues turn yellow and translucent and the bitter flavour disappears. This process may take five to six weeks. When fermentation is complete, the peel is repeatedly washed in warm water to remove the salt. It is then candied by repeated immersion in sugar syrups of increasing

concentration. Finally, the candied peel is coated in finely-ground sugar and dried on mats or trays before storage. A similar technique is used in India to prepare the peel of pomelo.

USE OF GATHERED WILD FRUITS

In most countries, the number of cultivated fruits is limited, but wild fruits are often numerous and abundant. Their importance in the diet varies with the season. Many minor fruits are eaten only occasionally, chiefly by children; a few species are eaten and traded in very considerable quantities. Usually they are eaten directly, in a fresh condition; sometimes the seeds are cracked and the kernels are eaten as nuts. Little is known of the quantities consumed but, at certain times of the year, fruits and their seeds probably make a significant contribution to rural diets. This is of particular value if the fruit is available during the pre-harvest "hungry season". Some wild fruits are dried and stored for further use, others may be processed as jams and jellies, or fermented as fruit-beers and wines. A few are consumed mainly in the form of a fruit drink.

It is not practicable to cover all species and aspects of tropical gathered fruits; a few examples will illustrate their variety and their utilization.

AFRICAN WILD LOQUAT

This tree is usually identified as *Uapaca kirkiana*; it is found in eastern Africa, in almost pure stands, in some areas of *Brachystegia* woodlands. Its Bantu name is *masuku*; a related species, *U. guineensis*, is distributed in the rain forests of West Africa. *U. kirkiana* fruits extremely heavily and is a symbol of fertility for the Bemba people of Zambia. The round fruit, 3-4 cm in diameter, is borne in clusters close to the stem. When fully ripe, the berries are brown, fleshy and juicy, with several whitish seeds. They ripen most evenly if picked early and kept in the dark for several days.

In areas where this tree is found, the fruits are collected and sold locally, or sent to more distant markets where the tree does not grow. The wild loquat is eaten fresh and is also made into fruit squash and wine. Other edible *Uapaca* species include *U. nitida*, and *U. sansibarica* which tastes like apricot.

SNOT APPLE, EBONY APPLE AND WILD ORANGE.

Snot apple

Snot apple (*Azanza garckeana*) is found in Tanzania, Zambia and Zimbabwe in wooded grasslands, especially on termite mounds. It is a small spreading tree which fruits during the dry season. The fruits comprise five to six segments containing seeds, embedded in an edible, sweet-tasting mucilage. They are popular as a snack for children and are marketed in some areas.

Ebony apple

Ebony apple (*Diospyros mespiliformis*) grows in *Brachystegia* woodland and along river courses in Tanzania and Zimbabwe. Related species including *D. kirkii* and *D. batocana* also bear edible fruit. The fruit has a tough outer skin containing a sweet, mealy pulp and dark-brown, shiny seeds.

Wild orange

The wild orange (*Strychnos cocculoides*) is widely distributed in eastern Africa. The ripe fruit is the size of a small orange. It has a smooth, yellow, woody shell containing a fleshy pulp with a refreshing flavour. The fruit is eaten fresh as a snack and is also used to prepare a sour-sweet non-alcoholic drink, but the seeds are said to be poisonous.

MOBOLA PLUM

This fruit tree (*Parinari curatellifolia*) is common in Africa; it is usually found on sandy soils where water is fairly near to the surface. The oval fruit is 2-3 cm long and the skin is rough and changes from green to dull brown when the fruit ripens. The acid-sweet mealy pulp is reported to have a high content of vitamin C. In Zambia, this fruit is called *mupundu*; it is very popular and can be eaten raw or cooked. The seed kernels are also edible and have a high oil content; they are pounded and added to soup. Another related species, *P. excelsa*, has edible fruit and the kernels are good when roasted.

MONGONGO, MARULA AND UVILLA

Mongongo

Ricinodendron rautanenii is called *mongongo* in Botswana and Zambia. It is a savannah tree which is used as a source of fruit and oil. The round fruits have a soft, edible pulp with a floury texture; this can be eaten fresh or may be dried for later use. The nuts are also eaten; they contain 25-28 percent protein and 50-60 percent of an edible oil and are usually cracked to extract the kernel, which is then pounded and roasted.

The nut, and to a lesser extent the flesh of this fruit, is very important in the diet of the Kalahari bushmen in northern Botswana. In parts of Namibia the nuts are an esteemed food. During the fruiting season, 100-300 may be gathered daily. The outer shell of the nut is tough and hard to crack; the yellowish-white kernels are eaten raw or after roasting. They may be pounded and mixed with the roots of *Vigna lobatifolia* and local leafy greens, such as *Talinum crispatum*.

Marula

The *marula* (*Sclerocarya birrea* subsp. *caffra*) is common in eastern and southern Africa. It bears pale-green, oval fruit, 0.5 cm in diameter, which ripens to pale yellow after falling to the ground early in the dry season. The flesh is very juicy with a flavour between that of the mango and litchi; the nuts within the stone are also delicious. This fruit is reported to contain four times as much vitamin C as sweet oranges; the nut is rich in protein, over 30 percent, and also contains 57 percent of oil. In South Africa a wild fruit liqueur is prepared from *marula* and is marketed commercially for local use or for export.

Uvilla

The *uvilla* (*Pourouma cecropiaefolia*) grows wild in the wet, equatorial forests of Brazil, Colombia and Peru where it is called the Amazon grape. It is also cultivated as single, compound trees around the houses of the Indian community, and in their home gardens. The fruit grows in grape-like bunches; the skin is acrid and inedible, but is easily removed when eating the sweet pulp. The *uvilla* is very prolific; it fruits heavily over a long period

during the wet, pre-harvest season. It is consumed raw and is also fermented to make wine. A related species, *P. sapida*, is found in the same locality and bears edible fruit.

