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UNDER-UTILIZED TROPICAL FRUITS OF THAILAND

**FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
REGIONAL OFFICE FOR ASIA AND THE PACIFIC
BANGKOK, THAILAND
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by

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FOREWORD

An estimated 1000 varieties of wild and cultivated tropical and sub-tropical fruits are found growing in Thailand. Of these, more than 100 varieties are grown primarily for local, non-commercial uses. Some are known and grown in several tropical and sub-tropical regions of the world, but for many their growth and utilization is confined to Thailand and the Southeast Asian region. Only a limited amount of scattered literature exists for these species, some of which are on the verge of extinction.

The objective of this publication is to put on record current knowledge on the common names, centers or origin, botany, agronomy, uses, and development prospects of 35 species of under-utilized tropical fruits of Thailand. Eight species are seen to have some potential for future commercial development; nineteen species are thought to have development potential primarily for home garden use, while the remaining eight species do not appear to have any current development potential for economic uses.

Realistically, it is unlikely that any of the edible fruits described in this publication will find their way to the world's supermarket shelves. Fresh, and even locally processed fruits of these species tend, at present, to cater for localized markets and taste preferences, even though several are highly nutritious. Many are primarily utilized in cooking to flavour local dishes. Nearly all have claimed ethnomedical properties for the treatment or relief of complaints ranging from diabetes to the common cold. One, 'Luk nieng', is downright dangerous if the seed is consumed in excess as it causes djenkolism. In addition, several of these species are hardy and may well have value as rootstock for related commercial species.

All the species described herein have Thai names and are known by the majority of ordinary Thai citizens and as such are part of Thailand's heritage. Despite this, little if any research has been carried out to assess their potential value as food, medicinal and genetic resources.

I hope, therefore, that this publication will be useful in raising interest in these under-utilized tropical fruits of Thailand among researchers, conservationists, students, extension officers, growers and entrepreneurs. Finally, I recommend this publication to all those in the public and private sectors concerned not only with commercial development, but also with the conservation of national and regional bio-diversity.

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UNDER-UTILIZED TROPICAL FRUITS OF THAILAND

INTRODUCTION

Thailand has ideal growing conditions throughout the year for fruit crops. An estimated 1000 varieties of wild and cultivated tropical and sub-tropical fruits are found growing locally under various systems, including natural growth in the forests, unattended growth in the villages, and cultivated growth in home gardens and commercial plantations. Of these more than 100 varieties are grown for local uses.

Unfortunately, only a limited amount of literature exists on many fruit species that are either being neglected or are under-utilized. Although the useful PROSEA publication “Plant Resources of South-East Asia No. 2” on edible fruits and nuts has compiled many species that are found growing in Thailand on a non-commercial scale, a number of species worthy of mention were not included. Some of these species are on the brink of becoming extinct, and if they are not to be lost forever they should be recorded in the hope that they may catch the attention of those persons in the public and private sectors concerned not only with commercial development, but also with the conservation of national and regional bio-diversity.

It is with this aim in mind that this report on under-utilized tropical fruits of Thailand has been compiled from various sources. Some 35 species of under-utilized tropical fruits have been identified, described and grouped under three major headings as follows:

Species with potential for commercial development

This group comprises species of tropical and sub-tropical fruits that are not presently grown on a real commercial scale, but may have good potential for commercial development if subjected to more research on marketing and post-harvest storage. Almost all of the fruit species in this group are currently cultivated in small-scale mixed orchards and are usually grown together with other economic crops. They are also commonly found growing in home gardens and the fruits from some species are sold at local markets when in season.

Species with possible development potential for home garden use

This group includes species that may have some potential of being developed for home garden use. The prospects for bringing fruits from this category into Thailand’s markets may be faced with difficulties. However, they may prove to be valuable genetic resources for future research. In this respect, research on utilization and nutritional value of these fruits should be undertaken in order to select suitable species for cultivation.

Species without current development potential for economic uses

This group includes species that, at the present time, do not have any potential for being developed commercially. Most of these species are found growing naturally in the forests or growing unattended in wasteland. Some are found growing along roadsides. Currently, the only value of the fruit species in this group is due to their use by local villagers as traditional medicine, or for other necessities. This in itself indicates that they may have value as genetic resources for further scientific investigation.

Many of the under-utilized tropical fruit species mentioned here are not indigenous to Thailand. Some of them were introduced many centuries ago and have acclimatized to Thai conditions. All of them have Thai names and are known by most ordinary Thai citizens and as such are part of Thailand's heritage. It is hoped, therefore, that the information contained in this report will at least prove useful to conservationists and others dedicated to preserving bio-diversity, for without their help some of the species mentioned here may soon be extinct.

PART 1.

SPECIES WITH POTENTIAL FOR COMMERCIAL DEVELOPMENT

This group comprises eight species of tropical and sub-tropical fruits that are not presently grown on a real commercial scale, but may have good potential for commercial development if subjected to more research on marketing and post-harvest storage. Almost all of the fruit species in this group are currently cultivated in small-scale mixed orchards and are usually grown together with other economic crops. They are also commonly found growing in home gardens and the fruits from some species are sold at local markets when in season.

1. Chomphu-mamieow (*Syzygium malaccense* (L.) Merr. & Perry)

Chomphu-mamieow (*Syzygium malaccense* (L.) Merr. & Perry) belongs to the Myrtaceae family. Like other species in the genus *Syzygium*, it is indigenous to the Southeast Asia Region. Malaysia was perhaps the first country to cultivate this plant and hence Malay apple is the common name for this species. The tree is naturally found in the rainforests of the lower mountain region of Java, Sumatra and Peninsular Malaysia including southern Thailand. Chomphu-mamieow trees are found cultivated in home gardens throughout Thailand.

1.1 Vernacular names

Malay apple, pomerac (English); **jambu bol** (Indonesia); **jambu merah, jambu bol** (Malaysia); **yanbu, tersana, makopang-kalabaw** (Philippines); **thabyo-thabyay** (Myanmar); **chomphu-mamieow, chomphu-saraek** (Thailand); **cay dao, cay roi** (Viet Nam).

1.2 General description

Chomphu-mamieow tree reaches a height of 15 m, with a straight trunk of 20-45 cm diameter. It is often branched near the base and has a broadly ovoid canopy. The leaves are opposite, with glossy green colour, and elliptic to lanceolate shape 20-35 cm long. The petiole is 0.5-1.5 cm long, thick, and with red colour when young. The branches bear dense clusters of conspicuous, four-petalled, bright red flowers, with 1-12 flowers in a cluster. The red flowers are 5-7 cm in diameter. The calyx tube is 1.5-2.0 cm long, ventricose towards the apex, and with broad lobes 4-8 mm long. There are four dark red petals, which are oblong-ovate or orbicular-ovate, and 2 cm long. The stamens with red filaments are numerous, up to 3.5 cm long (in the case of filaments) with 3-4.5 cm long red style (Panggabean, 1991). The two-celled ovary develops into a one-seeded red fruit as large as an apple and smelling like a rose. It is eaten raw or made into preserves.

1.3 Propagation and planting

Chomphu-mamieow is easily propagated from seed. However, the seeds lose their viability quickly and should be sown fresh from the fruit. Polyembryony has often been

recorded (Yaacob and Subhadrabandhu, 1995). Vegetative multiplication, especially marcotting, can be adopted.

It is essential to ensure adequate shade and to avoid drying out by the sun during the early stages of growth. Irrigation is often necessary for the young plants during the dry season. Spacing of 5 × 6 or 6 × 8 metres is commonly seen for cultivated chomphu-mamieow in the central parts of Thailand.

1.4 Growth and yield

In Thailand, the chomphu-mamieow is found to take 4-5 years to flower after planting. The maximum yield is recorded from the tenth year with the figure of 60-80 kg/tree. There are two or sometimes three flowering times in a year, but the timing varies from year to year. There seems to be no regular growth rhythm for chomphu-mamieow. Apparently the trees are triggered into bloom by wet weather following a dry period. Among the *Syzygium* species, the Chomphu-mamieow seems to have the most crops per year, and the fruits take about 60 days after bloom to ripen.

In Thailand, Chomphu-mamieow trees produce many flushes of flowers almost continuously all year. Therefore, if properly managed, harvesting time can be extended and last almost year round. The main harvesting time is in November, a time when most tropical fruits are scarce in the market.

1.5 Prospects

Fruit scientists have paid little attention to chomphu-mamieow; hence very little or no scientific research has been done on this crop. This may be due to the reputation of chomphu-mamieow as a home garden plant. They are not planted in orchards on a commercial scale. Also the short shelf-life of the fruit limits its possibilities for commercialization. At present, the fruit possesses value in local markets and there is a trend for increasing consumer demand for high quality fruits. It is suggested that pomologists should pay more attention to the growth and development of the trees to obtain a better insight into the growth rhythm including the timing and intensity of bloom, and quantitative aspects of yield as well as selection of superior clones.

2. Luk Yee (*Dialium indum* Linn.)

A synonym of this species is *Dialium cochinchinense* Pierre.

This fruit tree belongs to the Leguminosae family. The tree occurs wild in southern Thailand as well as in Malaysia. In Thailand, it is known as ‘yee’ and ‘keranji’ in Malaysia. The fruit has a typical flavour that is somewhat similar to tamarind. Thus, it has the English name as ‘velvet tamarind’.

2.1 General description

Luk Yee is a medium to very tall tree. The wood is very hard and compact and is highly valued. The leaves are pinnate with 3-9 coriaceous leaflets arranged alternately. Small white flowers are in large terminal panicles, with short calyx-tubes and lanceolated lobe. There are no petals, 2 stamen, and anthers are attached near the base. The ovary is

sessile, two-ovuled. The pod is oblong or ovoid and globose with a black pericarp. The endocarp is pithy and sweet with one seed inside.

According to Bamroongruga and Yaacob (1990), the luk yee tree is well adapted to tropical regions, especially in monsoon areas where the soil is well drained. The tree seems to tolerate good as well as poor soil. From observations, the tree tends to be shade tolerant as it is found that the young tree grows well under rubber stands and rises above them at the later stage. This confirms that the luk yee is a tall and large tree.

In Thailand, the flowering time of luk yee is from April to June, and about 3-4 months elapse before harvesting, that is about August to September. The main problem for expanding the plantation of this fruit tree is its long juvenile period. Many local farmers say that it takes 15-17 years; others say that it begins to flower when the stem diameter is more than one foot. A big tree in Pattani province was planted in 1944 but flowered in 1986 when it was 42 years old. It is also interesting that two trees grown nearby the toilet in the house compound began to flower within 5 years (Bamroongruga and Yaacob, 1990). This probably implies that if the tree receives good care, adequate fertilizer and moisture, the juvenile period can be shortened. Rain before flowering has been observed to accelerate fruiting. Inadequate soil moisture can cause fruit drop.

2.2 Propagation

Since the velvet tamarind tree has never been cultivated there is almost no available information relating to propagation. It is believed that under wild habitat, the tree grows from seed.

2.3 Uses

Luk yee or velvet tamarind is seen growing only in southern Thailand. The fruit is used for a dessert. Generally, ripened fruits are mixed with sugar and chilli peppers, wrapped in thin plastic sheet and are sold in markets, railway stations, and bus stations, as well as at many tourist centres in southern Thailand.

After harvesting, fruits are dried in the sun for few days until the separation of the shell and the brown pulp occurs. The fruit must be completely dried, or else it will be damaged by pests arising from eggs laid during the flowering within the fruit itself. To break the dried fruits, cloth bags are filled with the fruits and hit on the ground. Separation of broken shell and pulp is done by a shaking technique. Brown pulp with the seed inside is sold at about 30-40 baht per litre.

In Thailand two types of products from the fruits are worth mentioning.

- i. Luk yee paste. This is prepared from the brown pulp of fruits and mixed with sugar, chilli and salt. The pulp is then wrapped in thin plastic sheets for sale.
- ii. Coated luk yee. This is prepared from fruits which are free from the outer shells. The fruits are either coated with sugar or a mixture of sugar, chilli and other ingredients, depending on individual techniques. Coated luk yee may be called either “sweet” or “hot” luk yee, depending on the ingredients used.

2.4 Prospects

Luk yee fruit has value in processing, but at present the demand for the fruit is not big enough. It is generally restricted to people in southern Thailand and is bought as gifts by tourists. The long juvenile period of the tree renders its development as an economic fruit tree quite difficult. As luk yee trees have almost never been cultivated and wild trees are being cut for timber, promotion and research should be carried out to preserve them. There is urgent need to study the characteristics of the tree, particularly its propagation, growth, husbandry and harvesting.

3. Ma-praang (*Bouea macrophylla* Griff.)

3.1 General description

The ma-praang, or gandaria, or, marian plum is native to North Sumatra, Peninsular Malaysia and West Java (Rifai, 1991). It is cultivated widely as a fruit tree in Thailand and Sumatra.

Ma-praang (*Bouea macrophylla*) belongs to the same family as the mango (Anacardiaceae). It is becoming a popular fruit tree in Thailand. The tree is evergreen and can grow up to 27 m tall, with light brown, fissured bark. Branchlets are often smooth, hanging and angular or flattened. Leaves are ovate-oblong to lance shaped or elliptic, simple, entire, papery and shining. The leaf can be up to 45 cm long and 13 cm wide, but is usually smaller. Leaf base is acute to cuneate with 1-2.5 cm long leafstalk. The leaves form quite dense foliage. Inflorescences are 4-12 cm long panicles with mostly 4-merous, yellowish flowers turning brown. In Thailand, marian plum flowers in November-December and fruits from April-May, whereas in Indonesia it flowers from June-November and fruits from March-June.

The immature fruit is pale green when the fruit is small and becomes dark green as the fruit develops. The ripe fruit is yellow-orange, mango-like in character, roundish, and 2.5-5.0 cm in diameter. The fruit is juicy with a sour to sweet taste according to the variety, and has a faint turpentine smell. There is one seed in a fruit; the seed is similar to that of the mango but smaller in size. The endosperm is white and pinkish purple, and has a bitter and astringent taste.

3.2 Vernacular names

Marian plum and **gandaria** (English); **ma-praang** (Thailand); **ma-yong** (Thailand); **ramania** (Indonesia-Malay); **gandaria** (Indonesia-Java, Sunda); **kundang**, **rembungia**, **setar** (Malaysia).

In this *Bouea* genus, there is also *Bouea oppositifolia* (Roxb.) Meisner (synonyms *B. microphylla* Griffith; *B. burmanica* Griffith). The tree of this species also produces edible fruits, which are smaller and more acid than the ma-praang. In Thailand, the marian plum is divided into 3 groups according to the taste of fruits.

- i. Ma-praang prew or sour ma-praang. This refers to any tree that produces very sour fruits even when ripe. It is so sour that many birds turn away after the first taste of the fruit. Usually trees in this group are

not cultivated and they are found growing wild in the forests and unattended gardens. However, fruits in this group can be used to make prickle with salt or sugar added.

- ii. Ma-praang waan or sweet ma-praang. This refers to the common cultivated marian plum locally known as “ma-praang” in Thailand. This is the cultivated type and many clones have been selected according to fruit size and taste. The well known clone is “ma-praang Ta It” which was selected from an orchard in Ta It district, Nonthaburi province of Thailand over 100 years ago, and it is still popular even now.
- iii. Ma-yong. This group is similar to sweet ma-praang; the only difference is in the taste of the ripe fruit. A fully ripe “ma-yong” fruit contains some sourness in the taste. The well known “ma-yong chid” is a clone that produces a sweet tasting fruit with some acid flavour. In Thailand, some growers prefer to plant this “ma-yong chid” rather than “ma-praang”.

3.3 Agronomic characteristics

Ma-praang was normally grown from seed, thus there are quite a few selected clones known in Thailand. However, the plant can also be easily propagated by marcotting, inarching, grafting and stem cutting in the same way as the mango. At present, vegetatively propagated plants are commonly cultivated.

Seedlings or vegetatively propagated plants are planted in rows at a spacing of 10 × 12 m. Shading in the early stage for several months is favourable for early growth. Boosting the growth rate in the early years with manure, urea and other fertilizers is recommended to shorten the juvenile period. Normally the first harvest from seedlings can be obtained 6-8 years after planting or about 4-5 years for vegetatively propagated plants.

In Thailand, ma-praang is gaining popularity among local consumers in recent years. One of the reasons for this is the selection of clones with high quality fruits. Growers in the central and lower northern regions cultivate these high quality ma-praang clones in their orchards. In 1993, approximately 1,170 hectares of marian plum was recorded in the country. The three leading provinces that cultivated this fruit tree were Ang Thong, Nakhon Ratchasima and Nakhon Sawan, which contributed 21.4, 12.6 and 11.8 percent of the total planting area, respectively. Data in 1993 indicated that the total production was 5,652 metric tonnes. The three top producing provinces were Ang Thong, Uttaradit and Nakhon Sawan, which contributed 18.5, 18.4 and 10.4 percent of the total production of Thailand, respectively. The average productivity of marian plum in Thailand was 7 metric tonnes per hectare, while the average farm gate price was 13.65 baht (exchange rate in 1993 was 25 baht = 1 US dollar).

3.4 Uses

Ma-praang is becoming popular in Thailand. Although it is treated as a diminutive mango-like fruit, some of the selected cultivars are quite big (up to 50-100 g per fruit).

Fruits of the old varieties are rather acid even when fully ripe. However, many new clones with sweet flesh have been selected and cultivated commercially. The fruits are mainly consumed fresh, but sometimes they are cooked in syrup or made into an

excellent compote. Young fruits are used as an ingredient of a special kind of dish, a chilli-based condiment, and in pickles. Local people use the young leaves as vegetables and consume them with chilli and shrimp pastes.

