Collection and Evaluation of Under-Utilized Tropical and Subtropical Fruit Tree Genetic Resources in Malaysia

WONG, Kai Choo*

Abstract

Fruit tree genetic resources in Malaysia consist of cultivated and wild species. The cultivated fruit trees number more than 100 species of both indigenous and introduced species. Among these fruits, some are popular and are widely cultivated throughout the country while others are less known and grown in small localized areas. The latter are the under-utilized fruit species. Apart from these cultivated fruits, there is also in the Malaysian natural forest a diversity of wild fruit tree species which produce edible fruits but are relatively unknown and unutilized. Many of the under-utilized and unutilized fruit species are known to show economic potential. Collection and evaluation of some of these fruit tree genetic resources have been carried out. These materials are assessed for their potential as new fruit trees, as sources of rootstocks for grafting and also as sources of germplasm for breeding to improve the present cultivated fruit species. Some of these potential fruit tree species within the genera *Artocarpus*, *Baccaurea*, *Canarium*, *Dimocarpus*, *Dialium*, *Durio*, *Garcinia*, *Litsea*, *Mangifera*, *Nephelium*, *Salacca*, and *Syzygium* are highlighted.

Introduction

Malaysian fruit tree genetic resources comprise both cultivated and wild species. There are more than 100 cultivated fruit species of both major and minor fruit crops. Each category includes indigenous as well as introduced species. The major cultivated fruit crops are well known and are commonly grown throughout the country. Out of these, 17 species have been recommended for large-scale cultivation. They include indigenous species such as banana (*Musa* sp.), carambola (*Averrhoa carambola* L.), mango (*Mangifera indica* L.), durian (*Durio zibethinus* Murr.), rambutan (*Nephelium lappaceum* L.), citrus (*Citrus* sp.), duku langsat (*Lansium domesticum* Corr.), cempedak (*Artocarpus champeden* Spreng.), and mangosteen (*Garcinia mangostana* L.), as well as introduced species such as papaya (*Carica papaya* L.), pineapple (*Ananas comosus* Merr.), watermelon (*Citrullus lanatus* [Thunb.] Matsun. & Nakai), jackfruit (*Artocarpus heterophyllus* Lam.), ciku (*Achras zapota* L.), guava (*Psidium guajava* L.), soursop (*Annona muricata* L.) and passionfruit (*Passiflora edulis* Sims). As minor cultivated fruit crops, that also consist of both indigenous and introduced species, are grown on a small scale in localized regions of the country, some of these species are not well known. Apart from these cultivated fruit trees, in the Malaysian rain forest there is a diversity of wild fruit tree species which produce edible fruits but are relatively unknown. These less-known and unknown fruit species constitute the under-utilized fruit tree genetic resources of Malaysia. Many of these species have a potential for further exploitation. This paper discusses the diversity, collection and evaluation of some of these under-utilized fruit tree species.

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* Department of Agronomy and Horticulture, Universiti Pertanian Malaysia, (43400 UPM Serdang, Selangor Darnl Ehsan, Malaysia)

Diversity of under-utilized fruit tree species in Malaysia

The indigenous under-utilized fruit tree species are products from the Malaysian rain forests. These forests can be considered to be the center of diversity and origin of many of the *Artocapus* sp., *Durio* sp., *Citrus* sp., *Garcinia* sp., *Mangifera* sp., *Musa* sp., *Nephelium* sp., *Syzygium* sp. and other species (Li, 1970; Zohary, 1970; Soepadmo, 1979). The diversity of wild fruit tree species in the Malaysian rain forest is reflected in an inventory covering 50 hectares of primary lowland rain forest in Pasoh, Peninsular Malaysia (Saw *et al.*, 1991). Out of a total plot with tree flora amounting to 820 species, 76 species are known to bear edible fruits. The wild species of *Mangifera* (12 species), *Garcinia* (13 species), *Artocarpus* (10 species) and *Nephelium* (5 species) show a great diversity.