ROSELLE

The roselle (*Hibiscus sabdariffa*) is also called "red sorrel". It is an annual shrub, 2-3 metres high with reddish stems, leaves and fruit, and is native to the West Indies. It has been introduced to many tropical countries where it has often been naturalized and also domesticated.

This plant has many uses; after the flowers fall away, the fleshy sepals become enlarged and succulent, enclosing the fruit capsule. These enlarged sepals are juicy and full of flavour and are gathered in the unripe state for pickles. The ripe fruit is used for a beverage, "sorrel-drink", and for the preparation of a delicious roselle jelly. It may also be fermented for wine. The young, tender leaves of *H. sabdariffa* are gathered as a green leafy vegetable or as a pot-herb, and have an agreeable sour flavour. In Uganda, roselle seeds, known locally as *emalakang*, are pounded and added to water to make a sauce which may be used with cowpeas. They can also be eaten dry-roasted as a snack.

The fruit of other *Hibiscus* spp. may be used as a vegetable. This is the case with the okra (*H. esculentus*) which is widely grown for its mucilaginous, edible pods and for its young leaves. The Indonesian species, *H. manihot*, is exclusively used for its sulphur coloured, edible leaves.

NIGHTSHADE AND OTHER SOLANUM SPECIES

Species of *Solanum* occur throughout the temperate and tropical zones. The leaves and fruits of many species contain poisonous glycoalkaloids which sometimes disappear as the fruit ripens. The black nightshade (*Solanum nigrum*) is widely distributed in Africa. An East African form is a common weed of both arable and waste land. The young leaves and fruit are somewhat bitter, but both are gathered and eaten, although the unripe fruits and leaves are often considered to be poisonous. A variety, *S. nigrum* var. *guineense*, is grown for its leaves in West Africa. Another species, *S. nodiflorum*, is also regarded as a variety of *S. nigrum*.

S. macrocarpon, the African egg-plant, is partially domesticated and has been widely introduced into Southeast Asia. The young fruits are often eaten raw but the plant is grown mainly for its edible leaves. *S. aethiopicum*, or "mock tomato", is an African herbaceous species with small red fruits which are eaten cooked. The leaves are also eaten in soup or in sauces. Leafy green vegetables from many sources are an important component of tropical diets.

Leaves and flowers

LEAFY VEGETABLES IN TROPICAL DIETS

In many tropical countries, the diet is based on a starchy staple, supplemented and made palatable by adding a variety of flavoursome, spicy sauces and relishes. These relishes contain many different ingredients; green leafy vegetables play an important role in their preparation. Many different cultivated and gathered leafy green vegetables are recognized and utilized.

In tropical Africa, green leaves are an accepted part of the normal diet, generally added to the stew or soup which accompanies the staple. In this way, additional nutrients, especially vitamins and minerals, are included in the diet.

In Southeast Asia, including India and the Philippines, there is a most remarkable variety of edible greens, from all types of plants, including trees, herbs and aquatic species. Knowledge of their identity and the development of sophisticated recipes for their preparation provide impressive evidence of the energy, enthusiasm and ingenuity of these communities in obtaining a varied, tasty and nutritious diet.

In tropical America, there is an equal wealth and diversity of plant materials but the traditional knowledge of earlier cultures in the selection and use of these edible green leaves has not always passed down to the present generation.

IMPORTANCE OF EDIBLE GREEN LEAVES IN TROPICAL AFRICA

In tropical countries, green leaves are everywhere; they form part of the production of other crops, such as legumes, roots and tubers; they are found on shrubs around the house, on ornamental trees along the roadsides, and on the trees of the farmland and forests. Many are edible and many are utilized in sub-Saharan Africa.

Leaves of herbaceous plants

Leaves are gathered from crops which are already being cultivated for other purposes, including cassava, sweet potato and taro, cowpea and bean leaves, and the leaves of some varieties of pumpkin. Other vegetables are cultivated in home gardens especially as a source of green leaves.

Some arable weeds are particularly valuable as they grow very quickly with the first rains, and are harvested before there is any serious competition with the growing crops.

Vegetables, which are sown and cultivated domestically as a source of green leaves, include a number of *Brassica* spp., especially local varieties of rape (*B. napus*) and the semi-perennial kale (*B. oleracea* var. *acephala*). Semi-domesticated and gathered vegetables which are widely appreciated include roselle (*Hibiscus sabdariffa*), "cat's whiskers" (*Cleome gynandra*), wild okra (*Sesamum angustifolium*), jute or Jew's mallow (*Corchorus* spp.), blackjack (*Bidens pilosa*), nightshade (*Solanum nigrum*), "water leaf" (*Talinum triangulare*) and "bitter leaf" (*Vernonia* spp., especially *V. amygdalina*). Wild and cultivated species of *Celosia* and of *Amaranthus* are also very popular leafy vegetables. The nutritional content of a selection of these food plants is included in Table 10.

In addition to these herbaceous plants, use is made of the young leaves and shoots of a wide variety of trees and shrubs. Many of these shrubs and trees are identified only by their local names which vary from country to country, and between different localities within countries, depending on the vernacular tongue.

Edible leaves from shrubs and trees

The most important families are the Leguminosae and the Euphorbiaceae, which are widely distributed throughout the tropics. Trees of the Leguminosae include *Erythrina* (coral trees), *Cassia*, *Sesbania*, *Bauhinia* and *Acacia*, but not all species of these genera have edible leaves. Some are used in traditional medicine for their strong laxative effect and some are poisonous. Thus, careful identification is essential. A selection of some of the most commonly utilized tree leaves is shown in Table 11.