The Nutrition Division of the Thai Department of Health has analysed the composition of a fruit sample per 100 g edible portion as: water 86.6 g, protein 40 mg, fat 20 mg, carbohydrates 11.3 g, dietary fibre 150 mg, ash 20 mg, calcium 9 mg, phosphorous 4 mg, iron 0.3 mg, β -carotene 23 mg, thiamine 0.11 mg, riboflavin 0.05 mg, niacin 0.5 mg and vitamin C 100 mg.

3.5 Prospects

With the introduction of sweet-flesh clones, ma-praang has received more attention in recent years. It is commonly grown as home garden trees and the cultivation is expanding to small orchards. The Thai Government is trying to help in exporting this fruit as some Thai firms have started to advertise ma-praang fruit for export. This suggests that ma-praang has good prospects for wider commercialization.

4. Mafai (*Baccaurea ramiflora* Lour.)

The synonyms of this species are *Baccaurea sapida* (Roxb.) Muell. Arg., and *Baccaurea wrayi* King ex Hook. f.

This fruit tree belongs to the Euphorbiaceae family, the same as rambai and langkhae. It is native to the Southeast Asian region and found growing wild as well as under cultivation in Nepal, India, Myanmar, South China, Indo-China, Thailand, the Andaman Islands, and Peninsular Malaysia.

4.1 Vernacular names

Burmese grape (English); **mafai setambun**, **tajam molek** (Indonesia); **pupor**, **tampoi** and **tempui** (Malaysia); **kanazo** (Myanmar); **phnhiew** (Cambodia); **f'ai** (Laos); **mafai** (Thailand in general) **somfai** (southern Peninsular), **hamkang** (Phetchabun), **phayiu** (Surin), and **sae-khruea-sae** (Mae Hong Son); **giâu gia dât**, **giâu tiên**, and **dzâu miên dzu' ó'i** (Viet Nam).

4.2 General description

The tree can grow up to 25 m tall. The leaf is simple, alternately arranged, with petiole. It is ovate to ovate-lanceolate in shape and 10-20 × 4-9 cm in size. The petiole is 1-8 cm long with lanceolated and fimbriated stipules. Tomentose inflorescences appear on branches and on the trunk. The male racemes are 3-8 cm long; flowers are fascicled on very short rachises with 4-5 sepals, and 4-8 stamens. The female racemes are 14 cm long and are borne lower on the trunk. Female flowers are solitary, with 4-5 sepals, 3-locular ovary and 2-lobed stigmas. The fruits are glabrous and 2.5-3.0 cm in diameter. The fruits can be of various colours from yellowish, pinkish to bright red (Figure 1). In Thailand the fruits are harvested in June-July.

4.3 Propagation

Mafai seeds are easily germinated. Fresh seed germinates in a matter of days. Therefore, seed germination is the common method of propagation. Air layering can also be made as well as budding and grafting to obtain the required type of plant.

4.4 Uses

Mafai fruits are used as a refreshing nibble or as table fruit. As with other related fruits in this genus, to consume the fruit one is advised to break the fruit open with the fingers and/or peel the skin. The pulp is then eaten directly and usually the seeds are also swallowed.

4.5 Prospects

Mafai is regarded as a minor fruit in Thailand. It has little chance of being developed to the commercial level. At present, it is cultivated in the home garden and intercropped with other tropical fruits like durian, rambutan, and mango. Unless there is more market demand for this fruit, little attention on research and development in production technology of mafai will be seen.

5. Phut-saa (*Zizyphus mauritiana* Lamk.)

The phut-saa is thought to be a native of India, and was introduced to Thailand many centuries ago. It is cultivated widely as fruit tree in Thailand and other tropical countries in Asia.

5.1 Vernacular names

Indian jujube, common jujube (English); **jujubier** (French); **widara, dara, bidara** (Indonesia); **bidara, jujub, epal siam** (Malaysia); **manzanitas** (Tagalog-Philippines); **zee-pen** (Myanmar); **putrea** (Cambodia); **than** (Laos); **phut-saa** (Thailand - central), **ma-tan** (Thailand-northern); **tao, tao nhuc** (Viet Nam).

5.2 General description

Phut-saa (*Zizyphus mauritiana*) belongs to the family Rhamnaceae. It is a common fruit tree in Thailand and found growing wild especially in sandy soils of arid regions. It is a small thorny tree, which can grow to a height of 10 metres. The thorns arise from the leaf bases. The scented, greenish flowers appear in clusters at the base of the leaf stalks. Fruits are roundish to oblong in shape, each measuring 1.8-5.0 cm long and about 2.5 cm wide. The fruits are green and firm when young, and at maturity they turn yellow-orange to brown. They are eaten raw or pickled as preserved fruits. The flesh is whitish and tastes sourish to sweet depending on the variety. It is like a plum with a stony seed embedded in the flesh.

5.3 Ecology

Phut-saa is one of the hardy trees in the tropics. The tree can cope with extreme temperatures and thrive under rather dry conditions. Fruit quality is best under hot, sunny and dry conditions, but there should be a rainy season to support extension growth and

flowering, ideally having enough residual soil moisture to carry the fruit to maturity. If harsh weather persists, the tree stops growing and stays dormant. In its natural habitat the annual rainfall ranges from 125 mm to over 2,000 mm. The maximum temperature is about 37-48°C and the minimum temperature is about 7-13°C. The tree can be found growing from sea level to about 1,000 m elevation. The tree prefers fairly light, deep soils, but it can be grown on marginal land, alkaline, saline or slightly acid, light or heavy, drought-susceptible or occasionally waterlogged soils.

5.4 Propagation

Under wild areas the existing trees are raised from seeds. In the home garden and commercial orchards, high quality clones of the common jujube are vegetatively propagated. Trees can be propagated on their own roots through stem cuttings or marcotting. Budding and approach grafting are commonly practiced in Thailand. Root suckers or seedlings from wild species are used to raise the rootstocks for budding or grafting of the selected clones.

5.5 Uses

The fruit of good cultivars is either eaten fresh, crushed to make a refreshing drink, or it can be preserved by drying or candying. In Thailand, unripe fruit is eaten with a mixture of chilli, salt and sugar. The fruits, seeds, leaves, bark and roots are reported to possess medicinal qualities, in particular to aid digestion and to poultice wounds. 100 g. of edible jujube fruit was reported to contain 41 k cal of energy, 1.0 g protein, 0.1 g fat, 9.1 g carbohydrate, 0.5 g crude fibre, 2.2 g dietary fibre and 0.6 g of ash. The nutritional value includes 14 mg calcium, 6 mg phosphorous, 0.4 mg iron, 31 µg β-carotene, 32 mg vitamin C, 1.1 mg niacin, 0.21 mg riboflavin and 0.01 mg thiamine (Anon, 1992).

5.6 Production

Phut-saa is probably most common in Thailand as compared to other Southeast Asian countries. In season, several cultivars are found in local markets. Data in 1993 showed the total acreage of common jujube in Thailand to be about 2,345 hectares. The two leading cultivars were Rien-thong and Bombay, which comprised 42.1 and 39.5 percent of the total growing areas. The two leading growing provinces were Samut Sakhon and Ratchaburi, which occupied 52.3 and 24.1 percent of the total production area. The total production in 1993 was 36,701 metric tonnes. The three top provinces in production were Samut Sakhon, Ratchaburi and Nakhon Pathom, which produced 65.1, 24.1 and 11.4 percent, respectively. The average productivity of all cultivars was 16.8 mt/ha, and the farm gate price was 8.92 baht per kg (35 US cents per kg).

5.7 Prospects

Phut-saa could be developed into an economic fruit crop of Thailand if there is more market for the fruits. Research on cultivar improvement and control of insect pests, especially fruit fly, are needed for quality fruit production. The development of various processing techniques in utilizing jujube fruit is one of the keys to success for future commercial plantation.

6. Sa-ke (*Artocarpus altilis* Fosberg)

6.1 General description

The sa-ke is a common plant of Polynesia where it is an important staple food. It is a native of the Pacific and tropical Asia and is found widely distributed throughout the humid tropics.

Belonging to the Moraceae family, sa-ke is a monoecious tree and can grow up to 30 m tall. The tree is evergreen in the humid tropics and occasionally behaves like a semi-deciduous in monsoon climates. It has a straight trunk 5-8 m tall, often buttressed with very thick, spreading twigs. The leaves are alternate, ovate to elliptical in outline, and undivided when young, but older ones are entire or deeply pinnately cut into 5-11 pointed lobes. Inflorescences are axillary with 4-8 cm long peduncles. The male inflorescences are drooping, club-shaped, containing minute yellow flowers with single stamen. The female inflorescences are stiffly upright, and globose or cylindrical in shape. Numerous green flowers are found embedded in the receptacle.

Like jackfruit and cempedak, the sa-ke is formed from the whole inflorescence. The fruit is more or less round, measuring 10-30 cm in diameter. Two forms of fruits - seedless and seeded - are commonly found.

6.2 Vernacular names

Breadfruit (English); **arbre à pain** (French); **sukun** (seedless), **kelur**, **timbang** (seeded) (Indonesia); **sukun** (seedless), **kelor** (seeded) (Malaysia); **rimas** (seedless), **kamansi** (seeded) (Philippines); **sakée**, **khnaôr sâmlôo** (Cambodia); **sa-ke** (seedless), **khanun-sampalor** (seeded) (Thailand); **sakê** (Viet Nam); **kapiak** (Papua New Guinea).

6.3 Uses

Immature as well as ripe fruits and seeds are eaten after boiling, baking, roasting or frying. The fruit may be cooked whole or after cutting it. Thin slices are also fried. The slices may be ground up and made into biscuits. In Thailand and the Philippines the mature seedless fruit is boiled and coated with sugar and dehydrated. Immature seeded fruit is cooked as a vegetable with coconut milk. The edible portion, which constitutes about 70 percent of the fruit, contains per 100 g: water 65-85 g, protein 1.2-2.4 g, fat 0.2-0.5 g, carbohydrates 21.5-31.7 g, calcium 18-32 mg, phosphorous 52-88 mg, iron 0.4-1.5 mg, vitamin A 26-40 IU, thiamine 0.10-0.14 mg, riboflavin 0.05-0.08 mg, niacin 0.7-1.5 mg and vitamin C 17-35 mg. The energy value is 470-670 kJ/100 g.

6.4 Prospects

Although sa-ke is an important staple food of people in the Pacific Islands and Southeast Asia, remarkably little is known about yield levels, harvest seasons and other factors which determine whether sa-ke can replace other staple food and fruits. Selection of the proper cultivars for commercial plantation has yet to be done, as it is seen that cultivars not only differ greatly in tree and fruit characteristics, but also in their adaptation to specific environmental conditions.

7. **Sator (*Parkia speciosa* Hassk)**

Sator is regarded as a southern region crop in Thailand. It belongs to the family Leguminosae, sub-family Mimosaceae. It is found growing naturally in the rainforests of southern Thailand, Malaysia and Java. In Malaysia, it is known as ‘**petai**’. It is commonly found as village trees in many rural areas of southern Thailand, and is even being cultivated in some orchards.

7.1 **General description**

Sator is grown for its edible seeds. It is a large, evergreen tree that can grow up to 15-35 m in height. The crown is variable in shape but is usually rather flat-topped or umbrella-shaped. In a well-grown tree the shape can be oblong. The long, stalked leaves are bipinnate with 10-20 pairs of side branches bearing very small, dark green leaflets. Each leaflet is oblong with a blunt end and an asymmetric base. The inflorescence resembles a drumstick as it has a long stalk carrying a large globular head of close-packed, cream-coloured flowers at the end. The flowers produce a great deal of nectar and have a strong, somewhat sickly smell. They are pollinated by bats and only the apical flowers develop fruits. Six to ten fruits develop in each inflorescence. The pods are green at first, becoming dark brown or blackish brown when ripe. When the tree is fruiting, the groups of young, light green pods give it a distinctive appearance easily visible from a great distance. Pods are up to 50 cm long and 6 cm wide. They are usually collected when still green and are sold in the market (Figure 2).

7.2 **Variety**

There are many known varieties of sator, but only three varieties are common in southern Thailand (Limpaladisai, 1971). Many other varieties are cultivated elsewhere, but they are poorly documented at present. The three varieties of southern Thailand are described by Bamroongruga and Yaacob (1990) as:

- i. Kow-sator (or rice sator). This is the most popular variety of sator in the local markets. It has many small seeds in the pod. The seeds have a strong odour and are quite sweet. This variety is suitable for consumption. It can produce fruits at 4-5 years after planting and is also classified as an early maturing variety.
- ii. Darn-sator. This variety has larger pods and seeds than those of the kow-sator, but it produces fewer pods per tree. In addition, its stem canopy is larger and taller than that of the kow-sator. In this variety the first flowering can be seen at 6-7 years after planting. As the darn-sator had harder seeds, a stronger odour, and better taste than kow-sator, it is more popular.
- iii. Tae-sator. This variety has very hard pods and seeds, so it is not suitable for consumption.

7.3 **Propagation and husbandry**

In the old days sator was primarily propagated by seeds. This resulted in great genetic diversity with many named cultivars (Yaacob and Subhadrabandhu, 1995). At

present, vegetative propagation such as stem cuttings, budding and grafting have been reported successful, and seed is only used to produce rootstock. However, farmers in the remote villages still go out and collect young seedlings from wild trees and grow them in their holdings. The seedling plants should be larger than 1 cm in diameter at planting. For ease of harvesting, it is advisable to propagate shorter trees from stem cuttings. These trees will also flowers earlier (4-6 years). Air layering and budding are also recommended. All of the vegetative techniques mentioned might not be suitable for sator trees that are grown in the area prone to strong wind as they do not produce tap roots and hence they are sensitive to wind damage. Because sator is a tall tree, the budding of a good variety sator onto stock of seedling sator or riang (*Parkia timoriana* Merr.) to produce trees with better root systems is reported to be successful.

Not much information is known about the cultivation practices of sator. General recommendations include irrigation during pod development and in areas where the dry spell is long. However, in most growing areas of southern Thailand well-distributed rainfall is experienced so irrigation may not be necessary. Fertilizers can be applied at two growth stages. For the period from planting until bearing N:P:K fertilizer at 20:10:10 is recommended at the rate (amount) in proportion to the age (year) of the tree. For example with a 2 year old tree, one kilogram of the fertilizer per year can be used as split-application, i.e. half a kilogram is applied at the beginning of the rainy season and the other half at the end of the rainy season. Application of animal manure, where it is available, is strongly recommended together with chemical fertilizers. For the bearing tree, application of a combination of organic manure and chemical fertilizer (12:24:12 N:P:K) is recommended at the rate of half the amount (kilogram) in proportion to the age of the tree (year). The application time is the same as that applied in the juvenile tree.

Weeding is recommended especially during the early stage, i.e. the first few years after planting. Mechanical weeding such as hoeing or herbicides can be used.

In Thailand some growers prune sator trees to obtain a reasonable sized tree and they claim to get higher pod yield.

7.4 Uses

Sator is grown for its edible seeds. The seeds contain high nutritional value and are served as a local vegetable in many dishes of southern Thailand. The composition per 100 g edible seed is carbohydrates 11.4 g, protein 8.0 g, fat 8.1 g, fibre 0.5 g, ash 1.3 g, calcium 76 mg, phosphorous 83 mg, iron 0.7 mg, vitamin A 73.4 IU, vitamin B₁, 0.11 mg, vitamin B₂ 0.01 mg, and niacin 1.0 mg. This rather high nutritional value makes sator seed to one of the most nutritious local vegetables of southern Thailand.

7.5 Prospects

Sator is well known in Thailand but the popularity is still mainly confined to the southerners. If people from other regions start to consume sator seeds, then the cultivation will be increased and the tree will become more economically important. Research on using sator seeds in various dishes as well as processing are needed to increase the number of consumers in the future.

8. Thurian-thet (*Annona muricata* L.)

8.1 General description

The thurian-thet is a small slender evergreen tree of the Annonaceae family. It can grow up to a height of about 7 m. The tree thrives best in the tropical lowlands on rich deep loam. Among the cultivated *Annona* species thurian-thet, having few cultural requirements, is the easiest to grow and has prolific fruiting capacities. However, it is the least hardy of the *Annona* species, requiring a warm and humid tropical climate. It grows at elevations up to 1,000 m and as far as 20°N and 25°S in sheltered sites. Growth and fruiting are severely set back by cold spells and light frosts kill the tree (Nakasone, 1972). A dry season enhances leaf fall and synchronizes extension growth and flowering to some extent. Yields may be higher under these conditions, provided that high humidity prevails during the period of fruit set. Where humidity tends to be low, a sheltered site is recommended to reduce transpiration, as the tree is also shallow-rooted. This is why thurian-thet is commonly found growing in the southern and eastern parts of Thailand where humidity is rather high throughout the year due to frequent rainfall. Thurian-thet can be grown in most soils with good drainage, as the tree does not tolerate waterlogging.

8.2 Vernacular names

Soursop (English); **guanábana** (Spanish), **corossol** (French), **sirsak**, **nangka belanda**, **nangka seberang** (Indonesian); **durian blanda**, **durian benggala**, **durian makkah** (Malaysia); **saua sap** (Papua New Guinea); **guayabano** (Philippines); **tiep banla**, **tiep barang** (Cambodia); **khan thalot** (Laos); **thurian-thet**, **thurian-khaek** (Thailand); **mang câù-xiêm** (Viet Nam).

8.3 Botanical characters

The leaves are oblong-obovate, 8-16 × 3-7 cm in size, short acuminate at the apex, with 3-7 mm long petiole. Flowers are regular, greenish-yellow, pedicel up to 2.5 cm long with 3 sepals, 6 petals, and numerous stamens with densely pubescent filaments and numerous ovaries. The ripe fruit is a pseudocarp, long and heart shaped, grows up to 10-20 × 15-35 cm, with dark green skin covered with 6 mm long soft spines. The thurian-thet fruit is the largest among the *Annona* species, weighing around 1 kg or more. The flesh or pulp is white, soft, juicy and fragrant. In-between the pulp, numerous brown to blackish seeds are embedded.