Wild fruit tree species with edible fruits in Peninsular Malaysia include more than 164 species in total (Wan Razali Wan Mohd. *et al.*, 1993). Similarly the rain forests in Sabah and Sarawak, which occupy the northern and western regions of Borneo Island, are also reported to be exceedingly rich in wild fruit tree species (Meijer, 1969; Cockburn, 1976; Voon *et al.*, 1988; Wong and Lamb, 1988; Wong and Gan, 1990; Wong, 1992; Wong, 1993). Beside the indigenous fruit tree species, there is also a diversity of introduced species which are under-utilized. Table 1 shows the list of some of these under-utilized fruit tree species in Malaysia. In many cases the same species are recorded in Peninsular Malaysia, Sabah and Sarawak. However, some species are restricted to Borneo, and they are found only in Sabah and Sarawak. From this list it is apparent that a vast pool of fruit tree genetic resources remains to be exploited for future utilization.

Collection of under-utilized fruit tree species

Various organizations in Malaysia are involved in the collection of under-utilized fruit tree species. These organizations include Universiti Pertanian Malaysia (UPM), Malaysian Agricultural Research and Development Institute (MARDI), Forest Research Institute of Malaysia (FRIM), Department of Agriculture, Sarawak and Deprtment of Agriculture, Sabah. The fruit tree species collected are planted in several arboreta. MARDI's collection totalled 40 species up to 1990 which are planted in Serdang, Peninsular Malaysia (Rukayah Aman *et al.*, 1993). FRIM has planted over 54 species of indigenous wild fruits at the Forest Research Institute arboretum at Kepong and at Taman Bukit Kiara, Selangor (Wan Razali Wan Mohd.*et al.*, 1993). In addition, the Institute is involved in the conservation wild of fruit species in forest reserves in the country. In Sabah, the Department of Agriculture is preserving over 200 fruit tree species, including exotic and subtropical fruits, in arboreta located at the Agricultural Research Station at Lagud Sebrang, Tenom and the Ulu Dusun Agricultural Research Station in Sandakan (Wong, 1993). In Sarawak, the Department of Agriculture has collected and preserved over 40 species of wild fruit tree species at the Sibui arboretum and over 50 species at the Layar arboretum. Universiti Pertanian Malaysia has also a collection at Serdang as well as in the branch campus, in Bintulu.

The setting up of a national fruit arboretum at MARDI, Serdang, on a 60 hectare site is now under way (Mohamad Osman *et al.*, 1993). Fruit tree genetic resources already collected by the various organizations will be assembled here. Future collection of wild fruit tree species will also be planted in this arboretum.

Evaluation of under-utilized fruit tree species

A glance through Table 1, shows that there are more than 140 species of under-utilized fruit tree species remaining to be exploited. They deserve evaluation to determine their potential for either development into new commercial fruit crops or for the improvement of existing fruit tree species which are already under cultivation. Development of new crops will require selection and improvement which are tedious processes. Initial identificaton of potential fruit tree species from observations and tasting of the fruits can be the beginning of this selection process. Thus potential under-utilized fruit tree species are described in a separate section below. Nutritive value of fruits of some of these species has been analyzed by MARDI (Rukayah Aman *et al.*, 1993) and Department of Agriculture, Sarawak (Voon *et al.*, 1988).

Table 1 Some under-utilized fruit tree species which are known to produce edible fruits in Malaysia