TABLE 10. Nutritional content of some green leafy vegetables (values per 100 g edible portion)

	Food energy	Moisture	Protein	Fat	Carb.	Fibre	Ash	Ca	P	Iron	β -carotene equiv.	Thiamine	Riboflavin	Niacin	Vit. C
	(kcal)	(%)	(g)	(g)	(g)	(g)	(g)	(mg)	(mg)	(mcg)	(mcg)	(mg)	(mg)	(mg)	(mg)
<i>Amaranthus</i> spp.															
Raw	42	84.0	4.6	0.2	8.3	1.8	2.9	410	103	8.9	5 716	0.05	0.42	1.2	64
Cooked	43	84.5	4.0	0.9	7.1	1.3	3.5	506	62	1.7	—	—	—	—	52
Baobab leaves															
<i>Adansonia digitata</i>															
Raw	69	77.0	3.8	0.3	16.1	2.8	2.8	402	65	—	—	—	—	—	52
Dried	282	11.8	12.3	3.1	63.2	9.7	9.6	2 241	275	24.0	9 710	0.13	0.82	4.4	—
Blackjack															
<i>Bidens pilosa</i>															
Raw	43	85.1	3.8	0.5	8.4	3.9	2.2	340	67	—	1 800	—	—	—	—
Dried	33	88.6	2.8	0.6	6.0	1.3	2.0	111	39	2.3	—	—	—	—	—
Bitter leaf															
<i>Vernonia amygdalina</i>															
Raw	52	82.6	5.3	0.4	10.0	1.5	1.7	145	67	5.0	—	—	—	—	51
Dried	194	27.4	32.5	1.5	28.6	—	10.0	105	536	5.5	—	—	—	—	20
Cassava leaf															
<i>Manihot esculenta</i>															
Raw	91	71.7	7.0	1.0	18.3	4.0	2.0	303	119	7.6	11 775	0.25	0.60	2.4	311
Dried	194	27.4	32.5	1.5	49.2	—	5.2	313	431	8.0	—	—	—	—	—
Cat's whiskers															
<i>Cleome gynandra</i>															
Leaves, raw	34	86.6	4.8	0.4	5.2	1.2	3.0	288	111	6.0	—	—	—	—	13
Leaves + stems, cooked	41	86.6	4.2	1.0	6.3	1.3	1.9	135	94	3.4	—	—	—	—	—
Sweet potato															
<i>Ipomoea batatas</i>															
Leaves, raw	49	83.0	4.6	0.2	0.2	2.4	2.0	158	84	6.2	5 870	0.10	0.28	0.9	70
Leaves, cooked + groundnuts	66	82.5	2.6	3.0	9.1	0.9	1.8	93	68	3.3	—	—	—	—	—

TABLE 11. Wild and semi-wild leafy vegetables and flowers utilized as food in tropical Asia

Common name	Scientific name	Part(s) used
Moonflower	<i>Ipomoea alba</i>	Young shoots
Swamp cabbage	<i>Ipomoea aquatica</i>	Young shoot and leaves
Giant bamboo	<i>Gigantochloa levis.</i>	Bamboo shoot
Wild celosia	<i>Celosia argentea</i>	Young plant
Roselle	<i>Hibiscus sabdariffa</i>	Young leaves and calyx
Kapok	<i>Ceiba pentandra</i>	Young leaves
Ipil-ipil	<i>Leucaena leucocephala</i>	Young leaves and mature seeds
Sesbania	<i>Sesbania grandiflora</i>	Young leaves, flowers and pods
Bitter melon	<i>Momordica charantia</i>	Young leaves and fruits
Edible fern	<i>Athyrium esculentum</i>	Fiddle heads
Lotus	<i>Castalia pubescens</i>	Leaves, flowers, stalks and seeds
Swamp taro	<i>Cyrtosperma merkusii</i>	Leaves and stems
Eel grass	<i>Vallisneria gigantea</i>	Leaves and flower stalks
Rattan palm	<i>Calamus mollis</i>	Growing point or palm cabbage
Fishtail palm	<i>Caryota cumingii</i>	Palm cabbage (hearts of palm)
Banana	<i>Musa sapientum</i>	Flower buds
Madrede cacao	<i>Gliricidia seplum</i>	Flowers
Tamarind	<i>Tamarindus Indica</i>	Flowers, young leaves, seeds and pulp of pods
Parkia	<i>Parkia speciosa</i>	Immature pods and seeds
Wild egg-plant	<i>Solanum ferox</i>	Young fruits
Horse-radish tree	<i>Moringa pterygosperma</i>	Fruits, flowers and leaves

Source: Villareal, R.L. & Opena, R.T. 1976. The wild vegetables of Southeast Asia. *American Horticulturist*, 55 (3).

Knowledge of traditional food plants

In the past, a wealth of local knowledge on the value and use of indigenous plants was transmitted orally in rural areas from parents to children. This process now seems to be breaking down, many factors contributing to this loss.

Parents and children no longer spend the majority of their time together, in close contact, in a local learning situation. Schools and training institutions have taken over the parents' function, and formal education rarely includes this traditional knowledge. In some areas, parents are separated from each other, and from their children for relatively long periods, due to the claims of the wage economy. In these circumstances, children may be brought up without direct knowledge of local food habits and traditions.

In some communities, especially in urban and semi-urban groups, the indigenous vegetables may have been replaced by commercially promoted exotics, which are seen to command a higher social status. However, there is always a market for inexpensive and flavoursome traditional greens, among the most widespread and popular of these leafy plants being the vegetable amaranths.

VEGETABLE AMARANTHS

Grain amaranths have already been discussed in the first volume of this series; vegetable amaranths include many species of the same family. Vegetable amaranths produce small amounts of seed but are cultivated mainly for their leaves.