8.4 Uses

The fruit of thurian-thet can be consumed fresh as a dessert fruit when fully ripe or mixed with ice cream or milk to make a delicious drink. However, more often the puree is consumed after squeezing the pulp through a sieve. It can be made into a fruit jelly, juice (with the addition of sugar), nectar or syrup. It is also used in the preparation of ice cream. In Indonesia a sweet cake (dodol sirsak) is made by boiling thurian-thet pulp in water and adding sugar until the mixture hardens. In the Philippines young thurian-thet fruits with seeds that are still soft are used as a vegetable. Mature but firm fruit may be made into candies of delicate flavour and aroma.

In Thailand and Malaysia where the trees are cultivated mainly in the home garden the thurian-thet fruits are used as a good flavoured nutritional drink. The fruit consists of

about 67.5 percent edible pulp, 20 percent peel, 8 percent seeds and 4 percent core by weight. It is a good source of vitamin B (0.07 mg/100 g pulp) and vitamin C (20 mg/100 g pulp) and a poor to fair source of calcium and phosphorous (Koesriharti, 1991).

8.5 Prospects

At present, this species is confined to home gardens, and because of erratic yield and short shelf-life, there is little expansion of cultivation. More research on higher yield through improving pollination is needed before the processing industry requirements can be met. A breakthrough towards production in orchards can be possible if there is enough demand in the processing industry. The tree is easily propagated and due to its small tree size, which facilitates orchard management, and the short period from planting until first crop, this can greatly reduce the risk involved in commercial production.

PART 2.

SPECIES WITH POSSIBLE DEVELOPMENT POTENTIAL FOR HOMEGARDEN USE

This group includes nineteen species that may have some potential of being developed for home garden use. The prospects for bringing fruits from this category into Thailand's markets may be faced with difficulties. However, they may prove to be valuable genetic resources for future research. In this respect, research on utilization and nutritional value of these fruits should be undertaken in order to select suitable species for cultivation.

1. Champada (*Artocarpus integer* Merr.)

The synonyms are *Artocarpus integrifolia* L.f., *Artocarpus polyphema* Persoon, and *Artocarpus champeden* (Lour.) Stokes.

Champada belongs to the Moraceae family, the same family as the jackfruit and breadfruit. It is very popular in southern Thailand, particularly at Yor Island (Koh-yor) on Songkhla lake. The appearance is very similar to the jackfruit, but it can be distinguished by the long brown hairs on the leaves and twigs, and the fruits are somewhat smaller.

The champada is widely distributed in southern Thailand and Peninsular Malaysia. It is also cultivated in Indonesia, especially in the Lingga Archipelago, Sumatra, Borneo, Sulawesi, the Moluccas and Irian Jaya as well as in West Java (Jansen, 1991).

1.1 Vernacular names

Chempedak (English); **chempedak**, **campedak** (Malay), **baroh** (Lingga) (Indonesia); **chempedak** (cultivated), **bankong** (wild), **baroh** (Johor) (Malaysia); **sonkadat** (Myanmar); and **champada** (Thailand) (Jansen, 1991).

1.2 General description

Champada is an evergreen monoecious tree. It can grow up to 20 m tall, and is seldom buttressed. The bark is greyish brown with bumps on the trunk and main limbs where leafy twigs are produced, which bear the fruits. Brown wiry hairs 3 mm long cover twigs, stipules and leaves. Twigs are 2.5-4.0 mm thick with annulate stipular scars. The stipules are ovate up to 9 cm long. Leaves are obovate to elliptic, 5-25 × 2.5-12 cm in size, and the base is cuneate to rounded, with entire margin, and acuminate apex. The lateral veins are in 6-10 pairs, curving forward, with 1-3 cm long petiole. The inflorescences are solitary and borne on the axillary position of short leafy shoots. Male heads are cylindrical, 3-5.5 × 1 cm in size, and are whitish-yellow in colour with 3-6 cm long peduncle. The female heads occur with simple filiform styles exerted to 1.5 mm. The fruit is a syncarp, cylindrical to almost globose, and 20-35 × 10-15 cm in size. It is yellowish, brownish, or orange-green, and smells strongly at maturity. Pericarps, including the seeds, are ellipsoid to oblong about 3 × 2 cm in size. Cotyledons are unequal, thick and fleshy. Germination is epigeal.

1.3 Ecology

Champada is a common tree in secondary forests and locally abundant in primary lowland rainforest in its area of natural occurrence. It is a long living sub-canopy tree and can grow at altitudes of up to 500 m in Thailand, often on wet hillsides. It is strictly tropical and always restricted to regions without a distinct dry season. The tree thrives on fertile well drained soils, but prefers a fairly high water table. It can survive periodic flooding even with acid swamp water.

1.4 Propagation

The tree is usually grown from seed derived from nearby trees with desirable qualities. It can be propagated vegetatively by budding or suckle-grafting on seedling rootstocks of champada or other *Artocarpus* species, including jackfruit. The rootstock should be 8-11 months old at the time of budding, which may be done at any time of the year.

1.5 Harvesting

Harvesting is simple because the fruits are produced on the trunk and the main branches. In southern Thailand, the fruit is often bagged on the tree or enclosed in a loose basket of bamboo. The function of this basket is not clear. It is said that the bags protect the fruit against rodents, bats and fruit flies and attract ants that keep other insects away. There are no yield records, but champada is a prolific bearer and yields may be similar to those of jackfruit trees.

1.6 Uses

The fleshy perianths, which surround the seeds, are eaten fresh or cooked. The flesh, typically yellow or orange, sometimes white to pinkish, is soft and mushy with a strong and very characteristic odour. The flavour is sweet, resembling durian and mango. The seeds are eaten roasted or boiled in salty water for 30 minutes, and have a nutty flavour. Young fruits are cooked in coconut milk and eaten as a curried vegetable or in soup.

The dark yellow to brown wood is strong and durable and is used for building construction, furniture and boats. The bark can be used to make rope and the latex for the preparation of lime.

The total fruit weight varies from 600-3,500 g and is generally smaller than the jackfruit. The total edible portion (perianths + seeds) is 25-50 percent of fresh fruit weight. The total weight of all perianths of a fresh fruit varies from 100-1200 g. The composition of the flesh on dry weight basis per 100 g edible portion is approximately: protein 3.5-7.0 g, fat 0.5-2 g, carbohydrates 84-87 g, fibre 5-6 g, and ash 2-4 g. Water content (fresh weight basis) is 58-85 percent.

The composition of seeds, also based on dry weight, is approximately: protein 10-13 percent, fat 0.5-1.5 percent, carbohydrates 77-81 percent, fibre 4-6 percent and ash 3-4 percent. Water content (fresh weight basis) is 46-78 percent. The number of seeds per fruit varies from 14 to 131. Total seed weight per fruit varies from 65-880 g, and weight per seed from 1-12 g.

1.7 Prospects

Champada is one of the smelliest fruits, second only to durian. The smell and taste of the fruit are rather overwhelming and for the uninitiated it is easier to appreciate dishes made of the seeds. The crop is restricted to wet parts such as southern Thailand where it is generally more popular than the jackfruit. Thus, it is not so widespread and the demand for the fruit in the whole Thailand is still small. At present, it is regarded as a locally orientated fruit. Unless markets can be found, champada is regarded as having no potential for development at a commercial scale in Thailand.

2. Chomphu-nam dok mai (*Syzygium jambos* (L.) Alston)

Rose apple or “Chomphu-nam dok mai” as it is known in Thailand is also in the Myrtaceae family. It is believed to have originated in Southeast Asia and Malaysia and South Thailand may be its centre of origin (van Lingem, 1991). Some literature claims that it was introduced from India (Morton, 1987) and the East Indies (Kennard and Winters, 1960). The tree has been grown throughout the tropics and has become naturalized in many tropical countries.

2.1 Vernacular names

Rose apple, malabar plum (English); pome rose, jambosier (France); jambu air mawar, jambu mawar, jambu kraton (Indonesia); jambu kelampol, jambu mawer (Malaysia); tampoy (Tagalog), bunlaun (Bisaya), yambo (Philippines); châm-puu (Cambodia); chiêng, kieng (Laos); chomphu-nam dok mai (Central), manom hom (North), yamu-panawa (Malay-Yala) (Thailand); lý bô dào, roi (Viet Nam).

2.2 General description

Chomphu-nam dok mai is an evergreen tree, which can grow up to 10 m tall with a 50 cm trunk diameter. The tree is low branching and often found as a dense crown of wide-spreading branches. The stem is twisted at the base with brown, furrowed, smooth bark. The leaves are about 926 × 1.5-6 cm in size, shiny and pink when young then fading to pale green on the upper side and lighter green and obscurely glandular punctate on the lower side. They are narrow and gradually tapered to the base with 6-13 mm long petiole. Inflorescences are short terminal or axillary corymbs, with 4-10 flowers. The flowers are large and showy, white to pale green, sweetly scented, and about 5-10 cm wide. Fruit is a drupe, globose to ovoid and about 2.5-5 cm in diameter. The fruits are crowned by persistent calyx and style. When ripe they may be greenish, or dull yellow flushed with pink. The fruit skin is dull, the flesh is whitish, firm and rose scented. The fruit ripens in about 3 months after bloom. The rose-water smell of the fruit is a distinct character of this species.

2.3 Propagation

Chomphu-nam dok mai is normally propagated from seeds. The seeds have no dormancy and germinate well. A single seed often gives rise to 3-8 seedlings and most of them are true to type. Asexual propagation such as marcotting, budding and grafting can be done, but marcotting seems to be most common. Initial planting should be shaded.

The juvenile phase lasts 4-5 years, and the marcotted plants can bear fruit within 4 years. Little husbandry is required after planting.

2.4 Uses

The fruits, if meant to be consumed fresh, should be handled with care after harvest and marketed as quickly as possible. The fruits bruise easily and rapidly lose their crispness. Besides fresh consumption, the fruit is also cooked or preserved in various ways for home use. It can be distilled to yield a rose-water which is said to be equal to the best obtained from rose petals. A yellow coloured essential oil, important in the perfume industry, is derived from the leaves by distillation. The heartwood is heavy and hard, and is suitable for use in construction. However, the wood is very susceptible to termite attack and not durable in the soil. The bark contains 7 percent tannin on a dry weight basis and is used by local villagers for tanning and dyeing purposes. Several parts of the tree are used medicinally as a tonic or a diuretic.

The nutritional value per 100 g edible portion of the fruit comprises: 84-89 g water, 0.5-0.8 g protein, 0.2-0.3 g fat, 9.7-14.2 g carbohydrates, 1-2 g fibre, 0.3-0.4 g ash, 123-235 IU carotene, 0.55-1.01 mg Vitamin B complex and 3-37 vitamin C. The energy value is 234 kJ/100 g. The pulp has high pectin content and it is suitable for use as a settling agent.

2.5 Prospects

The prospect of developing Chomphu-nam dok mai production at commercial scale is slim. This is mainly due to lack of market demand. Low yield, susceptible to bruising and short shelf-life are the disadvantages of the crop. Thus, at present Chomphu-nam dok mai is expected to remain as a home garden tree, and is appreciated for its ornamental value as much as for its fruit.

3. Lang khae (*Baccaurea macrophylla* Muell. Arg.)

The scientific name of this fruit tree is *Baccaurea macrophylla* Muell. Arg. Sometimes it is also known as *Baccaurea malayana* King. The synonym of this species is *Cheilosa malayana* (Hook. f.) Corner ex Airy Shaw.

The tree belongs to the Euphorbiaceae family. Plants in this family love a humid and high rainfall climate. Lang-khæ is a native of South Thailand and Malaysia, and is found distributed in Peninsular Malaysia, Singapore, Borneo, and Sumatra. It is occasionally cultivated in these areas.

3.1 Vernacular names

There is no English name recorded for this fruit tree. **Gurak gatak** (Kalimantan), **bua tampoi** (Sumatra) (Indonesia); **tampoi**, **tampul**, **tempuni** (Peninsular Malaysia); **lang-khæ** (Thailand in general), however, there are other local names such as **lam-khæ** (Pattani), and **luk pui** (Phang-nga).

3.2 General description

Lang-khae is a medium sized tree that can grow up to 25 m tall. The leaves are elliptic-oblong, and about 25 × 10 cm in size. Flowers are borne on the main stem and big branches. The spike-like panicles are slender and 8 cm long. They occur solitary or fascicled on the branches. The fruiting racemes are short. About 5-6 fruits occur in a panicle. The fruit is an ellipsoid capsule and is about 4-5 cm in diameter. The fruit is dehiscent, pale green when young and becomes yellowish brown when mature. The pericarp is thick covering white flesh (pulp). There are 4-6 pulps in a fruit. The flesh is sweet. In Thailand, the harvesting time of lang-khae is from June-July.

3.3 Propagation

In the old days lang-khae was propagated by seeds. However, there is an increasing tendency for growers to vegetatively propagate the tree, as seedling plants gave rise to more male than the female trees. Budding and grafting of the desired scions on seedling rootstock are more preferable. The grafted tree can produce fruits within 4-5 years, which is quicker compared to that of the seedling tree.

3.4 Uses

The fruit is eaten as fresh fruit. The taste of the flesh is sweet with some sourness, which can attract a wide range of consumers. During the harvesting season, one can find lang-khae fruits in supermarkets of big cities in Thailand as well as in local markets in some southern provinces such as Phang-nga, Phuket and Hat Yai (Songkhla province). It is also popular among the Chinese, Malaysians and Indonesians.

3.5 Prospects

This fruit tree has a good future in Thailand. At present, it is cultivated in many orchards in southern Thailand such as in Phang-nga and Phuket provinces. There is an indication for increasing the plantation of lang-khae in the near future. One of the reasons for this is the demand for the fruit. In 1986 the price per kilogram of the fruit was only 3-4 baht, but this rose to 20-30 baht 10 years later. Another reason is its good yield. It was observed that one lang-khae tree yields up to 300 kg, and if the price of the fruit is 20 baht/kg, this means that one tree can give an income of 6,000 baht, which is quite good as the tree does not require much care in the management of pests, diseases, fertilizers etc. Therefore, lang-khae could be developed into an economic fruit tree of Thailand in the future.

4. Luk-nieng (*Archidendron jiringa* Nielson)

The synonyms are *Pithecollobium lobatum* Benth, *Abarema jiringa* Kosterm, and *Pithecollobium jiringa* Plain.

Luk-nieng is one of the common fruit trees of southern Thailand. It may be eaten raw as a vegetable or cooked as a fruit. In Malaysia and Indonesia, this plant is called ‘**jering**’, and it is eaten in a similar way to that of the people of South Thailand. Luk-nieng belongs to the Leguminosae family, sub-family Mimosaceae. It is believed to have originated and is widely distribution in Indonesia, Malaysia and South Thailand.

4.1 General description

Luk-nieng is a tree about 18-24 m tall with a spreading crown. It has a grey stem and one pair of glabrous leaves. The leaf is oblong, stiff and papery with 3-5 flowers, which are borne in a panicle. The calyx is sessile with a white corolla. The filament tube is shorter than the corolla. The pods or fruits are 20-50 cm long, 4-5 cm wide, horseshoe-shaped or twisted, deep purple, deeply lobed along the lower suture, and easily broken by hand. There are 3-6 seeds per pod. The seed is 3-5 cm across with yellow testa when young, which turns brown at maturity. The seed is edible with a strong odour (Figure 3).

The natural habitat of luk-nieng trees is in the forests of humid and mountainous areas, as well as along river banks of southern Thailand. Flowering time of luk-nieng is observed to vary with latitude. In the upper parts of southern Thailand, it is harvested during June and July, whereas in the lower parts, such as Yala and Narathiwat provinces, the fruits can be seen in the local markets during February and March (Bamroongrugs and Yaacob, 1990). In general it takes about 5 months from flowering to fruit maturity.

4.2 Uses

In southern Thailand, luk-nieng is used either as a vegetable or as a fruit. It is always eaten with curry or with any hot food. Young seeds normally taste better than the mature ones. Some people prefer to eat germinating mature seeds. Such seeds are starchy, odourous and crispy, which satisfies many people.

It was reported that djenkolic acid, an amino acid derivative, was found in luk-nieng. Ingestion of this seed causes djenkolism, a symptom that could be developed by the formation of sharp needle-like crystals of djenkolic acid in the kidney or urinary tract. In severe cases, crystals of djenkolic acid have been found in urine (Hijiman and Veen, 1936). Indeed people who are suffering from djenkolism show similar symptoms to those suffering from kidney or urinary stones for which it has been frequently mistaken.

To use luk-nieng as a dessert fruit, a special method for cooking is advised. Djenkolic acid, a toxic substance, is extracted a few times in a mixture of water, wood ash, bamboo leaves and pieces of steel or nails. Local people have used this method for centuries, although it is difficult to explain the function of each substance. The maturing seeds are boiled and the extracts are discarded several times. The seeds are then free from djenkolic acid and can be eaten. The taste of luk-nieng after this extraction is similar to that of beans and it has a high nutritive value. A mixture of fresh coconut endosperm and sugar is added to the cooked luk-nieng for consumption. Cooked luk-nieng in a solution of coconut milk and sugar is also popular in southern Thailand.

It has been reported by the Thai Department of Health that 100 g of edible seed contains: moisture 76.3 g, calorie 92 units, fat 0.2 g; carbohydrate 16.9 g, fibre 1.3 g, protein 6.2 g, calcium 23 mg, phosphorous 38 mg, iron 0.7 mg, vitamin A 658 IU, vitamin B₁ 0.14 mg, vitamin B₂ 0.01 mg, niacin 0.4 mg, and vitamin C 8.0 mg.