Family	Species with edible fruits	Local name
Anacardiaceae	*Bouea macropylla* Griff.	Kundag
	Bouea microphylla Griff.	Remia
	Mangifera caesia Jack.	Binjai, Beluno
	Mangifera cytherea Sonn.	Kedondong
	Mangifera foetida Lour.	Bacang
	Mangifera grafithii Hook. f. (syn. *M. microphylla* Griff. ex Hook.)	Rawa, Asam raba pisang, Asam raba tekuyong
	Mangifera lagenifera Griff.	Lanjut
	Mangifera laurina Blume.	Mempalam, Mangga air
	Mangifera longipetiolata King.	Sepam
	*Mangifera odorata*Griff.	Kuini
	Mangifera pajang Kost.	Embang, Bambagan
	Mangifera pentandra Hook.	Asam paoh
	Mangifera quadrifida Jack.	Asam kumbang
	Mangifera torquenda Kost.	Lamantan
	Pentaspadon motleyi Hook. f. ex King	Pelajau, Empit
	Spondias cytherea Sonn.	Kedondong
Annonaceae	*Annona atemoya* Hort.	Nona
	Annona cherimola Mill.	Nona
	Annona diversifolin Saff	Ilama
	Annona reticulata L.	Nona kapri
	Annona squamosa L.	Nona sri kaya
	Rollinia deliciosa Saff.	
Apocynaceae	*Carissa congesta* Wight	Kerandang
	Willughbeia sp.	Kubal susu, Tabau, Serapit
Bombacaceae	*Durio crassipes* Kost. et Soeg.	
	Durio dulcis Becc.	Durian tutong, Durian tahi, Durian merah
	Durio grandiflorus (Mast.) Kost. et Soeg.	Durian munjit, Durian hantu hutan
	Durio graveolens Becc.	Durian rimba, Durian burung
	Durio oxleyanus Griff.	Durian isu, Durian sukang, Durian beludu
	Durio kinabaluensis Kost. et Soeg.	Durian beludu
	Durio kutejensis (Hassk.) Becc.	Durian nyekak, Durian lai
	Durio lanceolatus	Durian kenyalang
	Durio lowianus Scort. ex King	Durian sepeh, Durian au
	Durio macrophyllus Ridl.	Durian tekura
	Durio testudinarium Becc.	Durian kura-kura
Burseraceae	*Canarium commune* L.	Kenari
	Canarium kadondon Benn. (syn. *Dacryodes rostrata* (Bl.) Lam)	Kembayau, Kedondong kerut, Keramoh
	Canarium littorale Blume	Meritus
	Canarium odontophyllum Miq.	Dabai
	Canarium patentinervium Miq..	Kedondong
	Canarium pilosum Benn.	Kedondong kerut, Keramoh batu
Ebenaceae	*Diospyros discolor* Willd.	Mentega
	Diospyros kaki L.	Pasimon
Elaeocarpaceae	*Elaeocarpus spheoblastus*	Tamang
Euphorbiaceae	*Antidesma bunius* (L.) Spreng.	Buni

(Table 1 continned)

(Table 1 continned)

Family	Species with edible fruits	Local name
Euphorbiaceae	*Baccaurea angulata* Meijer	Belimbing hutan, Uchong
	Baccaurea bracteata Muell. Arg.	Tampoi paya, Tampoi putih
	Baccaurea brevipes Hook. f.	Rambai bukit, Setambun lilin
	Baccaurea costulata	
	Baccaurea hookeri	Jelentik
	Baccaurea kunstleri King ex Gage	Rambai hutan
	Baccaurea lanceolata (Miq.) Muell.-Agri	Rambai hutan
	Baccaurea macrocarpa (Miq.) Muell.	Tampoi jintik merah,
	Arg. (syn. *B. griffithii* Hook. f.)	Puak, Larah
	Baccaurea parviflora (Muell. Arg.) Muell. Arg.	Setambun
	Baccaurea polyneura Hook. f.	Jentik jentik merah, Rambai kuning
	Baccaurea pyriformis Gage	Tampoi burung
	Baccaurea reticulata Hook. f.	Tampoi bunga, Tampoi merkeh
	Baccaurea velutina (Ridley) Ridley	Tampoi tungal, Taban burung
	Elateriospermum tapos Blume	Perah, Kelampai
	Ostodes sp.	Merenti
	Phyllanthus acidus (L.) Skeels.	Cermai
	Phyllanthus emblica L.	Melaka
Fagaceae	*Castanopsis inermis* Benth. & Hook. f.	Berangan
	Lithocarpus sp.	Empeli
Flacourtiaceae	*Dovyalis hebecarpa* Warb	
	Flacourtia indica Merr.	Kerkup kecil
	Flacourtia inermis Roxb.	Rokam masam
	Flacourtia jangomas (Lour.) Rausch.	Kerkup
	Flacourtia rukam Zoll & Mor.	Rokam manis
	Pangium edule Reinw.	Kepayang, Pangi
Elaeocarpaceae	*Elaeocarpus spheoblastus*	Tamang
Gnetaceae	*Gnetum gnemon* (L.) Bulso	Melinjau
Guttiferae	*Garcinia atroviridis* Griff.	Asam gelugur
	Garcinia bancana (Miq.) Miq.	Kandis
	Garcinia costata Hemsley ex King	Gelugur
	Garcinia dulcis Kurz.	Mundu
	Garcinia forbesii King..	Kandis
	Garcinia griffithii T. Anders.	Kandis gajah
	Garcinia hombroniana Pierre.	Manggis hutan, Beruas
	Garcinia malaccensis Hook. f.	Manggis hutan
	Garcinia nigro-lineata Planch	Kandis
	Garcinia parvifolia (Miq.) Miq.	Kundong
	Garcinia prainiana Roxb.	Cerapu
	Garcinia xanthochymus Hook.f.	Asam kandis
Lauraceae	*Litsea garciae* Vidal	Engkala
Leguminosae	*Cynometra cauliflora* L.	Nam-nam
	Dialium indum L.	Keranji
	Pithecellobium jiringo	Tering
	Tamarindus indica L.	Asam jawa
Melastomataceae	*Plethiandra* sp.	Jambu ara, Jambu Menakan
Meliaceae	*Sandoricum koetjape* (Burm. f.) Merr. (syn. *S. nervosum* Blume)	Sentul, Kecapi, Kelampu
Moraceae	*Artocarpus altilis* (Parkins.) Fosb.	Sukun, Kemensi