Distribution and characteristics

Amaranths adapt readily to new environments and many local cultivars have been developed in the tropics. In India, Southeast Asia and the South Pacific Islands favoured species include *Amaranthus dubius* and *A. cruentus* which are cultivated extensively. *A. hybridus* and *A. palmeri* are both tolerant of hot and arid conditions. These and other species, such as *A. spinosus*, often appear as short-lived arable weeds which are gathered before the cultivated crops.

Nutritional aspects

The nutritional quality of amaranth greens is similar to that of other leafy vegetables, as indicated in Table 10. In common with other greens, amaranth contains a number of anti-nutritional factors including oxalic acid. When grown under dry conditions, levels of oxalates can reach 1 or 2 percent and

can interfere with the absorption of calcium and other minerals. Boiling the leaves removes most of the oxalic acid.

UTILIZATION OF AMARANTH IN AFRICA AND ASIA

Preparation of *efo* soup

In Nigeria, a traditional soup is prepared using amaranth greens. The fresh leaves are chopped and washed in cold water; they are then blanched and left in salted water for a few minutes to soften.

Condiments including chili pepper, tomato, onion and dried fish are boiled together for about 15 minutes, then the drained amaranth leaves are added. The soup is again boiled until the leaves are tender, palm oil and salt are added, and the preparation is completed by simmering in order to cook the oil.

Preparation of *efo* relish

A relish or sauce is similarly prepared using the same condiments with the addition of ground dried shrimp. This sauce is thickened with melon-seed paste before the addition of the blanched and brined leaves. Meat or fish may also be added if available.

Preparation of amaranth *koottu*

In India, green leaves are often cooked with pulses. Amaranth *koottu* is prepared by adding chopped amaranth to a cooked mixture of green and black gram *dal*. This is then seasoned with a paste of ground coconut, onion, mustard and green chili.

DOMESTIC USE OF LEAFY VEGETABLES IN EASTERN AFRICA

There are many ways of preparing vegetable leaves; methods vary according to the characteristics of the leaves and the form of the consumed product. There are also local differences in preference and practice between communities, even within the same area.

Cooking techniques

One basis for differentiation in cooking techniques, recognized in eastern Africa, is the degree of slipperiness of the leaves. Green vegetables such as

pumpkin, cassava and bean leaves, "cat's whiskers" and the leaves of sweet potato are not mucilaginous. These leaves are finely chopped and washed before cooking; cassava leaves are washed and pounded. The leaves are then boiled in water, which may be retained as part of the soup or relish. If the flavour of the leaf is too strong, or bitter, the water is discarded.

Cooking times also vary, but leaves are usually boiled until they are soft and tender. Other items such as groundnut paste, onion, tomato and cooking oil are added, as available. Dried fish is a popular addition that is particularly favoured with the leaves of cowpea, pumpkin or beans.

Leaves which are mucilaginous, or old, especially the mature leaves from trees, are often cooked with soda. Locally produced soda or potash is an alkaline condiment which is purchased in the market as grey, rock-like chips. It is also prepared domestically from wood and plant ashes. The ash is placed in a perforated pot and the water to be used for cooking is allowed to percolate through it.

Vegetables which are very slippery, such as okra, are not chopped and washed, as slipperiness is a desired quality in food relishes. Cooking oil is not usually added to mucilaginous leaves.

Preservation of leafy vegetables by sun-drying

Some leafy vegetables are preserved for use in the dry season by sun-drying. Slippery vegetables are never blanched or boiled. The leaves are simply stripped from the stems and dried in the sun. Other leaves may be blanched or parboiled; tree leaves may also be pounded to soften them before drying. Dried baobab leaves are particularly appreciated.

The dried leaves may be added directly to soups and stews as required. Dried cowpea leaves may be fried, as well as boiled, when they are fried in oil, crumbled and sprinkled over maize porridge as a relish. During drying, nutrients such as vitamin A and ascorbic acid are often greatly reduced. The extent of the vitamin loss depends on the pretreatment, and the temperature and duration of the drying process.

VEGETABLES IN ASIA AND THE SOUTH PACIFIC

Vegetables form an important part of most Asian diets, particularly in the diet of vegetarian communities. Some data on the dietary role of vegetables

TABLE 12. Per capita energy and protein contribution from rice, pulses, vegetables and dairy products in Asia

Asian region (No. countries)	Energy				Protein			
	Rice	Pulses	Vegetable	Dairy products	Rice	Pulses	Vegetable	Dairy products
	(kcal/day)				(g/day)			
Southwest (10)	119	916	43	102	2	5	3	7
South (5)	592	85	20	89	12	5	1	5
Southeast (7)	1 282	82	22	22	24	4	2	1
East (4)	936	135	44	5	18	12	3	0.3

Source: FAO. 1971. Food Balance Sheets 1964-66. Rome.

in different regions of Asia are shown in Tables 12 and 13. Many different vegetables are cultivated; miniature garden plots are seen everywhere, especially around the perimeter of the great urban centres.

Cultivated vegetables

Many leafy vegetables are tolerant of high temperatures and humidity, and grow well in lowland areas, even in the hot season. Other vegetables including *Brassica*, onions and tomatoes are grown at high altitudes or in the lowlands during the cooler weather. Intercropping with sugar cane or field crops is commonly practised.

Headed and non-headed Chinese cabbage (*Brassica pekinensis* and *B. chinensis*) are extensively grown and marketed; Japanese or Chinese radish (*Raphanus sativus* var. *longipinnatus* and related varieties) are cultivated for their roots and leaves; the tender pods may also be eaten. Mustard greens (*Brassica juncea* and *B. japonica*) are popular, and bean shoots from mung bean (*Phaseolus aureus*) and soybean (*Glycine max*) are used widely. The green, immature pods of soybean are also used as a vegetable.