4.3 Prospects

Luk-nieng is known and consumed only by the people of southern Thailand, thus it may not have any prospects for being developed commercially due to little demand. Also the toxic effect due to djenkolic acid makes people unfamiliar with luk-nieng reluctant to purchase the fruits. It was observed that young luk-nieng seeds contain less djenkolic acid

than the mature ones. Thus, these seem more suitable for consumption. The toxic effects caused by luk-nieng tend to vary among individuals. Research, therefore, should look into the effects by age, sex and genetic background of the consumers. Selection of clones that have low djenkolic acid is worth investigating. At present, people in southern Thailand also use luk-nieng as a medicinal herb. They believe that it is also able to relieve the symptoms of diabetes.

5. Madan (*Garcinia schomburgkiana* Pierre)

This fruit tree belongs to the Guttiferae family, the same family as the mangosteen. The tree is small to medium in size, but can grow up to 5-10 m under its natural habitat. Madan is considered to be native to the Southeast Asian region. In Thailand it is commonly found growing wild near rivers, streams and swamps in dry evergreen forest, as the tree likes humid conditions and wet soils. It is grown for home uses and no commercial plantation has ever been recorded.

5.1 General description

Dark green leaves are opposite, lanceolate shaped, 9 cm long and 2.5 cm wide. Flowers are borne in clusters. Each cluster contains of 3-6 flowers. Flowers consist of 4 pinkish petals, which are 3 mm wide and 6.5 mm long. Green fruits are ovate to oblong, 5-7 cm long, and 2-3 cm wide. Mature fruits are shiny green.

5.2 Propagation

Madan is found growing wild in the lowland and swampy areas of evergreen forests in Central and Southern Thailand. Villagers in the Central Plain brought them from the forest to grow for home consumption. The trees are propagated from seeds, which are easily germinated. At present, air layering is used as a means of propagation to ensure that a female tree is produced.

5.3 Uses

The young leaf is served as a vegetable accompaniment to many Thai dishes and can be eaten either raw or cooked. The fruit is rich in vitamin A and calcium and is eaten fresh, but has a very sour taste. It can also be used in a sauce of shrimp paste and chilli and eaten with vegetables and fish. When cut into small strips it is included as a side dish in various Thai salads such as salty crab salad. The fruit of madan can be processed to make preserved fruit in syrup, pickled fruit and dried fruit. The fermented fruit is stuffed with minced pork to make a soup, or it can be made into a sweet. The fruit has demulcent properties (Jacquat, 1990). The compositions of madan fruits and young leaves are shown in Table 1 below.

The traditional ethnomedicinal uses of madan's leaves, root and fruit are as an expectorant, treatment of coughs, improvement of menstrual blood quality, treatment of diabetes and as a laxative (Poomipamorn and Kumkong, 1997).

Table 1. Composition of madan fruits and young leaves (Poomipamorn and Kumkong, 1997) (Figures expressed per 100 g of fresh wt)

Components	Fruit	Young leaves
Carbohydrates (g)	6.5	7.3
Protein (g)	0.3	0.3
Fat (g)	0.1	0.1
Fibres (g)	0.4	-
Calcium (mg)	17	103
Phosphorous (mg)	7.0	8.0
Iron (mg)	-	-
Vitamin A (IU) (carotene)	431	225
Vitamin B (mg) (thiamine)	-	0.01
Vitamin B ₂ (mg) (riboflavin)	0.04	0.04
Vitamin B ₅ (mg) (niacin)	-	0.02
Vitamin C (mg)	5.0	16.0

5.4 Prospects

It is difficult to develop madan as an economic fruit crop in Thailand. The fruit has limited use, as it cannot be eaten as fresh fruit due to its sourness. The value of the fruit is more as a vegetable and in cooking. Thus the consumer demand is not big enough for commercial development. However, because of its high nutritive value, attempts should be made to develop ways of processing the fruit such as healthy fruit drink to attract more consumption. At present madan is only regarded as a home garden plant even though it has nutritional and ethnomedical values.

6. Mafai-farang (*Baccaurea motleyana* Muell. Arg)

This fruit tree belongs to the Euphorbiaceae family, the same family as related fruits like lang-khae and mafai. Mafai-farang is a native of Sumatra, Borneo and Java. It is widely cultivated throughout Peninsular Malaysia, Sumatra, Borneo, Java and Bali, and has found its way to neighbouring countries like Thailand and the Philippines.

6.1 Vernacular names

The English name of this fruit tree is **rambai**, which is also the local name for this fruit tree in Indonesia and Malaysia where it originated. In the Philippines, it is known as **rambi**. In Thailand, it is called **mafai-farang** (general), **ramai**, or **lam-khae** (Pattani), and **raa-maa tee-ku** (Narathiwat).

6.2 General description

This is a densely leafy and heavy looking tree and can grow up to 15-25 m tall. The crown is 40 cm in diameter. The twigs, petioles and lower side of leaves are velvety. Leaves are obovate-lanceolate to elliptical shaped and 20-35 × 8-17 cm in size. Petioles

are 3-10 cm long with lanceolate stipules. The inflorescences are ramiflorous, and the male racemes are 13-20 cm long. The yellow flowers contain 2-5 fascicles, 4-5 sepals, and 4-8 stamens. The female racemes are 25-60 cm long, and female flowers are often borne in clusters. The flower has 4-6 sepals. The fruit is 2-4 cm in diameter, usually slightly longer than wide, and is smooth, thinly puberulous and buff-coloured. The fruits hang in communal strings (racemes) from the twigs, main branches and, to a lesser extent, from the upper part of the trunk (Figure 4). A variable number of seeds occur within each fruit enclosed in a translucent white pulp. The pulp varies considerably in its quality, ranging from rather acid to sweet and palatable. The mafia-farang season generally occurs around July-August.

6.3 Propagation

Seed propagation was generally used in the old days. However, as mafia-farang has both male and female trees, air-layering of female tree is recommended to make sure that propagated trees will bear fruit. Budding and grafting on mafia-farang rootstocks are also possible.

6.4 Uses

Mafai-farang is primarily grown for its fruit. The clone that produces sweet and palatable pulp is desirable and selected for propagation. The flesh usually adheres to the seed and both the flesh and seed are often swallowed when eaten. Sweet varieties make a refreshing nibble or table fruit. The juice of any variety may be used to make drinks by sweetening and diluting according to taste and served over ice. Alternatively the fruit may be pickled to serve with curries as is done in Indonesia. The fruit has a low vitamin content of 55 mg vitamin C per 100 g edible portion, low vitamin B₁ (thiamine = 0.03 mg) and vitamin B₂ (riboflavin = 0.09 mg). The fruit also contains 2 mg calcium and 20 mg phosphorous (Anon, 1992). To extract the pulp, the fruit is broken open with the fingers or a small knife. It is then eaten directly after the ejecting seeds (some people often swallow them). Juice is extracted by crushing the pulp in a sieve.

6.5 Prospects

There is little prospect for mafia-farang to become a major fruit tree in Thailand. Although the tree bears fruit abundantly the fresh fruit cannot be eaten in quantity, as this would upset the stomach. Unless a strong demand for the processed products can be generated, there is little chance of mafia-farang being developed commercially.

7. Mafai-jean (*Clausena lansium* Skeels.)

The synonyms are *Quinaria lansium* Lour., *Clausena wampi* (Blanco) Oliv., *Clausena punctata* (Sonn.) Rehder & Wilson, *Cookia punctata* sonn., and *Cookia wampi* Blanco.

7.1 Vernacular names

Wampee (English); **vampi** (French); **wampi**, **wang-pei** (Malaysia); **wampi**, **huampit** (Philippines); **wampoi**, **wang-pei** (Singapore); **kantrop** (Cambodia); **somz mafai** (Laos); **mafai-jean**, **som-mafai** (Thailand); and **hoàng bi**, **giôr** (Viet Nam).

7.2 Origin and distribution

Mafai-jean is native and commonly cultivated in Southern China and North to Central Viet Nam. The tree has been introduced to Southeast Asia, i.e. Cambodia, Indonesia, Laos, Malaysia, the Philippines, Singapore and Thailand. Outside this region it is occasionally grown in India, Sri Lanka, Australia (Queensland), the United States (Hawaii and Florida) and in Central America (de Bruijn, 1991).

7.3 General description

Mafai-jean is in the Rutaceae family. The tree is fairly fast growing. It is a quite attractive looking evergreen tree, which can grow up to 6-12 m tall. It has long, upward-slanting, flexible branches, and a grey-brown bark, which is rough to the touch. Its spirally arranged resinous leaves are 10-30 cm long, pinnate, with 7 to 15 alternate, elliptic or elliptic-ovate leaflets. The leaflets are 7-10 cm long, oblique at the base, wavy margined and with a shallowly toothed edge. They are thin, with minute hairs on the veins of the upper side and with a prominent yellow, warty midrib on the underside. The petiole is also warty and hairy. The sweet scented, whitish to yellow-green flower is subsessile, having 5 sepals about 1.25 cm wide and is borne in slender, hairy panicles 10-50 cm long. The fruit is a subglobose berry that occurs in loose clusters of several strands. It is hung in a showy stalk 0.6-1.25 cm long. The mafia-jean fruit may be round, or conical-oblong, 2.1 cm long with 5 faint, pale ridges extending a short distance down from the apex. The thin, pliable but tough rind is light brownish-yellow, minutely hairy and dotted with tiny, raised, brown oil glands. The rind is easily peeled but is too resinous to be eaten. The flesh, faintly divided into 5 segments, is yellowish-white or colourless, grapelike, mucilaginous, juicy, pleasantly sweet, and subacid or sour depending on the variety. Within a fruit, there may be 1-5 oblong, thickish seeds 1.25-1.6 cm long. The seeds are bright green with one brown tip.

7.4 Ecology

Mafai-jean needs a sub-tropical to tropical climate. It survives short slight frosts (-2°C) but trees have been killed at temperatures of -6°C and lower (Morton, 1987). They seem to tolerate a range of soils including the deep sand and oolitic limestone derived soils, but thrive best in rich loams. It requires watering in dry periods, though good drainage is essential. In general mafia-jean requires conditions similar to those for citrus trees.

7.5 Propagation and cultivation

Mafai-jean can be propagated by seed or vegetatively propagated by softwood cuttings, or air layering and can be veneer-grafted on mafia-jean seedlings. Germination occurs in a few days. Most propagation by softwood cuttings has been successful. Desirable clones can be grafted on mafia-jean seedlings at any time of the year. Grafting trials on various citrus rootstocks in Florida have shown various degrees of incompatibility and few, if any, can be said to have been really successful in the long run.

Pruning is recommended to avoid overcrowding of the branches. On limestone soils, mafia-jean is subject to chlorosis, which can be overcome by the application of manganese, zinc, manure and mulch. Well-developed mature trees can produce up to 45 kg of fruit per season.

In Thailand mafia-jean fruits mature from May-July, and can be only seen in some local markets.

7.6 Uses

A fully ripe, peeled mafia-jean of the sweet or subacid type can be eaten fresh after discarding the large seed or seeds. The seeded pulp can be added to fruit cups, gelatins or other desserts, or made into pie or jam. Jelly can only be made from the acid types when under ripe. The Chinese serve the seeded fruits with meat dishes.

In Viet Nam, fermenting the fruit with sugar and straining off the juice makes a bottled, carbonated beverage resembling champagne. The fruit is reported to contain 28.8–29.2 mg ascorbic acid per g of edible portion.

7.7 Traditional medicines

The fruit is said to have stomachic and cooling effects and to act as a vermifuge. The Chinese say that if one has eaten too many lychees, eating mafia-jean will counteract the bad effects.

The halved, sun dried, immature fruit is a Viet Nameese and Chinese remedy for bronchitis. Thin slices of the dried roots are sold in oriental pharmacies for the same purpose. The leaf decoction is used as a hair wash to remove dandruff and preserve the colour of the hair.

7.8 Prospects

Mafai-jean is easy to propagate and grow. Few disease problems have been encountered so far and the yield is fair. It is only known and grown on a very small-scale or as home garden fruit in Nan province, northern Thailand. However, the agricultural importance and the possibilities for canning the fruits as well as the plant's pharmaceutical properties are worthy of further study.

8. Ma-khaam pom (*Phyllanthus emblica* Linn.)

The synonym of this species is *Emblica officinalis* Gaertner.

Ma-khaam pom belongs to the Euphorbiaceae family. It is indigenous to tropical Southeast Asia, including Thailand. It is commonly cultivated in home gardens in India, Malaysia, Singapore and southern China. In India, and to a lesser extent in Thailand and Malaysia, ma-khaam pom fruit is important and esteemed, fresh as well as preserved, and it is prominent in traditional medicine. Fruits are gathered for home use and for market (Figure 5).

8.1 Vernacular names

Emblie myrabolan, Malacca tree and Indian gooseberry (English); **kan-tot, kam lam or kam lam ko** (Cambodia); **melaka, asam melaka or amlaka** (Malaysia); **mak-kham-pom** (Laos); **bong-ngot, chu-me** (Viet Nam); **neli** (Philippines); **ma-khaam**

pom (Thailand in general), **kan-tot** (Chanthaburi), **kam-thuat** (Ratchaburi), **mang-luu** and **san-yaa-saa** (Karen-Mae Hong Son).

8.2 General description

The ma-khaam pom tree is hardy, normally reaching a height of 18 m, and in some instances up to 30 m. The tree is many-branched with leaves that are distichously arranged on the slender branchlets so as to resemble pinnate leaves. Its fairly smooth bark is a pale greyish-brown and peels off in thin flakes like that of the guava. While actually deciduous, shedding its branchlets as well as its leaves, it is seldom entirely bare and is therefore often cited as an evergreen. The miniature leaf is linear-oblong, about 3 mm wide and 1.25-2.0 cm long. It is distichously disposed on very slender branchlets, which gives a misleading impression of finely pinnate foliage. The yellow flower is small with a short pedicel and occurs in fascicles, which are borne from the axils of the lower end of a growing branchlet, with the female flowers above them. But occasionally the trees are dioecious. The flower consists of 5-6 sepals, 3 stamens and connated filaments. The nearly stemless fruit is round or oblate, indented at the base, and smooth, although 6 to 8 pale lines, sometimes faintly evident as ridges extending from the base to the apex, give it the appearance of being divided into segments or lobes. The fruit is light green at first and becomes whitish or a dull, greenish-yellow or, more rarely, brick-red as it matures. It is hard and unyielding to the touch. The fruit skin is thin, translucent and adherent to the very crisp, juicy, concolorous flesh. A slightly hexagonal stone containing 6 small seeds is tightly embedded in the centre of the flesh.

8.3 Ecology

Ma-khaam pom can be regarded as a sub-tropical rather than a strictly tropical plant. In Thailand it flourishes from sea level up to an altitude of 1,500 m. The trees were planted at the Royal Ang Khang Station at an elevation of 1,400 m, and gave a good yield after 10 years. They showed a remarkable ability to tolerate cold winter months. Ma-khaam pom is also found growing wild in mixed forests in Central and South Thailand.

Ma-khamm pom seems to grow equally well under both arid and humid conditions (Morton, 1987). It is rather tolerant and can be grown in a wide range of soils, including alkaline soil. Ma-khamm pom is reported to thrive in regions too dry and on soil too poor for most other fruit crops (Morton, 1987). For maximum productivity, the tree requires deep soil ranging from sandy loam to clay, light or heavy, and slightly acidic to slightly alkaline. In a highly alkaline soil (pH 8.0) nutritional deficiencies are evident. Good drainage is essential for good growth.

8.4 Propagation

Ma-khaam pom is often propagated by seeds taken from over-ripe fruits, which are sun dried to facilitate removal of the stone, or cut in half right through the stone. The extracted seeds are given the float test and 100 percent of those that sink will germinate. In 4 months, seedlings will have a stem diameter of 8 mm and can be budded or grafted. The Forkert and patch graft gave 85-100 percent success. Chip-budding, using seedlings 1½ years old as rootstock, is easier and was 60-80 percent successful (Morton, 1987). Inarching is sometimes practiced in India but survival rate may be only 25 to 30 percent after separation from the stock and further losses may occur in the field (Ghosh, 1997).

Seedling trees normally take about 10 years to bearing, whereas budded and grafted plants start to bear after 6-7 years. A full grown tree of 10-15 years was reported to yield about 200 kg of fruit per year (Ghosh, 1997).

8.5 Cultural practices

No research work is reported on the cultural practices of ma-khaam pom in Thailand, as the plant does not have economic value. However, a report from India recommended that the trees be spaced 9-12 m apart and planted in well-prepared holes enriched with a composted manure and soil mixture and well-watered (Morton, 1987). Thereafter, watering is done only in the dry season.

There are no standard practices for fertilizer application in ma-khaam pom, but 28-42 g of nitrogen per tree for each year of its age up to 10 years has been suggested in India. After 10 years the nitrogen is increased and potash and superphosphate are added. Half of the fertilizer should be given after fruit set and the other half 4 months later. Ma-khaam pom branches are brittle and judicious pruning to develop a strong framework is advocated to avoid branch breakage from heavy loads of fruit.

Generally, harvesting is done by shaking the branches allowing the fruits that are ready to fall so that they may be gathered from the ground. The fruits stand handling well. The yield varies a great deal as many young fruits are shed throughout the period of fruit development, and there is considerable difference in the productivity of seedlings and cultivars.