(Table 1 continned)

Family	Species with edible fruits	Local name
Moraceae	*Artocarpus anisophyllus* Miq.	Bintawa
	Artocarpus dadah Miq.	
	Artocarpus elasticus Reinw. ex Blume (syn. *A. sericicarpus* Jarrett)	Terkalong, Pedalai
	Artocarpus gomezianus Wall. ex Trecul	Tampang
	Artocarpus kemando Miq.	Pudau
	Artocarpus lowii Hook. f.	Miku
	Artocarpus nitidus Trecul	Selanking
	Artocarpus odoratissimus Blanco.	Terap, Marang
	Artocarpus polyphema Pers.	Bangkong
	Artocarpus rigidus Blume	Pala munsoh, Tempunik
	Artpcarpus sarawakensis Jarrett	Pingan
Myristicaceae	*Myristica fragrans* Houtt.	Buah pala
Myrtaceae	*Eugenia uniflora* L.	Cermai belanda
	Myciaria cauliflora Berg.	
	Myciaria vexator McVaugh.	
	Myciaria paranensis Berg.	
	Syzygium aqueum (Blume. f.) Alston	Jambu air
	Syzygium cuminii (L.) Skeels.	Kerian
	Syzygium jambos (L.) Alston	Jambu mawar
	Syzygium malaccense (L.) Merr. & Perry	Jambu bol, Jambu merah
	Syzygium polyantha Wight	Salam
	Syzygium samarangense (Bl.) Merr & Perry	Jambu semarang, Jambu air mawar
	Eugenia uniflora L.	Cermai belanda
Oxalidaceae	*Averrhoa bilimbi* L.	Belimbing masam
	Sarcotheca griffithii (Planchon ex Hook.f.) Hall.f.	
Palame	*Arenga saccharifera* Labill.	Kabung
	Guilielma gasipaes L. H. Bailey	
	Salacca conferta Griff.	Kelubi, Assam paya
	Salacca zalacca (Gaertner) Voss (syn. *S. edulis* Reinw.)	Salak
Passifloraceae	*Adenia edemtis*	Janggut baong
Polygalaceae	*Xanthophyllum amoenum*	Langir
Punicaceae	*Punica granatum* L.	Delima
Rhamnaceae	*Ziziphus mauritiana* Lam.	Bedara
Rutaceae	*Citrus aurantifolia* Swingle	Limau nipis
	Citrus grandis Osbeck	Limau tambun
	Citrus microcarpa Bunge	Limau kasturi
	Citrus reticulata Blanco	Limau cembul
	Citrus sinensis	Limau cula
Sapindaceae	*Dimocarpus longan* Lour.	Matakucing, Isau, Sau, Kakus
	Lepisanthes alata (Bl.) Leenh.	Engkilili
	Leppisanthes rubiginosa (Roxb.) Leenh.	Kelat layu, Mertajam
	Nephelium cuspidatum Blume.	Lotong, Meritam
	Nephelium glabrum Noronha	Redan
	Nephelium macrophyllum	Kebuau
	Nephelium maingayi Hiern.	Serait, Mujau, Redan
	Nephelium melanomiscum	Melanjau
	Nephelium ramboutan-ake (Labill.) Leenh.	Pulasan