In the South Pacific, taro leaves (*Colocasia esculenta*) are used as a green vegetable. They are prepared in several ways; the leaves are boiled in water or in coconut cream, or wrapped in banana-leaf parcels and baked in an earth oven. When cooked in the earth oven, onion, coconut cream, salt and water

TABLE 13. Average food energy levels of diets in selected Asian countries (1971-1975)

	All food	Cereal	(Rice)	Roots & tubers	Pulses	Vegetables	Fruits	Meat	Milk	Egg	Others
	(kcal/day)										
Afghanistan	1 978	1 676	(146)	1.4	26	21	30	60	42	2.0	116
Bangladesh	1 957	1 639	(1 445)	40.0	31	11	25	20	28	1.6	163
India	1 977	1 311	(629)	41.0	140	30	31	6	73	0.4	345
Nepal	1 994	1 667	(971)	42.0	38	7	18	25	97	4.0	104
Pakistan	2 152	1 400	(274)	10.8	77	30	27	25	100	1.2	482
Sri Lanka	2 044	1 140	(830)	131.0	37	11	64	11	45	7.0	597
Myanmar	2 160	1 660	(1 622)	4.9	58	23	34	47	20	10.0	294
Cambodia	1 927	1 590	(1 465)	16.0	18	32	31	73	7	3.0	158
Indonesia	2 032	1 348	(1 107)	234.0	15	26	41	19	3	4.0	342
Laos	2 073	1 738	(1 642)	26.0	36	28	24	118	6	20.0	77
W. Malaysia	2 531	1 407	(1 123)	27.0	30	25	93	91	72	13.0	774
Philippines	1 962	1 282	(873)	67.8	6.2	21	45	102	20	14.0	407
Thailand	2 312	1 667	(1 602)	57.0	18	28	64	96	10	15.0	357
Taiwan	2 804	1 536	(1 207)	81.0	29	50	54	321	13	16.0	702
Korea, Rep. of	2 706	1 998	(1 129)	115.0	7	82	20	46	7	15.0	416

Source: Asian Development Bank. 1977. *Rural Asia: challenge and opportunity*. Asian agricultural survey, 1976. New York, Praeger Publishers.

or lemon juice are added to the parcels for flavouring. The leaf tips of sweet cassava varieties and of sweet potato plants are also used as green vegetables in this region.

Semi-domesticated and gathered vegetables

Bamboo shoots are an essential component of many dishes in Southeast Asia; a number of different species are used, including *Bambusa tulda*, *Dendrocalamus hamiltonii* and the giant black bamboo (*Gigantochlea nigrociliata*). The young shoots are prepared for consumption by boiling or pickling. The shoots of water bamboo (*Zizania palustris*) are also eaten.

Leaves and stems of swamp cabbage or water convolvulus (*Ipomoea aquatica*) and leaves of the sweet potato (*Ipomoea batatas*) are greatly appreciated; some use has also been made of the young leaves of the invasive water hyacinth (*Eichhornia crassipes*), although these may often be very fibrous. A number of other wild and semi-wild leafy vegetables and flowers are utilized. Information on a selection of these is included in Table 11.

Use of leaves in cooking and packaging foods

In most tropical countries, leaves are used extensively to wrap foods during cooking, and as a packaging material for marketing cooked foods. Species utilized depend on local availability, but use of banana leaves is very common; in the South Pacific plaited coconut fronds are a popular packaging material. Banana leaves are said to impart desirable flavour to foods, and may also help to preserve them for longer periods, especially when the steamed packages are tightly wrapped and tied.

Large leaves may be made pliable by removing the midrib and by wilting them over a fire. Before use, they are usually greased with palm oil, groundnut oil, or coconut cream to prevent glutinous food from sticking to them.

Flowers as vegetables

These are not of major importance but add variety to the diet. Edible flowers and buds include the flowers of pumpkins, melons and squashes, especially

those of *Cucurbita moschata*, *C. maxima* and *C. pepo*; the leaves and flowers of the "sunset hibiscus" (*Hibiscus manihot*) are also eaten.

Banana flowers (*Musa* spp.) are not true flowers but the male bud with its fibrous outer bracts removed; these are used in several dishes, as are the flowers of the ginger plant (*Zingiber officinale*).

Some use is made of other flowers including those of papaya, of horse-tamarind (*Leucaena leucocephala*), of *Moringa oleifera* and of *Sesbania grandiflora*.

Seaweeds and freshwater algae

In coastal areas, seaweeds are extensively used, either fresh or dried, and are important sources of iodine and fluorine. The many edible varieties include *Caulerpa racemosa*, *Euphausia* spp., *Neomycis intermedia* and *Sargestes lucens*.

In some countries, use is made of freshwater algae; in Laos, edible algae include *Cladophora* spp. and *Spirogyra* spp. These are marketed as a dark-green semi-liquid paste. When required for use, the water is squeezed out, the damp mass is chopped and added to vegetable or meat broth. It is often seasoned with garlic, onion and coriander; pounded sesame seeds may also be added to thicken the preparation.

In Java, young plants of *Limnocharis flava*, a freshwater aquatic, are cultivated in rice paddies and marketed as a green vegetable. The young leaves, stems and flower clusters are cooked and eaten; old plants are ploughed back into the rice fields as green manure. Another edible aquatic, found wild in swamps and rice paddies throughout tropical Asia, is the fern *Ceratopteris thalictroides*. The new fronds of this fern are eaten raw in salad; the entire plant, except the root, may be cooked as greens.

Mushrooms and edible fungi

Use of edible fungi depends on their correct identification; often this knowledge is based on local information and the species used are known by vernacular names. They generally fall into groups based on their appearance, texture and flavour, and on the substrate on which they are found.