8.6 Uses

- i. Food uses. Ma-khaam pom fruit is one of the richest sources of natural ascorbic acid (Vitamin C). The fruit is widely used by local Thais to quench the thirst when walking in the forest. In China, phyllanthus drink prepared from fruit extract is commonly known, and wine made from fruit extract is seen in the market. Many Hindus regard ma-khaam pom as sacred and the Hindu religion prescribes that ripe fruit be eaten for 40 days after a fast in order to restore health and vitality. It is a common practice for Indian housewives to cook the fruits with sugar and saffron and give one or two to a child every morning

Fresh fruits are baked in tarts, added to other foods as seasoning during cooking and the juice is used to flavour vinegar. Both ripe and half-ripe fruits are candied whole and also made into jam and other preserves, pickles and relishes. They are combined with other fruits in making chutney. In Indonesia, fresh ma-khaam pom is added to impart acidity to many dishes, and is often used as a substitute for tamarind.

- ii. Nutritional value. The food value per 100 g of edible portion of ma-khaam pom fruit as reported by the Finlay Institute Laboratory, Havana, consisted of moisture 77.1 g, protein 0.07 g, fat 0.2 g, carbohydrates 21.8 g, fibre 1.9 g, ash 0.5 g, calcium 12.5 mg, phosphorous 26.0 mg, iron 0.48 mg, carotene 0.01 mg, thiamine

0.03 mg, riboflavin 0.05 mg, niacin 0.18 mg, tryptophan 3.0 mg, methionine 2.0 mg, lysine 17.0 mg and ascorbic acid 625 mg.

The ascorbic acid in ma-khaam pom fruit is considered highly stable, apparently protected by tannins (or leucoanthocyanins), which retard oxidation. Biochemical studies at the Central Drug Research Institute, Lucknow, India, show 13 tannins plus 3 or 4 colloidal complexes. In juice extracted from fresh fruits, the ascorbic acid was found to be stable for at least a week. Fresh juice stored at 2°C loses only 14 percent ascorbic acid after 458 days. Only 30 percent was lost to evaporation over an open flame at 65°C, but the product loses 40 percent during a week in a refrigerator and 100 percent after 20 days (Morton, 1987).

iii. Other uses.

Medicinal uses. Ma-khaam pom is of great importance in traditional Asiatic medicine, not only as an antiscorbutic, but also in the treatment of diverse ailments, especially those associated with the digestive organs. In Thailand ma-khaam pom fruits are traditionally used as an expectorant, antipyretic, diuretic, antidiarrhoeal and antiscurvy (Saralamp, 1992).

Wood. The hard but flexible red wood, though highly subject to warping and splitting, is used for minor construction, furniture, implements, gunstocks, hookahs and ordinary pipes. Durable when submerged and believed to clarify water, it is utilized for crude aqueducts and inner braces for wells. Branches and chips of the wood are thrown into muddy streams for clarification and to give a pleasant flavour. The wood is also used as fuel and as a source of charcoal by villagers.

Leaves and bark. The foliage can be used as fodder for cattle and branches are lopped for green manure. They are said to correct excessively alkaline soils. The tannin-rich bark, as well as the fruit and leaves, are highly valued and widely employed in conjunction with other so-called myrobalans, especially fruits of various species of *Terminalia*. The twig bark is particularly esteemed for tanning leather and is often used with leaves of *Carissa spinarum* A.DC. and *Anogeissus latifolia* Wall.

8.7 Prospects

Ma-khaam pom can be utilized in many ways, yet the future prospects for this fruit tree in Thailand are not bright. No established orchard of ma-khaam pom is known nor is there any germplasm collection for good fruit characteristics. The study of this fruit tree in Thailand will only be attractive when its overseas market value is known. At present it is still regarded as a neglected fruit crop and can only be found in its natural habitat of mixed forests throughout the country.

9. Ma-kiang (*Cleistocalyx operculatus* var. *paniala*)

Ma-kiang is a perennial tree belonging to the Myrtaceae family. Its original habitat is unknown, and the tree was introduced into Thailand long time ago. At present, it is found growing in scatter locations in some villages of the northern provinces of Thailand such as Chiang Rai, Chiang Mai, Lamphun, Lampang and Mae Hong Son. The synonym is *Eugenia paniala* Roxb. (Smitinand, 1980), which was used in some old texts. However following the report of Chantaranothai (1989), ma-kiang is classified in the genus *Cleistocalyx* and is the only species that is cultivated in Thailand. The other two related species found in Thailand are *Cleistocalyx khaoyaiensis* and *Cleistocalyx phengklaii* (Chantaranothai and Parnel, 1990).

9.1 General description

Ma-kiang is a medium to large tree, which can attain the height of 20 m. However, the average tree is 10-15 m high, with 8-12 m canopy diameter. It has many branches, with grey or brownish grey bark. The trunk is rather smooth with a thin bark, which is easily stripped. Simple leaves are opposite, elliptic-cordate to obovate-oblong, and 8-10 × 20-25 cm in size. The upper side is shiny, and dark green in colour. The veins are clearly seen and within each leaf there are 10-13 pairs of veins. The purplish-red petiole is 2-3 cm long. The pale yellow inflorescence is a compound cyme, and is born on the lateral branch. The inflorescence is 10-13 cm long with a 8-10 cm stalk. In each inflorescence there are an average of 30-40 flowers, and the flower stalk is 3-4 cm long. The flower is perfect, having a diameter of 0.7-0.8 cm with 4 yellow petals about 4.0-4.5 mm at full bloom with 1.0-1.2 cm diameter. There are numerous stamens (about 200-250) and 1 pistil 6.0-7.5 mm long. The fruit is a fleshy berry, white fleshed and juicy, and bruises easily. It is ellipsoid, 1.5-1.8 cm long and 0.9-1.2 cm in diameter (Figure 6). The young fruit is green in colour and its flesh is sour and astringent. At ripening, the fruit skin becomes red to purplish red, is still sour, but the astringency disappears. It has a strong odour. Very ripe fruit is purplish black. The fruit weighs about 1.4-2.4 g. The seed is rather big compared to the size of the fruit. It has an oval shape of 0.7-0.8 cm diameter and is 0.8-1.0 cm long. The fully ripe fruit contains a seed weighing 0.4-0.5 g. The seed loses viability quickly, and should be germinated soon after harvesting.

In Thailand ma-kiang flowers from February-March and the fruits ripen from July-August.

9.2 Uses

Ma-kiang fruit is sour and slightly astringent with scant smell. Local Thais consume it as fresh and prickled fruit. At present there is no cultivation at orchard scale, as it is only found growing in some villages. Currently, it has value in making fruit drink, wine, jam and nectar. These products may become better known in Thai market in the future, as ma-kiang fruit is rich in vitamins and minerals necessary for health.

The nutritional value per 100 g of edible portion of ma-kiang is reported as: moisture 78-92.5 percent; protein 0.56-1.73 percent; fat 0.15-0.71 percent; fibre 2.30-8.24 percent; ash 0.33-1.15 percent; carbohydrates 4.77-14.75 percent; total sugar 0.09-7.32 percent; energy 23.7-64.5 kilocalories; calcium 22.2-135.1 mg; magnesium 4.89-25.4 mg; iron 0.16-1.11 mg; zinc 0.10-0.90 mg; vitamin B₁ 15.6 µg; vitamin B₂ 33.3 µg; vitamin C

14.6 mg; β -carotene 34.3-2115.1 IU. Apart from the above nutritional values, the following amino acids have been analysed from 100 g of edible flesh.

Aspartic acid	38.1 – 130.2	mg
Treonine	17.9 – 63.4	mg
Serine	21.9 – 76.1	mg
Glutamic acid	46.1 – 165.0	mg
Proline	18.8 – 41.0	mg
Glycine	20.8 – 72.7	mg
Alanine	23.7 – 77.1	mg
Valine	19.0 – 68.4	mg
Cystine	8.1 – 31.0	mg
Methionine	5.1 – 17.2	mg
Isoleucine	13.9 – 52.5	mg
Leucine	30.5 – 109.0	mg
Tyrosine	7.7 – 28.9	mg
Phenylalanine	28.6 – 144.9	mg
Histidine	9.2 – 33.9	mg
Lycine	27.2 – 90.5	mg
Arginine	14.4 – 75.1	mg
Thryptophan	5.9 – 14.6	mg

9.3 Prospects

The prospect of cultivating ma-kiang for consumption as fresh fruit is negligible. The only chance of growing ma-kiang is for processing either as a fruit juice or for making wine. Consumer promotion of this highly nutritious fruit is needed to create demand together with research on cultivation and clonal selection. Otherwise this fruit tree will be left growing wild in remote villages as is seen at the present time.

10. Makok-farang (*Spondias cytherea* Sonn.)

Makok-farang belongs to the Anacardiaceae family, the same family as the mangoes. The plant is native throughout South and Southeast Asia and has spread throughout the tropics. Makok-farang is also an important fruit tree in some Pacific Island countries such as Samoa. It is fairly common in Thailand and found growing mainly as individual trees in rural areas and home gardens.

10.1 Vernacular names

Great hog plum, otaheite apple, ambarella (English); **kedondong manis** (Indonesia); **kedondong** (Malaysia); **hevi** (Philippines); **gway** (Myanmar); **mokak** (Cambodia); **kook hvaan** (Laos); **makok-farang** (Thailand); and **cóc** (Viet Nam).

10.2 General description

Makok-farang is a fast growing tree, which can grow up to a height of 10-20 m. It can bear fruit within 4 years from seed, and fruits all the year round. In the humid tropics like Thailand, the tree produces more or less continuously, following flushing and flowering of individual twigs. In a monsoon climate, flowering is concentrated in the dry

season while the trees are more or less leafless. The fruit matures 6-8 months after flowering. The flowers are perfect, and are tiny and greenish white in colour. They are grouped together as a panicle. The fruits are bright green and turn yellowish with a lot of greyish brown freckles when ripe. Each fruit is about 7.5-10 cm long by 2.5-3.7 wide (Figure 7). It is eaten fresh or pickled. The flesh is white and crunchy when immature and becomes fibrous on ripening. Inside each fruit is a large fibrous seed.

Makok-farang grows well in the tropics, but it can also be grown in warm subtropical areas. The tree is slightly less hardy than the mango. In the tropics it is commonly found growing in areas from sea level up to 700 m altitude. To be productive, the tree requires much light, as shaded trees produce little or no fruits. Sheltered locations are advised as the brittle branches can break easily. The trees are drought-tolerant, and under stress they may briefly lose their leaves. Makok-farang can grow on limestone derived soils as well as on acid sands, but the soil should be well drained.

10.3 Propagation

In Thailand, makok-farang is commonly propagated from seed. The seed germinates within one month. However, clonal propagation of superior trees is beginning to gain more recognition and the method is not difficult. It is reported that large stumps are stuck in the ground to obtain live fence posts, and cuttings as well as air layers root easily. Grafting or shield budding on *Spondias* rootstocks is also possible, however seedling trees are more vigorous than budded or grafted trees.

10.4 Properties and uses

Fruit of the best forms is eaten raw. When green the fruit is crisp and subacid. As the fruit ripens to a yellow colour, the flesh softens; the flavour changes and the fibres become more noticeable. The fruit flesh is a good source of vitamin C and iron. When unripe it contains about 10 percent pectin. One hundred g of fresh fruit contains 0.8 g protein, 11.1 g carbohydrate, 1.2 g or crude fibre and 0.6 g ash. The nutritional value is 20 mg calcium, 2 mg phosphorous and 1.2 g of iron as well as 1382 IU of vitamin A, 70 mg vitamin C, 0.4 mg niacin, 0.02 mg riboflavin and 0.06 mg thiamine (Anon, 1992).

Most ripe fruit is stewed and used for jams, jellies and juices. Boiled and dried fruit can be kept for several months. Young steamed leaves are eaten as a vegetable. The wood is light brown and buoyant, and has no value for timber. There are diverse medicinal uses of fruits, leaves and bark in different parts of the world. The treatment of wounds, sores and burns is reported from several countries.

10.5 Prospects

In Thailand, makok-farang has a little chance of being developed on a commercial scale. This is due to very limited demand for the fruit. Being subacid in taste, the fruit does not agree with Asian taste, which prefers rather sweet and juicy fruits. Unless the other forms of processed makok-farang fruits are developed to suit the market, this fruit tree only has value as a home garden plant.

11. **Ma-kruut (*Citrus hystrix* D.C.)**

Ma-kruut belongs to the Rutaceae family. It is very common in every Thai household as an ingredient for many Thai dishes. In fact, the famous dish “Tom Yum Kung” dish derives its strong flavour from ma-kruut leaves and peel.

The origin of ma-kruut is not known, but it is widely naturalized in Thailand, Sri Lanka and Myanmar. Interestingly, people in these countries are mainly Buddhists; hence there might be some traditional link between the uses of ma-kruut and the cultures of these people.

11.1 Vernacular names

Mauritius papeda, **leech lime** (English); **citron combera** (French); **jeruk purut**, **limo purut** (Indonesia); **limau purut** (Malaysia); **kabuyau**, **kulubut** (Tagalog), **kolobot** (Bisaya), (Philippines); **shouk-pote** (Myanmar); **krauch soeuch** (Cambodia); **khi-hout** (Laos); **ma-kruut** (Thailand); and **trúc** (Viet Nam).

11.2 General description

Ma-kruut is a small tree about 1-2 m high, but can grow up to 12 m tall if left unattended. The tree has a crooked trunk and short stiff spines. The leaves are broadly ovate to ovate-oblong 3-15 × 2-6 cm in size. The white flowers are small with good fragrance. The fruit is an ovoid to ellipsoidal berry, 5-7 cm in diameter, and is green to yellow in colour (Figure 8). The shape of the fruit is irregular and the skin is very bumpy with 10-12 segments.

11.3 Uses

Ma-kruut leaves and fruit skin are used in many Thai dishes. The juice of the fruit is used for seasoning and to prepare drinks. Extracts from the skin as well as juice are used as an insecticide for washing the head and treating the feet to kill land leeches. Leaves are commonly used to season food in Thailand and other neighbouring countries.

11.4 Prospects

Ma-kruut has many roles in Thai everyday life, but its commercial plantation has not developed. At present the trees are grown in home gardens for home use. In some districts, they are found growing in mixed orchards as a minor plant. Ma-kruut is easily grown and does not seem to have any problem in production, so there are has been no research on this plant. It may take a long time for ma-kruut to be brought into orchard plantation unless processing factories are developed that use ma-kruut as raw material.

12. Maphuut (*Garcinia dulcis* Kurz.)

Maphuut is in the Guttiferae family. It is believed to be a native plant of the Philippines and Indonesia (Jansen, 1991). Maphuut is also found cultivated as a home garden plant in Thailand and other Southeast Asian countries. The fruit is occasionally sold in the local markets of Thailand, but no commercial plantation is known.

12.1 Vernacular names

No English name is known for this tree. **Mundu** (Indonesia and Malaysia); **baniti** (Tagalog), **bagalot** (Bisaya) and **buneg** (Ilokano), (Philippines); and **maphuut** (Thailand).

12.2 General description

Maphuut is a medium sized tree 5-20 m high. The tree has a short trunk and brown bark with white latex. On exposure to air the latex turns pale brown. The latex in the fruit is yellow, the same as that of mangosteen. The leaves are opposite, lanceolate shaped, 10-30 cm long and 3-15 cm wide. The leaf is pale green when young and becomes dark green and shiny on the upper surface at maturity. The lower leaf surface is often hairy. The midrib is prominent with numerous veinlets arranged in parallel. The thick petiole is short being only 2 cm long. Flowers are borne in the axil. They are yellowish white with a sour smell. Male flowers are very small, about 6 mm. wide. They are borne in small clusters. Female flowers are larger, 12 mm wide, and with a 1.5-3.0 cm long pedicel. The stigma is 5-lobed. Fruits are globose, 5-8 cm wide with slightly pointed ends, often rather compressed and crowned by the persistent stigma. The fruit is soft with a thin skin and has a light yellow colour, which turns to orange when ripe (Figure 9). The seeds are enveloped in an edible pulp of a darker colour than the skin and have a pleasant taste. One fruit contains 1-5 brown seeds about 2.5 cm long.

12.3 Propagation

Seed germination is commonly used as a propagating means at the present time. Other means of vegetative propagation may be introduced when this fruit tree becomes more economically recognized.

12.4 Uses

The fruits can be eaten fresh, but they are sour and can be made into an excellent jam. The fruits contain high phosphorous and carbohydrate as shown in Table 2.

Table 2. Composition of Maphuut fruits (data expressed per 100 g. fresh weight) (Poomipamorn and Kumkong, 1997)

Carbohydrates (g)	12.2
Protein (g)	0.4
Fat (g)	0.5
Fibres (g)	1.0
Calcium (mg)	5.0
Phosphorous (mg)	13.0
Iron (mg)	0.4
Vitamin A (carotene) (IU)	42.0
Vitamin B (thiamine) (mg)	0.06
Vitamin B ₂ (riboflavin) (mg)	0.04
Vitamin B ₅ (niacin) (mg)	0.3
Vitamin C (mg)	5.0

The traditional ethnomedical uses of maphuut in Thailand are as follows. The crushed extract of maphuut's fruit is used as a relief expectorant, for coughs, and scurvy. The crushed extract from the root is used for the relief of fever, and to reduce poisoning and detoxification. The crushed extract from the bark is used for cleaning wounds (Subchareon, 1997). In Java and Singapore pounded seeds are applied to cure swellings. In Java the bark is used to dye mats.

12.5 Prospects

It is very difficult to develop maphuut for economic purposes. The fresh fruit is not delicious, and methods of processing the fruit require research. At present the only value of maphuut may be for ethnomedicinal uses.

13. Matoom (*Aegle marmelos* (L.) Correa)

Matoom belongs to the Rutaceae family. It is believed to have originated in the Indian Peninsula, Sri Lanka, Pakistan and Bangladesh (Sunarto, 1991). Matoom is a tree that is related to religion and it is particularly found in temple grounds in India. The species has spread to Indo-China and Southeast Asia, particularly Thailand and northern Malaysia. In Thailand, it is commonly found growing in many Buddhist temples as its dried, sliced fruit is boiled with water and used as a popular drink for monks.