(Table 1 continned)

Family	Species with edible fruits	Local name
	Pometia pinnata J. R. & G. Forster	Kasai
	Xerospermum laevigatum Radlk	Rambutan pacat
	Xerospermum noronhianum (Blume) Blume	Rambutan pacat
Sapotaceae	*Chrysophyllum cainito* L.	Kameta
	Manilkara kauki (L.) Dubard.	Sauh
Sonneratiaceae	*Sonneratia alba* J. Smith	Pedada
Sterculiaceae	*Scaphium macropodum* Beumee	Kembang semangkuk
	Sterculia foetida L.	Kelumpang

(Compiled from: Meijer, 1969; Cockburn, 1976; Hashim Md. Noor, 1987; Corner, 1988; Voon *et al.*, 1988; Wong and Lamb, 1988; Lemmens *et al.*, 1989; Zainal Abidin Mohamed *et al.*, 1989; Saw *et al.*, 1991; Verheij and Coronel, 1991; Wong, 1992; Rukayah Aman, 1993; Wan Razali Wan Mohd., 1993; Wong, 1993)

Studies on propagation methods, morphology, productivity and fruit storage of some under-utilized fruit tree species have also been carried out (Wong, 1990; Rukayah Aman *et al.*, 1993). Reproductive biology of some of these species has been studied and these have been reviewed by Soepadmo (1979, 1989). A number of products such as jams, juices, light snacks and others have been obtained from the fruits of some of these under-utilized fruit species (Rukayah Aman *et al.*, 1993).

Apart from evaluating the under-utilized fruit tree species for development into new fruit types, the genetic resources are also assessed for their potential to improve existing cultivated fruit crops. The taxonomic proximity of these under-utilized fruit tree species to cultivated fruit crops is of economic significance. This is particularly true for the wild relatives of fruit tree species already cultivated. These wild fruit tree species could be useful for plant breeders looking for ways to improve existing cultivars. Disease resistance, dwarfing ability, adaptation to certain environments are some of the traits being evaluated for the wild fruit tree resources.

Potential of under-utilized fruit tree species

Among the under-utilized fruit tree species, some have been found to have a potential for either development into new fruit crops or for use of traits which may be important for improving the existing cultivated fruit trees. Within the limits of this paper, some of these species are described below.

1. Genus *Artocarpus* (Family Moraceae)

The better known species which are commonly cultivated are the jackfruit (*Artocarpus heteropyllus* L.) and breadfruit (*A. altilis* (Perkins.) Fosb.), both of which are introduced species, and the "cempedak" (*A. integer* Merr.), which is an indigenous species. Majority of the species are found in lowland forests while some species occur in swampy areas as well as on highlands up to 1700m above sea level. The fruit of *Artocarpus* is a syncarp with a husk which is usually not edible. The fleshy perianths surrounding the seeds which are eaten though the seeds are edible after roasting or boiling. Under-utilized fruit species of *Artocarpus* species which are indigenous to Malaysia and can be promoted as new fruit species in their own rights are as follows:

Artocarpus anisophyllus Miq.

Locally known as "bintawa", the almost globose syncarp shows fairly dense spines and is yellowish brown when ripe. The inedible husk can be easily peeled off to reveal the yellowish orange fleshy perianths which are very sweet. Seeds are edible when roasted.

Artocarpus elasticus Reinw. ex Blume (syn. *A. sericicarpus* Jarrett).

Locally called the "pedalai" or "terkalong". The oblong yellowish brown syncarp, 8.5cm × 5cm, has long flexible spines. The inedible husk can be easily peeled. Fleshy perianths whitish in color, sweet in

taste display a strong aroma. Seeds are edible when roasted.