In Laos, a popular white mushroom known as *hed-khao* is commonly eaten; it resembles the pale-brown marketed mushroom, *hed-bod*, which is believed to be *Lentinus kurzianus*. Other edible mushrooms found on dead or decaying trees are considered to be species of *Agaricus*, *Amanita* or *Lepiota*. Jelly mushrooms are usually marketed in the dried form and reconstituted as required. There are several different kinds with vernacular names which mean "mouse-ear", "rat-ear" or "monkey-ear"; all are believed to be varieties of *Auricularia polytricha*.

Cultivation of mushrooms

A number of mushrooms are especially cultivated for marketing, including the common edible mushroom (*Agaricus bisporus*) and the paddy-straw mushroom (*Volvariella volvacea*), which is cultivated on rice straw. The *shiitake* mushroom, grown on oak or maple logs in Japan, is also very popular in Malaysia; it is generally classified as *Lentinus edodes*. The "oyster mushroom" (*Pleurotus ostreatus*), or a related species, is commonly sold in markets in Thailand.

A flow chart for the production of oyster mushroom on oil-palm waste is shown in Figure 2. Pericarp waste gives higher yields than bunch waste as it is softer and less fibrous.

DOMESTIC USE OF LEAFY VEGETABLES IN SOUTHEAST ASIA

In Indonesia, many people eat vegetables at every meal; these may be fresh or cooked and are often dipped into a spicy relish or *sambal*. The vegetables most commonly consumed are the green leaves of various cultivated and wild plants, including aquatics. Thus, the daily menu is rice, or an alternative starchy staple, served with fresh, salted or dried fish, raw or cooked leafy vegetables and a hot relish.

Several vegetable sauces are prepared using such leaves as papaya, amaranth and sweet potato, or the leaves of trees and shrubs including the "tulip tree" (*Gnetum gnemon*) and the leafy shrub, *Sauropus androgynus*. The leaves are blanched and chopped, and are then mixed with a spiced groundnut paste, or with toasted grated coconut, together with palm sugar, tamarind pulp, onions and garlic. This sauce is served with rice, accompanied by fish sauce or shrimp paste.

In Thailand, crisp fresh vegetables may be served as a salad; in addition to a selection of green leaves, this may also contain pickled vegetables and bean shoots, spring onions, slices of giant white radish, fresh ginger and a garnish of mint and coriander leaves.

In Taiwan, many interesting methods of using mung bean shoots have been developed. They may be spiced and boiled, or fried and prepared as a mixed vegetable curry with spinach leaves, chopped and flavoured with ginger, turmeric, garlic and chili. They are also soaked, ground to a paste, mixed with onion, egg and seasonings, and fried as an appetizer.

A cold salad is prepared from boiled and salted seaweed, with blanched bean sprouts, flavoured with sesame oil, lemon juice, salt, sugar and ginger.

Chinese cabbage is served in many ways. It may be stir-fried and mixed with cornstarch and soy milk to form a sauce; alternatively, after frying it may be combined with boiled water chestnuts, chopped green onion and ginger. It may also be braised, with dried mushrooms, rice wine and dried shrimps. Rice wine is used to pickle Chinese cabbage with the addition of salt, ginger, chili and peppercorn.

The use of vegetables in Asia is a fine culinary art. Every cook has an individual approach and the resultant salads, soups, sauces and side dishes provide an almost infinite variety to the diet.

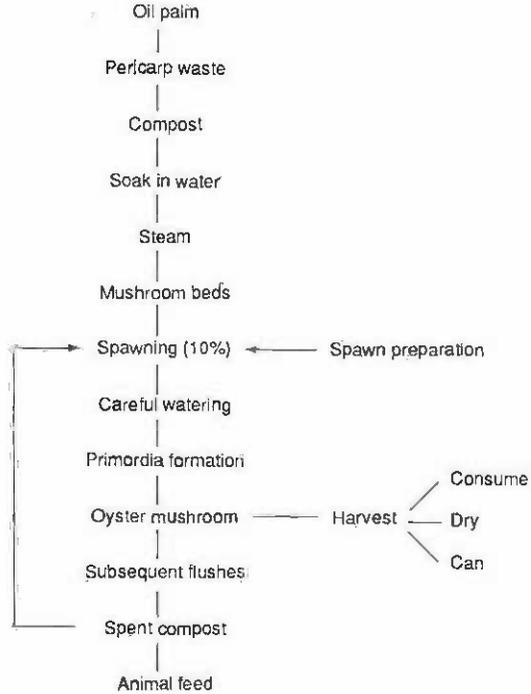
ACID PRESERVATION TECHNIQUES

Preparation of chutneys and pickles

Vegetables are preserved in various forms by lowering the pH of the product. This may be achieved by cooking the vegetables while adding acids, salt, sugar and spices as in the preparation of chutneys and pickles. Acids added to these products include vinegar, lime juice or tamarind.

In the preparation of chutney, the components may also include fruits; both fruit and vegetables are finely chopped, and sugar, salt, spices and acid are added and the mixture is then cooked to a soft paste. Pickles usually retain a firmer consistency as fruit and vegetables are cut into bite-sized pieces. They may or may not be cooked but are often brined. They are then covered with a hot, spiced, acidic liquor.

Figure 2
Production of *Pleurotus* mushroom on oil palm waste



Source: Ng, C.H., Wang, C.W. & Ong, K.C. 1977. Production of *Pleurotus* mushroom on oil palm pericarp wastes. *Symposium on Fermented Foods*. Bangkok, Thailand.

In other processing techniques, the pH is lowered by fermenting the vegetable with acid-forming bacteria, under controlled conditions.