13.1 Vernacular names

The English names are **bael** or **bel fruit**. **Bel indien** (French); **maja**, **maja batu** (Indonesia); **bilak bila**, **bel** (Malaysia); **bael** (Philippines); **opesheet**, **okshit** (Myanmar); **bnau** (Cambodia); **toam** (Laos); **matoom**, **tom**, **ma pin** (Thailand); and **traï man** (Viet Nam).

13.2 General description

Matoom is a small to medium deciduous tree and can grow up to 10-15 m in height with a 25-50 cm in diameter trunk. Old branches and stems are covered with sharp spines. The spines occur in singly or in pairs and are 1-2 cm long. The bark is greyish brown. Leaves are alternately arranged in a trifoliate pattern with 2-4 cm long petioles. The lateral petioles are up to 15 mm long. The lateral leaflets are ovate to elliptic, and up to 7 × 4.2 cm in size. The terminal leaflets are obovate, and up to 7.5 × 4.8 cm in size. The inflorescences are 4-5 cm long, are borne on the axillary racemes, and occur in clusters. The 1.5 mm long sepals are broadly deltoid. The greenish to white petals are oblong-ovate, and 14 × 8 mm in size. The white stamens occur in a group of 35-45, with 4-7 mm long filaments. The ovary is 8 × 4 mm in size with very short style. The fruit is a subglobose berry 5-12.5 cm in diameter with a hard woody shell. Inside the fruit, there are 8-16 (-20) segments, with 6-0 seeds in a clear, sticky, edible yellow pulp. At ripening the pulp contains scented mucilage, which has a sweet taste. The seeds are woolly-pubescent and are enclosed in a sac of adhesive mucilage, which solidifies on drying. The testa is white. In Thailand matoom trees flower from December-March.

13.3 Ecology and husbandry

Matoom is a hardy, deciduous tree of the tropics and sub-tropics. It can grow under harsh conditions, including extremes of temperature in India. In Thailand, it only flowers and fruits well where there is a prominent dry season. The tree can tolerate alkaline soil.

Matoom is usually propagated by seeds. It can be propagated vegetatively by root suckers, or through budding on seedling stocks. Vegetatively propagated plants bear fruit after 5 years and full bearing can be attained in about 15 years. The fruit ripens in the dry season when most leaves have been shed in anticipation of bloom for the next crop. Harvesting is done by picking individual fruits, which should not be allowed to drop. The fruit is packed in baskets, gunny bags or wooden boxes. Cracked fruit is rejected, as it is susceptible to fungal infection.

The matoom tree does not need special care in cultivation. No fertilizer recommendation is reported, as the tree can tolerate even poor soil. Also no serious pests and diseases have been reported.

13.4 Uses

The yellow or orange pulp is soft, very fragrant and pleasantly flavoured. The edible portion, i.e. the pulp, comprises 56-77 percent of the fruit and its composition per 100 g includes: water 61.5 g, protein 1.8 g, fat 0.39 g, carbohydrates 31.8 g, ash 1.7 g, carotene 55 mg, thiamine 0.13 mg, riboflavin 1.19 mg, niacin 1.1 mg and vitamin C 8 mg. The fruit rind is rich in tannin. Marmelosine (C₁₃H₁₂O₃), volatile oil, limonene, alkaloids, coumarines and steroids are also present in different parts of the tree

Ripe fruit is eaten fresh and is also prepared as sherbet, syrup, marmalade and fruit nectar. The mucilage around unripe seeds is used as an adhesive and household glue. Ripe fruit extract is used against rectum inflammation. The rind of unripe fruit can be used as a yellow dye and as a tanning agent.

13.5 Prospects

The prospects of matoom are dependent on the utilization. Since the pulp from ripe fruit turns brown and develops off-putting flavours during extraction and processing, ripe can only be consumed fresh, and green fruit has to be used to make preserves. New processing techniques can preserve the quality of pulp from ripe fruits. As the soluble solids content of the pulp is 28-36 percent, about twice as high as in most other fruits, a wide range of processed products from matoom would be feasible. If the product can find a market, the expansion of cultivation and research into selection and breeding of cultivars of high yielding and good fruit quality would follow.

14. Mayom (*Phyllanthus acidus* (L.) skeels)

This fruit tree is in the Euphorbiaceae family. It is commonly seen in home gardens throughout Thailand. Its origin may have been Madagascar, but it is now naturalized and cultivated pan tropically in Thailand and some other Southeast Asian countries.

14.1 Vernacular names

The English name is **star-gooseberry**. **Ceremoi, cereme, cerme** (Indonesia); **chermai** (Malaysia); **iba** (Tagalog), **bangkiling** (Bisaya), **karmay** (Ilokano) (Philippines); **thinbozihpyoo** (Myanmar); **kântûet** (Cambodia); **nhôm baanz** (Laos), **mayom** (Thailand); and **chùm ruôt** (Viet Nam).

14.2 General description

Mayom is a small tree or shrub that can grow up to 2-9 m tall. Leaves are ovate, 2-7 cm long, and arranged like a pinnate leaf along the branches. Flowers are borne in clusters composed of male, female or hermaphrodite flowers. The flowers have 4 to numerous rosy petals, arranged in panicles up to 12 cm long. The fruit is a globose drupe with 6-8 lobes and is 1-2.5 cm in diameter. It is yellow-white in colour (Figure 10). The fruit is very sour. There are 4-6 seeds in a fruit. Mayom can be grown in any part of Thailand, but the tree prefers growing in moist sites.

14.3 Propagation

Mayom is usually propagated by seeds. The seedlings grow rapidly and bear fruits within 2-3 years. Budding and stem cutting can be used as another means of vegetative propagation.

14.4 Uses

Due to its sour taste, the fruit is mainly used for cooking, although pickled fruit with sugar and chilli is well known dish for Thais and is sold in local markets. The nutritive values of mayom fruit (per 100 g edible portion) are 28 k cal of energy, 91.7 g moisture, 0.7 g protein, 6.4 g carbohydrate, 0.6 g crude fibre, 5 mg calcium, 23 mg phosphorous, 0.4 mg iron, 0.01 mg thiamin, 0.05 mg riboflavin and 8 mg vitamin C (Anon, 1992).

The traditional ethnomedical uses of mayom are reported as using the extract from the root to cure skin diseases especially relief from itching. Leaves are used as one of the ingredients in Thai medicine to control fever.

14.5 Prospects

There is very little prospect for mayom to be recognized as a commercially economic fruit of Thailand. The demand for the fruit, even in the local market, is small as many villagers in rural areas grow this fruit tree for their own use and consumption.

15. Ngoh khon san (*Nephelium mutabile* Blume)

The synonym of this species is *Nephelium ramboutan-ake* (labill.) Leenh.

15.1 General description

The ngoh khon san belongs to the Sapindaceae family, the same family as rambutan, longan and lychee. It is similar to rambutan in tree form and foliage, but the main distinguishing characteristics are: the tree is smaller, 10 to 15 m high, leaflets are narrower, form (branches) is more open and there is less fruit on the panicle. In the fruit the pericarp is thicker, and is usually dull red with spines or tubercles, which are very much shorter (Figure 11). The aril is usually white and the taste is quite sweet. The aril clings to the seed and accounts for around 35 to 45 percent of total fruit weight. The fruit size range is 40 to 70 mm long and 40 to 60 mm in diameter. In Thailand, the fruiting season of ngoh khon san is from late April to May.

Ngoh khon san is a species that closely resembles rambutan (*N. lappaceum*). The spines on the fruits are usually short and stubby in ngoh khon san whereas in rambutan the spines are long filiform. In southern Thailand and Malaysia, ngoh khon san is found mostly in lowland primary forests, often on river banks but rarely in swamps, and usually on sand or clay soils.

Ngoh khon san is indigenous to Myanmar, Indonesia, Malaysia, Thailand and the Philippines and is cultivated in Malaysia. There are some ngoh khon san clones developed in Malaysia such as P6 and P26 with a few good local selections from Sabah (Van Welzen *et al.*, 1988).

15.2 Vernacular names

The English name is **pulasan**. **Kapulasan** (Indonesia); **pulasan** (Peninsular), **meritam** (Sabah, Sarawak), (Malaysia); **bulala** (Philippines); and **ngoh khon san** (Thailand).

15.3 Uses

The fruit of ngoh khon san is sweet and appreciated by the local people of Malaysia, Indonesia and southern Thailand. The edible sarcotesta is thinner and less sweet than the rambutan, and it often adheres tightly to the seed kernel.

The fruit of ngoh khon san contains per 100 g edible portion: water 85 g, protein 0.8 g, fat 0.6 g, carbohydrates 13 g, fibre 0.1 g and ash 0.4 g.

15.4 Prospects

Being overshadowed by good rambutan cultivars, ngoh khon san has little prospect of being developed for commercial plantation in Thailand. The tree stands as good genetic sources in breeding and selection within the species or crossing with its relative the rambutan. However, the possibility of using ngoh khon san as rootstock for rambutan has not been investigated.

16. Noi nong (*Annona reticulata* L.)

Noi Nong is a member of the Annonas group and belongs to the Annonaceae family. In Thailand, it is less popular than its relative, the sugar apple (*A. squamosa* L.), which is grown commercially. Noi nong is a native of the West Indies and was introduced into Asian countries many centuries ago. It is occasionally found growing in the home gardens in Thailand. It is also found growing in Malaysia and the Philippines.

16.1 Vernacular names

The English names are **custard apple** and **bullock's heart**. **Coeur de boeuf** (French); **buah nona** (Malay), **kanowa** (Java), **serba rabsa** (Aceh), (Indonesia); **nona**, **nona kapri**, **lonang** (Malaysia); **sarikaya** (Philippines); **mo bat**, **mean bat** (Cambodia); **khan tua lot** (Laos); **noi nong** (Central), **noi nang** (South), **manong** (North), (Thailand); and **binh bat**, **qua nam máng cáu dai** (Viet Nam).

16.2 General description

Noi nong is a medium sized tree and is slightly taller than the sugar apple. The tree can grow up to 8-10 m tall and has an erect habit with trunk diameter of 35 cm. The tree sometimes sheds its leaves and behaves like a semi-deciduous tree, especially when it is grown in dry summer areas. Flowers are produced in clusters. The mature fruit is heart shaped and sometimes oval or conical. The fruit of noi nong is slightly larger than that of the sugar apple. The weight of a fruit ranges from 0.1-1.2 kg. It takes longer to mature as compared to that of the sugar apple. The surface of the fruit is smooth with hexagonal lines appearing in a reticulated manner. The colour of the fruit skin is yellow-brown and reddish brown. The cream-white flesh, like the other Annonas, is pulpy and contains numerous brown seeds. The flesh does not taste as good as the others, lacking flavour, so it is not so popular on the local market.

16.3 Ecology

Noi nong needs a tropical climate for good growth, but it can survive in sub-tropical conditions. It is less drought-tolerant than the sugar apple and prefers a humid atmosphere. In Thailand it has been grown as a mixed home garden plants along with big trees like mango, ma-praang, coconut etc. At present, it is normally propagated by seeds, but grafting and budding onto other Annona seedlings are known to be successful.

16.4 Uses

The fruits are eaten fresh or prepared as juices, ice-cream, puddings etc. The leaves are employed in tanning and also yield a blue or black dye. Young twigs provide good fibre. The yellow wood is soft, fibrous but durable, and is used to make utensils. Ethnomedically, the leaves are used internally against worms, and externally to treat abscesses. Unripe fruits and the bark are used to treat diarrhoea and dysentery. The seeds, leaves and young fruits have insecticidal properties. The hard seeds are very toxic, but can be swallowed whole with no ill effects. All non-fruit parts are quite toxic.

16.5 Prospects

At present noi nong has value as a home garden plant, although it is not as popular as sugar apple. However, it may have value as rootstock for superior *Annona* species such as sugar apple and atemoya, especially under humid conditions. It may also be useful as a genetic resource for hybridization work on *Annona* species, which needs further research.

17. Som-khaek (*Garcinia atroviridis* Griff.)

Som-khaek belongs to the Guttiferae family, the same family as the well-known mangosteen. The tree is a native of Peninsular Malaysia, Thailand, Myanmar and India (Assam), where it has been cultivated as a home garden plant. It is fairly common in southern Thailand where it is found growing as individual trees in the mixed forest of high rainfall areas.

17.1 Vernacular names

There is no English name specified for this tree; but is generally known as **garcinia**. In Thailand it is known as **som-khaek**, **ma-khaam khaek**, **som-ma-won**, **som-pha-ngum** and **som-khaai**. In Indonesia and Malaysia it is known as **asam gelúgor** and **gelugor**.

17.2 General description

The tree can grow up to 20 m tall, with drooping twigs and leaves. The bark is smooth, pale grey in colour and has colourless latex. The leaves are narrowly oblong and about 20-30 × 6-7.5 cm in size. Young leaves are bright red and turn to dark green when mature. Several male flowers are borne together on the end of twigs. Female flowers are solitary, 4-5 cm wide, having 4 thick green sepals and 4 fleshy dark red petals with red stigma. The fruits are globose and about 7-10 cm in diameter. A mature fruit can weigh up to 2 kg. The fruit contains 12-16 grooves from top to bottom, with a fruit stalk 3-4 cm long. The bright orange-yellow fruit skin is thin and smooth. The fruit contains several seeds 1.5 cm long, which are flattened and surrounded by bright orange pulp (arillode).

17.3 Propagation

Som-khaek is commonly propagated by germinating seeds. It was observed, but not scientifically proven, that trees grown from seedlings resulted in more male than female trees. Thus, it is suggested that grafting or inarching bud wood of known sex onto

seedling trees may produce plants of desired sex which can bear fruits within 4-5 years of grafting.

17.4 Uses

The mature fruits are sour. The fully grown but still green fruits are sliced, dried, and used as seasoning or sour relish. In Thailand the traditional ethnomedical uses of som-khaek are as follows. The dried fruit is used for improving blood circulation, as an expectorant, treatment of coughs and as a laxative (Poomipamorn and Kumkong, 1997). Now it is believed that the fruit extract has efficacies in health promotion such as reducing cholesterol and enlarging the blood vessels, absorbing excess fat and use in diets. At present, the products of som-khaek are becoming popular as health food, and a lot of som-khaek products are sold in the markets in different forms such as som-khaek tea, som-khaek capsules and som-khaek fruit slices.

17.5 Prospects

In Thailand som-khaek has some prospects for development as health food and an increase in production area can be expected. The demand for som-khaek is rather steady, but is slowly increasing. Slices of dry fruit is are sold at 200-300 baht (5-7.5 US dollars) for one kilogram throughout the year. Two kilograms of fruit yields 200 g dry weight. The average price of som-khaek fruit is 20 baht. One advantage in cultivating som-khaek is that the plant is easily grown with almost no pest and disease problems and requires very little care. Thus, it is a promising fruit for use as a health food.

18. Som-saa (*Citrus medica* L. var. *limetta*)

Som-saa belongs to the Rutaceae family. It has been known in Thailand for many centuries and it is believed that the tree was introduced into the country from China. In Thailand, it is known as ‘**som-saa**’ in the Central Plain, ‘**ma-kun**’ in the North and ‘**som-sah**’ in the Northeast.

18.1 General description

Som-saa is a small to medium sized tree similar to tangerine in size. Leaves are simple, ovate-elliptic, and dark green with a smooth and shiny surface. There is an oil gland on the leaf, which has a small, narrow wing at the petiole. It has small white flowers. The fruit is about the same size as tangerine when ripe, but the rind is thicker and bumpier than that of tangerine. The juice sac is white like pummelo, with a sourish-sweet taste. In Thailand it is used in cooking.

Propagation is done by seed germination and marcotting.

18.2 Uses

Som-saa has many uses. The fruit rind or skin is chopped into small, thin pieces and placed as side-dish to many Thai dishes such as ‘mee krop’ and ‘pa-naem’ to make them smell and taste better. The skin is also used as an anti-flatulent. The juice is used to cure coughing, and leaves are used to treat skin diseases etc.

18.3 Prospects

In Thailand som-saa is only grown for home consumption. It has no potential for development at a commercial scale. However, more research should be done on the use of som-saa as a genetic resource for improving citrus varieties for the future of the citrus industry in Thailand.

19. Taling pling (*Averrhoa bilimbi* L.)

19.1 General description

Taling pling (*Averrhoa bilimbi* L.) is related to the carambola (*Averrhoa carambola* L.) and both species belong to the Oxalidaceae family. Taling pling is native to the Southeast Asian region and is found growing all over the humid tropics. It is a small tree, about 5-12 m high with rusty pubescent young parts and petioles. The taling pling tree can be easily distinguished from the carambola in that it has large leaves with 10-14 leaflets which are paler green than those of the carambola. The pinnate leaves are 20-60 cm long, opposite, and have 10-17 pairs of leaflets. The leaflets are pointed at the tip, 5-10 cm. long and rather narrow. The inflorescences are borne on the trunk, large branches and on short branchlets below the leaves and are 15 cm or less in length. The crimson coloured flowers are about 1.5 cm long and somewhat fragrant, with hairy a calyx. The 5 petals are reddish purple, often marked with white, and measure 1.2-1.9 cm in length. The stamens are all anther bearing. The haploid chromosome number is 12 (Ramirez, 1959). Flowers are produced all year round, especially during the drier part of the year.

The fruits are somewhat cylindrical or slightly pentagonal in shape, vary from 5-10 cm in length and weigh about 18-19 g. They are light green, becoming greenish yellow and translucent when ripe. The ripe fruit is juicy, acidic, and contains few, flattened, non-arillate seeds.