Artocarpus odoratissimus Blanco.

Known as "terap" or "marang" this species is reported mainly in Sarawak and Sabah. The subglobose greenish yellow syncarp has densely set, short and stiff spines. Fleshy perianths are white, juicy, and fragrant.

Artocarpus rigidus Blume

Known as "pala munsoh" or "tempunik", this plant probably belongs to the subspecies *rigidus*. Fruit consists of a globose syncarp, measuring 8cm in diameter, with densely-set, rigid, long spines. When ripe, fruit turns yellowish brown and husk can be easily peeled. There are humorous fleshy perianths, golden yellow and sweet in taste.

2. Genus *Baccaurea* (Family Euphorbiaceae)

The trees are of medium size and frequently found in lowland forests although they have been recorded over a wide range of habitats from fresh water swamps to the top of mountains. The better known species is the "rambai" (*Baccaurea motleyana* Muell. Arg.) while the under-utilized species with a potential as new fruit crops are described below.

Baccaurea angulata Meijer

Known as "bilimbing hutan" or "uchong", the tree is small to medium-sized and a heavy bearer. Fruits, borne on trunk and branches, are narrowly spindle-shaped, sharply angled, resembling the fruit of carambola (*Averrhoa carambola* L.). When ripe, they show a red to purplish black color. Fruit is often sour and suitable for making pickles or fruit juice. Forms bearing sweeter fruits can be found and show a potential for cultivation as new fruit crop. Analysis of the fruits revealed the presence of relatively high potassium and carbohydrate contents.

Baccaurea bracteata Muell. Arg.

Known as "tampoi paya" or "tampoi putih", this species is closely related to the "rambai" (*B. motleyana* Muell Arg.). Tree, up to 20m in height. Fruits, borne on trunk, show a globose capsule, 5cm in diameter, with thick, inedible, orange to brown rind with a distinct outline of tricarpellary lobes. Pulp is orange and very sweet.

Baccaurea macrocarpa (Miq.) Muell. Arg. (syn. *B. griffithii* Hook. f.)

Known as "tampoi jintik merah" or "puak" or "larah". Tree, 10–15m in height. Fruit has a globose trilocular capsule, 5–7cm in diameter with thick, brown to grey rind. Pulp is cream-white, with a total soluble solids content of 24.4% and Vitamin C content of 28.9mg/100g.

3. Genus *Canarium* (Family Burseraceae)

Species are found mainly in lowland primary forests. Species with a potential for development into new fruit crops include :

Canarium kadondon Benn. (syn. *Dacryodes rostrata* (Bl.) Lam.

Known as "kembayau" or "kedondong kerut" or "keramoh". Tree is small to medium-sized up to 25 m in height, sometimes with buttresses. Fruit is a drupe, ovoid to oblong, 1.3–2.6cm × 0.7–1.0cm, showing yellow to purple ripening. Mesocarp softens in hot water, and is eaten in a similar manner to that of "dabai", with a flavor of avocado. Analysis of the fruits revealed a high fat content of about 37% and high protein and manganese contents.

Canarium littorale Blume

Known as "Meritus." Fruit, green, broadly triangular, 4 × 1.5—7 × 3cm. Stone acutely triangular. Seeds 1–2, sterile cells visible but reduced.

Canarium odontophyllum Miq.

Known as the "dabai", the tree can grow up to 21m in height. Flowers are white. Fruit is an ellipsoid dark purple drupe with persistent calyx. Mesocarp encloses a stony seed which is often broadly triangular or egg-shaped. The rich oily mesocarp is eaten after steeping the fruits in boiling water for a period of 10–15 minutes. Addition of fine salt to enhance the taste of the mesocarp is usually recommended. Fruiting season is from August to December in Sarawak and Sabah. Shelf life of the fruit is rather short. When stored under ambient temperature beyond 3 days, the normally hard fruit wall becomes soft and

wrinkles.

4. Genus *Dialium* (Family Leguminosae)

Species occur mostly in lowland forests. Of particular interest is the species *Dialium indum* L. which is already cultivated to a certain extent in southern Thailand.