Preservation of vegetables by brine fermentation

Most vegetables can be preserved by this technique, in which fermentable carbohydrates are converted into acids and other products by selected micro-organisms in the presence of salt. Properties of the individual vegetable determine the concentration of salt needed for its preservation and, in turn, the salt concentration greatly influences the type and extent of microbial action. Other factors which influence the course of the fermentation include the temperature of the substrates, and the degree of exposure to the air.

In Korea, a number of vegetables are prepared as salted, acidic pickles called *kimchi*. In this form, the original crisp texture of the fresh vegetable is retained; acidic conditions are produced during bacterial fermentation.

Preparation of *kimchi*

At the household level, ingredients for the preparation of *kimchi* include salted vegetables, fresh and pickled fish and seasonings. Chinese cabbage (*Brassica pekinensis*) and Korean radishes are the main vegetable substrates for *kimchi*. Fish components may include pickled shrimp and anchovy, fresh oyster, octopus or pollack, with seasonings of garlic, onion, ginger, chili, and *cheng-gak*, which is a kind of seaweed.

Whole cabbages are salted with 15 percent brine for three to seven hours, and are then washed twice with fresh water and drained. The additional ingredients are chopped and mixed with the salted cabbages; the mixture is then packed tightly into containers and sealed. At this stage, the salt concentration of the pickle is 3-3.5 percent. In the subsequent fermentation, micro-organisms involved include both lactic acid-forming and aerobic bacteria, such as *Leuconostoc mesenteroides* and *Pseudomonas* spp.

In warm weather, the *kimchi* is ready in less than a week; it then has a pH of approximately 4.2. In winter, the jars are placed in an underground storage room where fermentation takes up to two months. A flow chart for the preparation of *kimchi* is shown in Figure 3. *Kimchi* is served as a main

TABLE 14. Composition of several types of *kimchi*
(values per 100 g edible portion)

	<i>Tongbaechu-kimchi</i>	<i>Kakduggi</i>	<i>Dongchimi</i>	<i>Moisanju</i>
Calories (kcal)	19.0	31.0	9.0	27.0
Protein (g)	2.0	2.7	0.7	2.7
Fat (g)	0.6	0.8	0.2	0.7
Sugar (g)	1.3	3.2	1.1	2.4
Calcium (mg)	28.0	5.0	1.0	3.0
Vitamin B ₁ (mg)	0.03	0.03	0.01	3.0
Vitamin B ₂ (mg)	0.06	0.06	0.03	0.07
Niacin (mg)	2.1	5.8	10.0	3.3
Vitamin C (mg)	12.0	10.0	7.0	19.0

Source: Korea FAO Association. 1975. *Recommended dietary allowance for Koreans*. Seoul, Korea.
Note: *Kimchis* are reported to contain from 1.03 to 1.52 mcg vitamin B₁₂ per 100 g. Lee *et al.* 1958. Studies on the composition of *kimchi*. *Bull. Sci. Res. Inst. Korea*, 5:43-50.

relish, or side dish with boiled rice. The composition of various types of *kimchi* is given in Table 14.

Preparation of "cat's whiskers" as *pak-sian-dong*

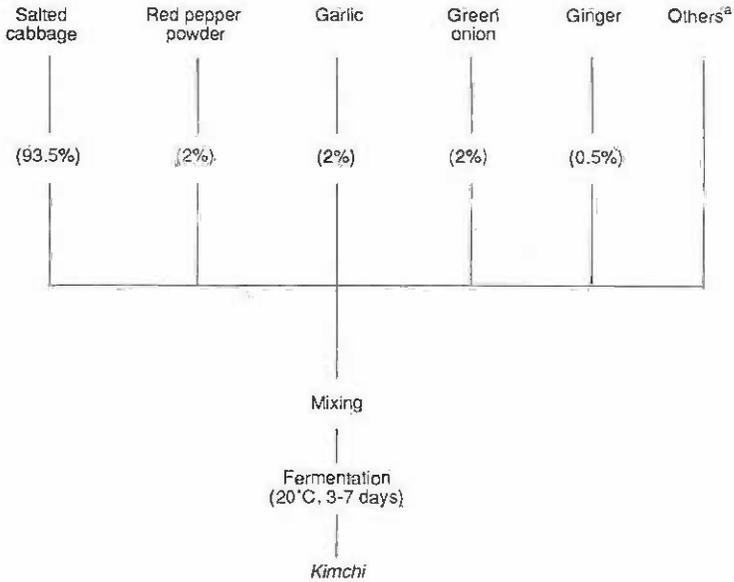
In Thailand, fresh leaves of cat's whiskers (*Gynandropsis gynandra*) are gathered and washed; bitter varieties may then be soaked in salt water overnight; sweeter leaves may be processed without presoaking. The washed leaves are first wilted in the sun, then mixed with water containing salt and raw cane or palm sugar. One kilogram of leaves requires about 50 grams of salt and 60 grams of sugar to one litre of water. This mixture is packed into tightly sealed jars and allowed to ferment for about 72 hours, by which time the pH of the liquid is about 3.9. Both homofermentative and heterofermentative strains of lactobacilli have been isolated from *pak-sian-dong*.

Similar processes are used for the fermentation of black mustard leaves (*Brassica juncea*) and *pak-gard-dong* and for young bamboo shoots (*Bambusa arundinacea*) as *naw-mai-dong*. Flow charts for *naw-mai-dong* are given in Figures 4 and 5.

Preparation of green mustard leaves as *gundruk*

Gundruk is a non-salted acid fermentation of leafy vegetables developed in Nepal to provide a relish product during the off-season when fresh greens are not available. Micro-organisms involved include *Lactobacillus cellobiosus* and *Pediococcus pentosaceus*. This process is also used for leaves of rape and of radish. *Gundruk* is consumed as an appetizer; it has a fresh, sour flavour and is served with soybeans, or with the cherry-like fruit of *Spondias auxiliaris*.