19.2 Vernacular names

The English names of this species are **bilimbi** and **cucumber tree**. **Cornichonier** (French); **belimbing asam**, **blimbing wuluh**, **blimbing buluk** (Indonesia, Malaysia); **kamias**, **iba** (Philippines); **trâlông tống** (Cambodia); **taling pling** (Thailand); and **khê tau** (Viet Nam).

19.3 Ecology

Taling pling thrives well on any soil type provided it is well drained (Ochse *et al.*, 1961). However, for best performance, it should be grown in deep, fertile, sandy loam or clay loam soils with plenty of organic matter (Coronel, 1983). The trees are found to grow well at low altitudes from sea level up to 500 m in areas having an even distribution of rainfall throughout the year (Ochse *et al.*, 1961). They are also quite tolerant to dry periods (Manipon, 1972).

19.4 Propagation

Taling pling trees are usually propagated by seeds but they may also be asexually propagated by budding, grafting, marcotting and marching (Galang, 1955; Ochse *et al.*, 1961). Seed propagation is discouraged since great variation occurs among the seedling trees. Outstanding mother trees should be kept for asexual propagation. Shield budding is successfully practised in the Philippines and is recommended for large scale propagation. Marcotting can be done in taling pling trees, but this is not recommended for large scale propagation as it is a laborious and slow process and it takes a long time to root. Inarching can be done with success, but it is a slow process as it takes quite some time before inarches can be separated from the trees. There is no report on the success of stem cutting in taling pling trees. However, root cutting may be possible as it has been observed that severed roots of taling pling trees are able to produce adventitious growths that are able to establish themselves as independent plants (Wester, 1929).

19.5 Uses and food values

The composition of taling pling fruit is shown in Table 3. The fruit is rich in moisture, calcium, phosphorous, potassium and vitamin A, but low in other constituents, including ascorbic acid. The organic acids in the fruits are predominantly citric acid and oxalic acid (Table 4).

The fruit of taling pling is occasionally eaten raw with salt or sliced thin and added to salad. It is used extensively as a souring agent for many native dishes. It may also be processed into candies or made into chutneys, relishes and pickles. Its raw juice is an effective remover of stains or spots on clothes, rust stains on brassware and stubborn food particles on enamelware (Pratt and Del Rosario, 1913).

Table 3. Food composition of taling pling fruit, data per 100 g. edible portion (Intengan, 1968)

Edible portion (%)	100.0
Moisture (g)	94.1
Food energy (cal)	21.0
Protein (g)	0.7
Fat (g)	0.2
Carbohydrates (g)	4.7
Fibre (g)	0.6
Ash (g)	0.3
Calcium (mg)	7.0
Phosphorous (mg)	11.0
Iron (mg)	0.4
Sodium (mg)	4.0
Potassium (mg)	148.0
Vitamin A (I.U.)	145.0
Thiamine (mg)	0.01
Riboflavin (mg)	0.03
Niacin (mg)	0.3
Ascorbic acid (mg)	9.0

Table 4. The organic acid contents of taling pling fruits (after Carangal *et al.*, 1961). Data expressed in meq acid/100 g total solid

Acetic acid	1.6 – 1.9
Citric acid	92.6 – 133.8
Formic acid	0.4 – 0.9
Lactic acid	0.4 – 1.2
Malic acid	Trace
Oxalic acid	5.5 – 8.9

The taling pling tree also has some medicinal properties (Coloma, 1972). When applied hot externally the leaves prevent itching. They can also be used to cure syphilis when taken internally fresh or fermented. A decoction of leaves is used to cure inflammation of the rectum and the paste is applied for mumps, rheumatism and pimples. An infusion of the flowers is used for coughs. The fruit is an astringent stomachic and refrigerant and its juice is made into syrup as a cooling drink for reducing fever. It is antiscorbutic and is used in some slight cases of hemorrhage from the bowels as well as the stomach and internal hemorrhage. It is also used to cure beriberi, biliousness and coughs.

The fruits of taling pling tree can be processed in many ways. They can be dried, candied, preserved in syrup or made into jam and pickle.

19.6 Prospects

At present, it is difficult to see the development of established plantations of taling pling trees in Thailand. This is due to the lack of major market demand. Cultivation is confined only to home gardens and the fruits are only utilized for local use.

PART 3.

SPECIES WITHOUT CURRENT DEVELOPMENT POTENTIAL FOR ECONOMIC USES

This group includes eight species that, at the present time, do not have any potential for being developed commercially. Most of these species are found growing naturally in the forests or growing unattended in wasteland. Some are found growing along roadsides. Currently, the only value of the fruit species in this group is due to their use by local villagers as traditional medicine, or for other necessities. This in itself indicates that they may have value as genetic resources for further scientific investigation.

1. Chammaliang (*Lepisanthes fruticosa* Leenh)

The synonyms of this species are *Otophora cambodiana* Pierre, *Otophora fruticosa* Blume, and *Otophora resecta* Radlk.

Chammaliang belongs to the Sapindaceae family. It is found distributed in Thailand, Myanmar and Indo-China. It is mostly found growing as a home garden plant, and is only occasionally cultivated.

1.1 Vernacular names

There is no English name for this species. **Mojowontu** (Indonesia); **setengok** (Malaysia); **linaunau** (Tagalog), **buli-buli** (Bisaya), **ara** (Ibanag), (Philippines); **kandak** (Cambodia); **kwad khaaz** (Laos); and **chammaliang**, **phumriang** (central), **mathao** (north), (Thailand).

1.2 General description

Chammaliang is a shrub or small tree, usually 4-7 m tall. Leaves are usually paripinnate, 1-14-jugate. The leaf is ovate and acute at the apex, 7-21 × 2-3 cm in size, with a round stipule. The leaf is thick and shiny. Inflorescences 10-20 cm long are borne on branches and stems. The inflorescence contains perfect and non-perfect flowers. The flower has 5 purple sepals and petals. The petals are quite similar to the sepals, but are thinner. The flower is 0.3-0.4 × 0.5-0.6 cm in size. In Thailand the chammaliang flowers around December-January. The fruit is a subglobose to ellipsoid berry up to 4 cm in diameter. At ripening, it is dark red to black. The flesh is sweet. The seeds are subglobose to semi-ellipsoid, flattened on one side, and can grow up to about 2 cm in diameter. Propagation is done by seed germination.

1.3 Uses

The fruit can be eaten fresh, as it is sweet when ripe. The seeds are eaten roasted. The root is used in a compound poultice to relieve itching and to lower temperature during fever.

1.4 Prospects

There is no prospect for developing chammaliang into fruit orchards. It may be used as an ornamental plant in landscaping due to its attractive form.

2. Khanun sampalor (*Artocarpus odoratissimus* Blanco)

The synonyms of this species are *Artocarpus tarap* Becc. and *Artocarpus mutabilis* Becc.

This fruit tree belongs to the Moraceae family and its relatives are jackfruit and breadfruit. It originated in Borneo and has been introduced into neighbouring countries, including the Philippines, Malaysia and Thailand. It is now cultivated in the Philippines.

2.1 Vernacular names

The English name is **marang**. **Pingan** (Iban), **pi-ien** (Bidayuh), **keiran** (Kelabit), (Indonesia); **terap** (Malaysia); **marang** (Sulu), **madang** (Lanao), **lolo** (Tagalog), (Philippines); and **khanun sampalor** (Thailand).

2.2 General description

Khanun sampalor is rather similar to breadfruit (*Artocarpus altilis* Fosberg) in its tree shape, however, the leaves and fruit shapes are quite different. It is an evergreen tree, which can grow up to 25 m tall and has a 40 cm diameter trunk with low buttresses. Twigs are 4-10 mm thick with long, yellow to red, spreading hairs and stipule-scar rings. The stipules are hairy, 1-8 cm long and ovate in shape. The leaves are broadly elliptic to obovate, 16-50 × 11-28 cm in size. They are cuneated at base to slightly decurrent, margin entire or shallowly crenate, and apex blunt or shortly acuminate. Inflorescences occur in leaf axils, solitary. Male heads are ellipsoid to clavate and 4-11 × 2-6 cm in size, whereas female heads occur with pubescent peltate bracts, mostly shed and simple styles are exerted to 1.5 mm. The fruit is quite large, averaging about 16 cm in length, 13 cm in diameter and weighing about 1,000 g. It is roundish oblong, regular, and thickly studded with short, brittle, greenish yellow spines. The rind is thick and fleshy. The flesh is snowy white, very sweet when ripe, juicy, very aromatic and of excellent flavour (Coronel, 1983). The flesh is separated into segments clinging to the central core and each segment contains a seed. The seeds are many, whitish, 8 × 15 mm in size, smooth surfaced and readily separated from the flesh (Galang, 1955).

2.3 Ecology

Khanun sampalor is found growing naturally in Sarawak in secondary forests up to 1,000 m altitude on sandy clay soils. It is also found cultivated as well as growing wild in the Philippines. Under cultivation, it grows best in regions with abundant and equally distributed rainfall on rich loamy, well drained soils. It is also found in partially shaded locations from sea level to 800 m elevation.

2.4 Propagation and agronomy

Khanun sampalor is propagated from seed. The seeds are extracted from ripe fruit, thoroughly cleaned with water and sown immediately on sandy loam soil as they lose their viability quickly. Vegetative propagation by budding, grafting and inarching also give some degrees of success.

No serious pests and diseases have been observed apart from oriental fruit fly attacking ripe fruits (de la Cruz, 1991). Mature fruits are usually harvested by hand with the help of a curved knife attached to the end of a long bamboo pole.

2.5 Uses

The fruit is eaten raw and the large seeds are edible when boiled or roasted. The fruit also makes an excellent flavouring for ice-cream. It has 24-33 percent edible portion and contains, per 100 g edible portion: 65.7-84.2 percent moisture, 63-122 calories food energy, 0.8-1.5 g protein, 0.2-0.3 g fat, 32.4 g carbohydrates, 0.5-0.8 g ash, 0.6-0.8 g crude fibre, 17 mg calcium, 35 mg phosphorous, 2.1 mg iron and 30 mg ascorbic acid (Galang, 1955).

2.6 Prospects

Khanun sampalor may not have any prospects in Thailand as its very sweet taste and strong smell are unfamiliar to the general Thais. It has low yield and short shelf-life as compared to jackfruit. It is grown as a home garden plant in some villages in southern Thailand. However, if the fruits can be processed, there may be some possibilities of expanding its plantation.

3. Lamut khamen (*Pouteria campechiana* (Kunth) Baehn.)

The synonym of this species is *Lucuma nervosa* A. DC.

This fruit tree belongs to the Sapotaceae family. It is a native of Mexico and has been introduced into the Philippines and later to other Southeast Asian countries including Thailand where it has been found growing as a collectors plant in home gardens in some villages in the North and Northeastern regions.

3.1 Vernacular names

The English names are **canistel**, **egg-fruit**, and **yellow sapote**. **Tiesa**, **canistel**, (Philippines); **lamut khamen**, **khe maa**, **to maa** (Thailand).

3.2 General description

Lamut khamen is a medium sized evergreen tree 12-20 m tall and with a 25-60 cm wide trunk. The dark grey bark is finely ribbed and 4-5 mm thick. It is rich in white gummy latex in every part of the tree. The branches are mainly horizontal. The leaves whorl at the tips of the branches, are obovate-elliptic, 6-25 × 2.5-8 cm in size, glossy, bright green, and tapering towards both ends. The petioles are 5-25 cm long. Flowers are axillary borne in the lower leaves. They are solitary or clustered and fragrant. The pedicel

is 5-12 mm long. The fruit is a spindle shaped to ovoid, obovoid or subglobose berry, often beaked at the apex with a thin, tough, waxy smooth, yellow skin. The flesh is more or less musky aromatic, moist or dryish, mealy and very sweet with 1-5 seeds. The glossy brown seeds are ovoid and 4-5 × 1.5-2 cm in size.

3.3 Propagation and Agronomy

Lamut khamen is usually propagated from seeds. The seeds lose viability quickly and should be germinated within a few days after removal from the fruit. Seedlings grow fast and may produce fruit in 3-4 years. Vegetative propagation such as grafting can be done and the grafted plants can produce fruit in 2-3 years. Trees tend to flower over an extended period, as the dry season progresses in the tropics. In some areas the trees may flower intermittently throughout the year. Fruit ripens 5-6 months after bloom.

3.4 Uses

After removal of the skin and seeds, the fruit may be eaten as a sweet fruit, or as a vegetable with salt and pepper, lemon juice or mayonnaise. Blended with milk and nutmeg, it makes a highly nutritious cold beverage. It may be added to custards and to ice-cream before freezing. The flesh can be dehydrated, powdered and employed as a rich food additive.

The edible portion constitutes up to 70 percent of fruit weight. Chemical analyses showed that 100 g edible portion of ripe fruit contain: water 57.2-60.6 g, protein 1.7-2.5 g, fat 0.1-0.6 g, carbohydrates 36.7-39.1 g, fibre 0.1-7.5 g, ash 0.6-0.9 g, calcium 26.5-40 mg, phosphorous 30-37.3 mg, iron 0.9-1.1 mg, carotene 0.32 mg, thiamine 0.02-0.17 mg, riboflavin 0.01-0.03 mg, niacin 2.5-3.7 mg and vitamin C 43-58 mg. The energy value is 580-630 kJ/100 g (Morton, 1991). Thus, the fruit is rich in carbohydrates, carotene and niacin.

3.5 Prospects

Lamut khamen is still little known in Thailand and is grown only in some villages as home garden plants. However, the high nutritional value of the fruit may attract more interest and promote its wider growth in the future. Promotion based on its high food value and research on how to use the fruits is needed for future development of lamut khamen in Thailand.

4. Ma-kham-thet (*Pithecellobium dulce* (Roxb.) Benth)

The synonyms of this species are *Mimosa dulcis* Roxb. and *Inga dulcis* (Roxb.) Willd.

Ma-kham-thet belongs to the Leguminosae family and is very common in Thailand. It is found growing in many unattended waste areas. The tree is said to have originated in Central America, but it has been naturalized throughout Southeast Asia, especially in Indonesia, Malaysia, the Philippines and Thailand.

4.1 Vernacular names

The English names are **guayamochil**, **Manila tamarind**, and **sweet inga**. **Asam belanda**, **asem londo**, **asam koranji** (Indonesia); **asam kranji**, **asam tjina** (Malaysia); **kamatsile**, **kamanchilis**, **damortis** (Philippines); **kway-tanyeng** (Myanmar); **âm pül tük** (Cambodia); **khaam theed** (Laos); **ma-kham-thet** (Thailand); and **me keo**, **keo tây** (Viet Nam).

4.2 General description

Ma-kham-thet is a medium sized to large tree, which can grow up to 10 m or more. The ultimate branches are often pendulous and armed with short, sharp, stipular spines at the bases of leaves. Leaves are abruptly bipinnate and 4-8 cm long. Each single pair of oblique, ovate oblong leaflets is 1-4 cm long. Inflorescences occur in terminal panicles, puberulent, up to 10 cm long. Peduncles are 1-2 cm long bearing globular heads with 15-20 sessile white flowers. The calyx and corolla are tubular, 1.5 mm and 3.5 mm long, respectively, with white filaments. The fruit is a pod and is turgid, twisted, and often spiral, 10-18 cm long, about 1 cm wide, and weights about 10-20 g. It is dehiscent along the lower suture and the valve is red or reddish brown when ripe. The seeds are black, flat and shiny and 6-8 seeds are found per pod. The seed is surrounded by an edible, whitish, pulpy aril (Galang, 1955). The pulp is either red or white, sweet and rather dry and mealy.

4.3 Planting and propagation

Ma-kham-thet grows well at low and medium altitudes in both wet and dry areas under full sunlight. Although well drained soil is best, it also grows successfully in heavy clay soils.

Ma-kham-thet is usually propagated from seeds, which take about 2 weeks to germinate. Outstanding clones should be propagated vegetatively by marcotting, grafting or budding. Once planted in the field, the tree does not need any treatment other than occasional pruning. Pests and diseases do not seem to cause any serious problems.

4.4 Harvesting

The pods are usually picked by climbing the tree or using a long bamboo pole. When mature the pods split open at the lower suture exposing the edible pulp. For this reason the fruit does not keep long and has to be consumed within a few days.

4.5 Uses

The pulp of the ripe fruit is edible when raw. Fresh pods contain 50.3 percent pulp, 25.3 percent seeds and 24.4 percent peel (Gam and Cruz, 1957). The pulp per 100 g edible portion contains: 75.8-77.8 g. water, 2.3-3 g protein, 0.4-0.5 g fat, 1.1-1.2 g crude fibre, 0.6-0.7 g ash, 18.2-19.6 g carbohydrates, 79 calories food energy, 13 mg calcium, 42 mg phosphorous, 0.5 mg iron, 19 mg sodium, 20.2 mg potassium, 25 IU vitamin A, 0.24 mg thiamine, 0.1 mg riboflavin, 0.6 mg niacin and 133 mg ascorbic acid (Gamo and Cruz, 1957).

The seed contains 70.6 percent kernel, 21.7-56.4 percent water, 10.5-29.9 percent protein, 8.0-17.7 percent fat, 3.9 percent crude fibre, 1.6-2.3 percent ash, and 19.6-28.4 percent carbohydrates (Padilla and Soliven, 1933). The seed oil contains 51.1 percent

oleic acid, 24.0 percent linolic acid and 24.3 percent saturated acids while the seed meal (after oil extraction) contains 27.6 percent protein, 2.2 percent fat, 8.5 percent crude fibre, 3.6 percent ash and 49.1 percent carbohydrates (Gamo and Cruz, 1957). The oil is edible and is used for the manufacture of soap and other purposes for which peanut oil may be used. Due to its high protein content, the seed meal may be used for animal feed.