Dialium indum L. (Syn. *Dialum cochinchinensis* Pierre)

Known as "keranji". Medium to big tree up to 35m in height and 2.5m in girth. Pod is ellipsoidal and velvety black or dark brown with a hard and brittle pod wall. Pod contains one seed surrounded by a reddish, sweet, rather pithy, edible pulp which can be mixed with sugar or chilli pepper to enhance the taste. Flavor resembles that of tamarind. Long shelf life of several months. Many forms are known to exist. Analysis revealed high iron, manganese and sugar contents.

5. Genus *Dimocarpus* (Family Sapindaceae)

The genus *Dimorcapus* is reported to contain six species of trees or shrubs. Five of the species (*D. longan*, *D. dentatus*, *D. gardneri*, *D. foveolatus and D. fumatus*) are found in Asia, from Sri Lanka and India to Sabah and Sarawak; one (*D. australianus*) occurs in Queensland, Australia (Leenhouts, 1971, 1973). In Sabah, three species of *Dimocarpus* have been reported viz. *D. longan*, *D. dentatus* and *D. fumatus* (van Welzen *et al*., 1988). Among these species, *D. longan* is the most promising species where the commonly cultivated longan occurs in subtropical regions in South China, Taiwan, northern Thailand and Australia.

Dimocarpus longan Lour

This species can be separated into 2 subspecies and 5 botanical varieties viz. ssp. *longan* var. *longan*, ssp. *longan* var. *longepetiolulatus*, ssp. *longan* var. *obtusus*, ssp. *malesianus* Leenh. var. *malesianus*, and ssp. *malesianus* Leenh. var. *echinatus*. The main cultivated subspecies is the longan (ssp. *longan* var. *longan*) mainly in subtropical regions in south China, Taiwan, northern Thailand, and Australia. Beside the longan, the other members of *D. longan* are less commonly cultivated. Among these, the ssp. *malesianus* var. *malesianus* shows the greatest variation in Borneo where it may be distinguished from 30-40 local races or forms (Leenhouts, 1971). This taxon has created a great interest since some forms have sweeter and nearly as thick arilloid as the longan (Wong and Gan, 1990; Wong *et al*., 1991). With selection and horticultural manipulations these superior forms may offer an attractive alternative to the longan for the humid tropical lowlands.

The local races of *D. longan* spp. *malesianus* var. *malesianus* can be grouped into four broad forms, differing in vegetative, floral and fruit characteristics (Wong and Gan, 1990; Wong *et al*., 1991). The most common form is globose with a smooth pericarp which turns brown when ripe. This is the true "mata kucing" which is usually identified as *Nephelium malaiense* Griff. The fruits show a very thin arilloid. This form is found in Peninsular Malaysia, Sabah and Sarawak. The other three forms known locally as "isau", "sau" and "kakus" are found mainly is Sabah and Sarawak. These are superior forms where the fruits have a thicker arilloid and the pericarp is densely warty. Fruits of "isau" are globose and remain green when ripe, those of "sau" are sighty ellipsoid (or oblong) and also remain green when ripe, whilst fruits of "kakus" are globose but turn brown when ripe. The "isau" shows the greatest potential for exploitation because fruits of this form usually have the thickest arilloid which also displays the highest Brix value, vitamin C, calcium and iron contents.

6. Genus *Durio* (Family Bombaceae)

Among all the species with edible fruits, only *Durio zibethinus* Murr. or the ordinary durian is widely cultivated. The fruit, a dehiscent capsule, is often dubbed as the "king of tropical fruits". The large spiny fruits with their repugnant odor are much sought after by those who have acquired the taste. Besides *D. zibethinus*, the other species are under-utilized and occurring wild in the Malaysian forests, particularly in Sabah and Sarawak.

Durio dulcis Becc.

Known as "durian tutong" or "durian tahit" or "durian merah", it is found mainly in Sabah and Sarawak. Large tree, up to 40m tall. Fruit is a globose capsule, up to 15cm in diameter, dark red to red-

dish brown in color, with long, slender spines. Aril is usually thin, yellow, very sweet with strong odor and brown seeds. Offers a potential as new fruit crop as well as material for improving the cosmetic look of the cultivated ordinary durian.