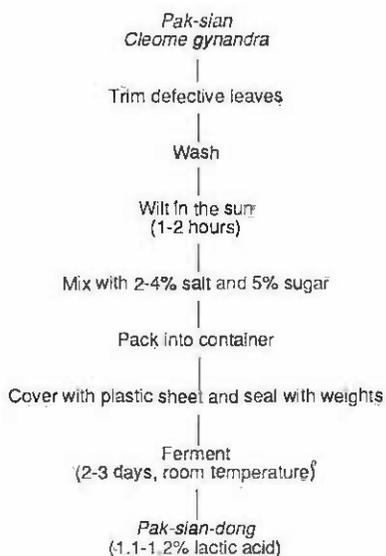
Figure 3
Flow chart of *kimchi* processing



^a Sugar and salt, fermented fishery products, fresh fish and seaweed.

Source: Lee, C.H. 1983. Traditional food technologies in Korea. Conference paper, UNU Workshop on Traditional Food Technologies, Mysore, India.

Figure 4
Flow chart for the fermentation of "cat's whiskers."



Micro-organisms involved:

Leuconostoc mesenteroides
Pediococcus cerevisiae
Lactobacillus plantarum
Lactobacillus brevis
Lactobacillus buchneri
Lactobacillus fermentum

Source: Adapted from Dhavises, G. 1972. *Microbial studies during the pickling of bamboo and of pak-sian*. MS thesis, Kasetsart University, Bangkok.

- C. aurantium* 29
C. grandis 30
C. grandis var. *acemosa* 31
C. hystrix 31
C. limon 30
C. medica 31
C. nobilis 31
C. paradisi 31
C. reticulata 31
C. sinensis 29
Cladophora spp. 47
Cleome gynandra 38
Colocasia esculenta 44
Corchorus spp. 38
Cucurbita maxima 47
C. moschata 47
C. pepo 47
- Dendrocalamus hamiltonii* 46
Diospyros batocana 33
D. kirkii 33
D. mespiliformis 33
Durio zibethinus 22
- Eichhornia crassipes* 46
Embllica officinalis 17
Eriobotrya japonica 27
Erythrina 38
Eugenia spp. 15
E. aquea 15
E. caryophyllus 15
E. cuminii 15
E. curranii 16
E. dombeyi 16
- E. jambolana* 15
E. javanica 16
E. klotzschiana 16
E. luschnathiana 16
E. malaccensis 15
E. michelii 16
E. tomentosa 16
E. uniflora 16
E. uvalha 16
Euphausia spp. 47
Euphorbiaceae 38
Euphoria longana 20
- Garcinia* spp. 25
G. cambogia 25
G. livingstonei 25
G. mangostana 23
G. xanthochymus 25
Gigantochlea nigrociliata 46
Glycine max 44
Gnetum gnemon 48
Gynandropsis gynandra 52
- Hibiscus* spp. 35
H. esculentus 35
H. manihot 35,47
H. sabdariffa 35,38
- Ipomoea aquatica* 46
I. batatas 46
- Lactobacillus cellobiosus* 53
Leguminosae 38
Lentinus edodes 48

- L. kurzianus* 48
Lepiota 48
Leucaena leucocephala 47
Leuconostoc mesenteroides 51
Limnocharis flava 47
Litchi chinensis 19

Malpighia puniceifolia 28
M. glabra 28
Mangifera indica 3
Manilkara achras 22
Moringa oleifera 47
Musa spp. 47

Neomycis intermedia 47
Nephelium chryseum 19
N. lappaceum 19
N. litchi 19
N. longana 20
N. malaiense 19
N. mutabile 19

Opuntia spp. 27
O. amyclaea 27
O. ficus-indica 27

Parinari curatellifolia 33
P. excelsa 33
Passiflora edulis 25
P. edulis f. *flavicarpa* 25,26
P. ligularis 25
P. quadrangularis 26
Pediococcus pentosaceus 53
Persea americana 1

Phaseolus aureus 44
Photinia japonica 27
Phyllanthus acidus 17
P. emblica 17
Physalis peruviana 17
Pistacia vera 3
Pleurotus ostreatus 48
Pourouma cecropiaefolia 34
P. sapida 35
Pseudomonas spp. 51
Psidium cattleianum 21
P. friedrichsthalianum 21
P. guajava 20
P. guineense 21
P. pomiferum 21

Raphanus sativus
 var. *longipinnatus* 44
Rhus vernicifera 28
Ricinodendron rautanenii 34

Sauropus androgynus 48
Sclerocarya birrea subsp. *caffra* 34
Sergestes lucens 47
Sesamum angustifolium 38
Sesbania 38
S. grandiflora 47
Solanum spp. 35
S. aethiopicum 36
S. macrocarpon 36
S. nigrum 35,38
S. nigrum var. *guineense* 35
S. nodiflorum 35
Spirogyra spp. 47

Spondias auxiliaris 53
Strychnos cocculoides 33
Syzygium spp. 15
S. aqueum 15
S. calubcob 16
S. cordatum 16
S. cuminii 15
S. guineense 16
S. javanicum 16

Tachardia lacca 28
Talinum crispatum 34
T. triangulare 38

Uapaca spp. 32
U. guineensis 32
U. kirkiana 32
U. nitida 32
U. sansibarica 32

Vernonia spp. 38
V. amygdalina 38
Vigna lobatifolia 34
Volvariella volvacea 48

Zingiber officinale 47
Zizania palustris 46
Ziziphus abyssinica 28
Z. jujuba 27
Z. mauritiana 27