4.6 Ethnomedical uses

Ma-kham-thet leaves can be used as a plaster to allay pain even from venereal sores, and can relieve convulsions. The leaves together with salt can cure indigestion and also induce abortion. The bark of the root is good for dysentery. The bark of stem is used for tanning (De Padua *et al.*, 1978) and produces dull, but light coloured leather, which reddens on exposure to light. It is also used for dyeing fish nets (Galang, 1955). The bark, however, contains irritating substances, which can cause eye infection (Coronel, 1983).

4.7 Prospects

In Thailand Ma-kham-thet is mainly grown as a hardy, easy to manage roadside tree. Now some growers in the Central Plain select the clones with large pods containing small seeds and sweet pulp. These clones may be cultivated in home gardens and there are possibilities for commercial development in the future.

5. Naam daeng (*Carissa carandas* L.)

Naam daeng (*Carissa carandas* Linn. or its synonyms *Carissa congesta* Wight.) belongs to the Apocyanaceae family. The tree is a native of India, Sri Lanka, Myanmar, Thailand and Peninsular Malaysia. It has also been introduced and naturalized in Indonesia and the Philippines. At present, naam daeng is widely cultivated in Thailand, Indo-China and East Africa.

5.1 Vernacular names

There are many English names such as **natal plum**, **bengal currant**, **karandang** and **karaunda**. **Karandan** (Java), **senggaritan** (Timor), (Indonesia); **kerenda**, **kerandang**, **berenda** (Malaysia); **karanda**, **caramba perunkila** (Philippines); **naam daeng** (Bangkok), **manaao ho** (southern peninsula), **naam khee haet** (Chiang Mai), (Thailand); and **cây sirô** (Viet Nam).

5.2 General description

Naam daeng is a small tree usually 3-5 m tall. The stem is rich in white latex and the branches contain sharp spines. Flowers are small, measuring 3-5 cm in diameter, with white colour. The fruit is a berry, which is formed in clusters of 3-10 fruits. The fruit is globose to broad ovoid in shape and about 1.0-2.5 cm long. Young fruits are pinkish white and become red to dark purple when mature.

5.3 Propagation

Naam daeng is usually propagated by seeds. Vegetative propagation is not yet known.

5.4 Uses

The fruit is very sour at maturity but it is sourish sweet when ripe. It can be eaten raw or stewed with sugar. In Thailand it is mainly used as pickles, however, it can also be made into jam, jellies and puddings. Furthermore, the fruit is also used to make beverages, curries and tarts. Naam daeng trees are suitable for hedging in the home garden and are sometimes grown as an ornamental plant due to its beautiful cherry-like fruits.

Ethnomedically the fruits are used as an astringent, antiscorbutic and as a remedy for biliousness. A leaf decoction is used against fever, diarrhoea, and earache. The roots serve as a stomachic, vermifuge, remedy for itches and insect repellent. The wood is hard and is used to make small utensils.

5.5 Prospects

Naam daeng has no future for development as a well known fruit tree. It has a place growing as a home garden tree with the fruit being processed as home made jam or pickles, mainly for home consumption.

6. Star apple (*Chrysophyllum cainito* L.)

The synonym of this species is *Achras cainito* Ruiz & Pavon.

Star apple is in the Sapotaceae family, the same family as sapodilla (*Manilkara zapota* L.). The tree is indigenous to the West Indies and spread over tropical America in the early days. At present it is found growing throughout the tropics, and is found as a home garden plant in Thailand, the Philippines and Viet Nam.

6.1 Vernacular names

It is known as **star apple** and **cainito** in English. **Caimite**, **caimitier** (French); **caimito**, **estrella** (Spanish); **cainito**, **ajara** (Portuguese); **sawo ŷo** (Indonesia - Java); **caimito** (Philippines); **chicle durian** (Singapore); and **star apple** (Thailand).

6.2 General description

The star apple is an evergreen tree. It is erect, 8-30 m tall, and has a short trunk up to 1 m thick with a dense, broad crown, brown hairy branchlets, and white gummy latex. The alternate leaves are elliptic or oblong-elliptic, 5-15 cm long, slightly leathery, rich green and glossy on the upper surface, and coated with silky, golden-brown pubescence beneath when mature, although they are silvery when young. Petioles are 0.6-1.7 cm long. Inflorescences are borne axillary on the current season's shoots. The small, inconspicuous flowers are greenish yellow, yellow, or purplish-white with tubular, 5-lobed corolla and 5 sepals. The fruit is round, oblate, ellipsoid or somewhat pear-shaped and 5-10 cm in

diameter. The mature fruit may be reddish purple, dark purple or pale green. The glossy, smooth, thin, leathery skin adheres tightly to the inner rind. In purple fruits, the flesh is dark purple; in green fruits, it is white. Both purple and white flesh have soft, white, milky, sweet pulp surrounding 6 to 11 gelatinous, somewhat rubbery, seed cells in the centre. When cut through transversely, they are seen to radiate from the central core like an asterisk or many-pointed star, giving the fruit its common name. The fruit may have up to 10 flattened, nearly oval, pointed, hard seeds 2 cm long, nearly 1.25 cm wide and up to 6 mm thick. Usually, several cells are not occupied and the normal fruits have as few as 3 seeds. The seeds appear black at first with a light area on the ventral side, and become light brown upon drying.

6.3 Climatic requirements

Star apple grows successfully on almost all types of soil and in a range of tropical or near tropical areas. Throughout Southeast Asia it thrives in the lowlands (up to 400 m elevation) and in areas with a distinct dry season. If the dry period is most pronounced, undue loss of leaves and less juicy or even shriveled fruit are evident, which indicates that the drought is too severe and irrigation is needed. Fertile, well drained and slightly acid soils are ideal for good growth.

6.4 Propagation

Star apple trees are widely grown from seeds, which retain viability for several months. The seedlings bear fruits in 5-10 years. Vegetative propagation hastens production and should be more commonly practiced. The cuttings taken from mature stems root well (Morton, 1987). Air-layers can be produced in 4 to 7 months and bear early. Budded or grafted trees have been known to fruit one year after being set in the ground.

Asexual propagation is recommended to multiply healthy, good quality trees. Cleft grafting is the most common propagation method and gives a high percentage take. *C. oliviforme* is a compatible rootstock, but most grafts are made on star apple seedlings (de la Cruz Jr., 1991). In the field, planting space is usually set at 10 × 12 m. In Thailand planting is done at the onset of the rainy season.

6.5 Harvesting

Fruits should be harvested when fully ripe, which can be seen by shiny light green or yellowish-brown skin for the green type and pale to dark purple for the purple type. Harvesting is done on individual fruits as all fruits on a tree do not ripen at the same time. Fruits are harvested by cutting the stalk with a pair of clippers or by using a long bamboo pole with a net. After harvest, the protruding stalk is clipped off and the unblemished fruit is packed in bamboo baskets lined with banana leaves and transported to the market. Ripe fruit keeps only for a few weeks if stored under refrigeration.

6.6 Uses

Star apple fruit is usually consumed fresh, but it must not be bitten into. The skin and rind are not edible. When opening a star apple fruit, one should not allow any of the bitter latex of the skin to contact the edible flesh. The ripe fruit, preferably chilled, is cut in half and the flesh spooned out, leaving the seed cells and core. A better way of serving the fruit is to cut around the middle completely through the rind and then, holding the fruit stem-end down, twisting the top gently back and forth. As this is done, the flesh will be

felt to free itself from the downward half of the rind, and the latter will pull away, taking with it the greater part of the core.

Besides being consumed fresh, the fruit may be used as an ingredient of ice-cream, and sherbet. The nutritional values per 100 g edible portion are: water 80.5-82.6 g, protein 0.7-1.3 g, fat 0.6-1.1 g, carbohydrates 15.3-17.4 g, fibre trace-0.7 g, ash 0.2-0.3 g, calcium 14-17 mg, phosphorous 9-13 mg, iron 0.2-0.4 mg vitamin A trace-10 IU, thiamine 0.01-0.02 mg, riboflavin 0.01-0.02 mg, niacin 0.8-0.9 mg, and vitamin C 6-7 mg. The energy value is 280-300 kJ per 100 g.

6.7 Ethnomedical properties

The ripe fruit is eaten to sooth inflammation in laryngitis and pneumonia. It is given as a treatment for diabetes mellitus, and as a decoction is gargled to relieve angina. A decoction of the rind, or of the leaves, is taken as a pectoral. A decoction of the tannin-rich, astringent bark is drunk as a tonic and stimulant, and is taken to halt diarrhea, dysentery and hemorrhages, and as a treatment for gonorrhoea and “catarrh of the bladder”. The bitter, pulverized seed is taken as a tonic, diuretic and febrifuge. The latex of the tree is applied on abscesses and, when dried and powdered, it is given as a potent vermifuge. It is also taken as a diuretic, febrifuge and remedy for dysentery.

6.8 Prospects

In Thailand star apple has little chance of being developed into an economic crop. It will remain as a garden tree for the relatively dry lowland areas where irrigation is not available. Unless the people are educated in the eating and utilization as well as the nutritional values of this fruit, the chance of its development is still uncertain due to the lack of market demand.

7. Takhop farang (*Muntingia calabura* L.)

Takhop farang (*Muntingia calabura* L.) belongs to the Elaeocarpaceae family. It is a small to medium sized evergreen tree commonly found in Southeast Asia as it has an incredible property for very quick establishment. The tree is a typical pioneer species and found colonizing disturbed sites in tropical lowlands, which can sustain continuous growth. It is one of the most common roadside trees in Southeast Asia.

7.1 Vernacular names

The English names are **capulin**, **Jamaica cherry**, and **Panama berry**. **Cerri kersen**, **talok** (Indonesia); **kerukup siam** (Malaysia); **datiles** (Philippines); **krâkhôb barang** (Cambodia); **khoom sômz**, **takhôb** (Laos); **takhop farang** (Thailand); and **trúng cá**, **mât sâm** (Viet Nam).

7.2 General description

Takhop farang is a small to medium sized evergreen tree 3-12 m tall, with spreading, or fan-like branches. The branches are horizontal and pendent towards the tip, which is soft and hairy. The leaves are simple, alternate, ovate-lanceolate, long-pointed at the apex and oblique at the base. They are 4-14 cm long and 1-4 cm wide. The leaves are

dark green and minutely hairy on the upper surface, and greyish pubescent on the lower surface, with serrated leaf margin. The flowers are borne singly or 2-3 in leaf axils. They are 1.25-2 cm wide, hermaphrodite, with 5 green sepals and 5 white petals with many prominent yellow stamens. The fruits are abundant, round and 1-1.25 cm in size. The fruit is red or sometimes yellow with smooth, thin and tender skin. Within a fruit, there is a light brown, soft and juicy pulp with a very sweet taste and a musky somewhat fig-like flavour, filled with exceedingly minute, yellowish seeds too fine to be noticed when eating.

7.3 Phenological characters

Takhop farang is a typical pioneer species. It can colonize disturbed sites in tropical lowlands that can sustain continuous growth. The growth and development of this tree are neatly structured at the shoot level, in a system that allows continuous growth extension and fruit production (Verheij, 1991). The flowers open just before dawn and only last for one day. Bees are the main pollinators. The species is self-compatible and intensive pollination is needed to reach the normal number of several thousand seeds per fruit. The flowers in a fascicle open sequentially at intervals ranging from 4-9 days. Within 2 weeks from the opening of the last flowers, the first flower of the following fascicle may already have reached bloom. A series of remarkable pedicel movements lifts each flower bud above the plane of the plagiotropic shoot just before anthesis and turns the flowers to a pendent position within 2 days from fruit set. Thus the flowers are conspicuous to pollinators and segregated from the concealed fruit. This favours bats and birds as the main dispersers of the seed and reduces the likelihood of them damaging the flowers. The fruit ripens in 6-8 weeks from anthesis and the life span of the mature leaf is only slightly longer.

7.4 Propagation

Fresh seed germination is enhanced by passage through the digestive tract of bats and birds. The seed is well represented in the seed banks of forest soils and requires high temperature and light conditions for germination. The seedlings do not tolerate shade.

Planters use fresh seeds mixed with the sweet juice of the fruit to sow directly into the field. To prepare seeds for planting, water is added repeatedly to the squeezed-out seeds and juice, and as the seeds sink to the bottom of the container, the water is poured off several times until the seeds are clean enough. They are then dried in the shade.

7.5 Cultural practices

Takhop farang is not normally cultivated in Thailand as the tree spreads spontaneously. Seedlings flower within two years due to their fast growth. Air-layer plants fruit straight away. The tree has the reputation of thriving with no care in poor soils and it does well in both acid and alkaline soils and even on old tin tailings in South Thailand and Malaysia. It is drought resistant, but not salt-tolerant.

7.6 Uses

The fruit is widely eaten by children as it is sweet. They usually climb up the tree and pick the fruits by hand, or sometimes shake the tree and wait for the fruits to drop. The fruit is also cooked in tarts and made into jam. The leaf infusion is drunk as a tea-like beverage.

The nutritional value per 100 g of edible portion of the fruit contain approximately: moisture 77.8 g, protein 0.32 g, fat 1.56 g, fibre 4.6 g, ash 1.14 g, calcium 124 mg, phosphorous 84 mg, iron 1.18 mg, carotene 0.019 mg, thiamine 0.065 mg, riboflavin 0.037 mg, niacin 0.554 mg, and ascorbic acid 80.5 mg. The energy value is 380 kJ/100 g (Morton, 1987).

The flowers are said to possess antiseptic properties. An infusion of the flowers is valued as an antispasmodic. It is taken to relieve headache and the first symptoms of a cold (Morton, 1987).

The sapwood is yellowish and the heartwood is reddish brown, firm, compact, fine grained, moderately strong, light in weight, durable indoors and easily worked. It is useful for interior sheathing, making small boxes, casks and general carpentry. The wood is valued mostly as fuel as it ignites quickly, burns with intense heat and gives off very little smoke. It is also used as wood for cooking and is valued in Brazil as a source of paper pulp.

7.7 Prospects

Takhop farang is very common in Thailand, but has hardly been studied. Although it is commonly seen growing in wasteland, it has received very little attention by scientists. This may be due to the fruits having little market demands, so it does not appear worthwhile developing takhop farang for cultivation.

8. Takhop-thai (*Flacourtia rukam* Zoll & Moritzi)

The synonym of this species is *Flacourtia euphlebia* Merr.

Takhop-thai belongs to the Flacourtiaceae family. It is found widely distributed but scattered, both cultivated and wild, all over Malaysia. It is said to be a native of Indo-China, India and Thailand.

8.1 Vernacular names

The English name is **rukam**. **Prunier de chine, prunier café** (French); **ganda rukem, rukam** (Java), **Klang tatak kutang** (Borneo) (Indonesia); **rukam manis, rukam gajah** (Malaysia); **amaiit** (Tagalog), **aganas** (Bisaya), **kalominga** (Igorot), (Philippines); **kén** (Laos); **takhop-thai** (Central), **khrop-dong** (Pattani), (Thailand); and **mung guan ru'ng** (Viet Nam) (Hendro Sunarjono, 1991).

8.2 General description

Takhop-thai is a many-branched, crooked tree 15-20 m tall. Usually it is heavily armed with forked, woody spines on the trunk and old branches. The leaves are evergreen, spiralled, red when young, elliptic-oblong, 7.5-15 cm long and 3.2-6.25 cm wide, coarsely toothed and slightly shiny. Flowers occur in small clusters and are borne in the leaf axils. Male and female flowers are usually borne on separate trees; although occasionally both are found occurring on the same plant. There are no petals and the male have many stamens. The fruits are borne on old branches or on the trunk. They are nearly

round, slightly flattened at the apex, 1.25-2.5 cm wide. The dark purple-red fruits have a smooth skin with whitish, juicy, acid flesh. There are 4-7 flat seeds in a fruit.

8.3 Ecology

Takhop-thai grows under humid tropical conditions up to 1,500 m above sea level. Its natural habitat is primary or secondary forest; often along rivers and the trees grow in the shade as well as in full sunlight. The tree appears to be fairly adaptable to a range of temperatures, rainfall and soil conditions.

8.4 Propagation

Takhop-thai is usually grown from seed, but the tree produces root suckers which can be used for vegetative propagation, e.g. of spineless trees. Budding or grafting on its own rootstock or on other *Flacourtia* species is also possible.

8.5 Uses

The ripe fruit can be eaten raw by rubbing between the palms of the hand because bruising the flesh eliminates astringency. It is also served as a fruit salad with spicy sauce, and pickled or sweetened with sugar to make jam or confectionaries. The young leaves are eaten raw in side dishes. Immature fruit is used to prepare traditional medicine against diarrhoea and dysentery. The juice of the leaves is applied to inflamed eye-lids. The wood is hard and strong and is used to make household utensils such as pestles and furniture.

The dark purple-red fruit has white flesh. Analyses of the edible portion in the Philippines show the following composition per 100 g edible part as: water 77 g, protein 1.7 g, fat 1.3 g, carbohydrates 15 g, fibre 3.7 g, ash 0.8 g. The energy value is 345 kJ (Hendro Sunarjono, 1991).

8.6 Prospects

Takhop-thai has very little prospect of being developed for large scale plantation. This is due to the lack of market demand, especially in Thailand where many high quality fruits are available. The pattern of growth, flowering and fruiting through the year needs to be understood to strengthen the basis for selection of superior trees. This could widen the perspectives for the fruit, including production for processing.

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Figure 1. Mafai



Figure 2. Sator



Figure 3. Luk-nieng



Figure 4. Mafai-farang or Bambai



Figure 5. Ma-khaam Pom



Figure 6. ma-Kiang



Figure 7. Makok Farang



Figure 8. Ma-kruut



Figure 9. Maphuut



Figure 10. Mayom



Figure 11. Ngoh khon san