Durio grandiflorus (Mast.) Kost. et Soeg.

Known as "durian munjit" or "durian hantu hutan", this species is only found in Sabah and Sarawak. Tree, up to 20m in height. Fruit is an ellipsoid capsule, up to 20cm × 15cm, with stiff spines up to 2cm long. Aril is yellow, edible. Found mainly in rainforests of Borneo.

Durio graveolens Becc.

Known as "durian rimba" or "durian burning." Fruit is a globose to ellipsoid capsule, about 10–15cm in diameter, green to orange in color, with sharp pyramidal spines, dehiscent into 5 valves while still attached to the tree. Aril is red or orange, sweet, creamy, dry and without aroma. Its early precocity can offer a potential for improving the cultivated ordinary durian.

Durio oxleyanus Griff

Known as "durian isu" or "durian sukang" or "durian beludu", this species is considered to offer the highest potential as wild durian. Fruit is globose, 15–20cm in diameter, with broad, long and curved spines, remaining green when ripe. Aril is thin, yellow or orange, sweet with good flavor and aroma and high vitamin C, protein and fat contents.

Durio kutejensis (Hassk.) Becc.

Known as "durian nyekek" or "durian lai", this species is found only in Sarawak and Sabah. Tree, up to 24m tall and trunk 40cm in diameter. Fruit is an ovoid or ellipsoid, pentangular capsule, up to 20cm × 12 cm, with short spines which are slightly curved, golden yellow when ripe. Aril is yellow or dark orange, sticky, and with a flavor comparable to that of ordinary durian. This species has been domesticated in Sabah (Cockburn, 1976; Wong and Lamb, 1988). In addition, this species may offer a potential as dwarfing rootstock for the ordinary durian since it has been reported that cultivated trees start fruiting when 4–5 m tall.

Durio testudinarium Becc.

Known as "durian kura-kura" this species is rare and confined mainly to Sabah and Sarawak. Tree, up to 25 m tall. Fruit borne mainly on the trunk close to the ground. Fruit is a globose capsule 10–15 cm in diameter, with short conical-pyramidal spines, turning yellow on ripening. Aril is yellow, has a caramel custard flavor with a watery texture and an unpleasant smell occurs. In lowland rain forests. Has been reported to be tolerant to soil-borne diseases such as Phytophthora and, therefore, may be a valuable rootstock.

7. Genus *Garcinia* (Family Guttiferae)

The trees are small to medium-sized and occur in the forest as understorey trees. The better known species which is widely cultivated is the mangosteen (*Garcinia mangostana* L.). Fruit is a berry, with a thick pericarp enclosing edible pulp with flattened seeds. Rind usually exudes a yellow latex when damaged. Usually the pericarp is not edible, though in some species it is edible. Less known species occurring in the wild stab are:

Garcinia atroviridis Griff.

Known as "asam gelugur". Tree, up to 20m in height. Fruit is a depressed globose berry, about 7cm in diameter, with many grooves. Pulp is pale rose to crimson. The sour rind, when dried, can be used as seasoning.

Garcinia nigro-lineata Planch.

Known as "kandis", the fruits are small and round, turning yellowish green to orange when ripe. The rind is sour and can be used for cooking.

Garcinia parvifolia (Miq.) Miq.

Known as "kundong". Tree is small to medium-sized. Fruit is a globular to ovoidal berry with thin rind and ripening yellow to red. Pulp is white, watery and sweet.

8. Genus *Litsea* (Family Lauraceae)

Under-utilized species with a potential under this genus is *Litsea garciae* Vidal.

Litsea garciae Vidal

Known as "engkala", tree, medium-sized, 10-20m in height. Fruit is a depressed-globose pulpy berry, 2.5-4.5cm in diameter and is seated on a persistent green calyx cup, showing yellow to pink or dark red ripening. Fruits are sometimes sold in small baskets. They are eaten after steeping in hot water for about 10-15 minutes. The soft, white oily pulp is then scooped up with a teaspoon during eating. Fine salt may be added to enhance the taste.

9. Genus *Mangifera* (Family Anarcardiaceae)

The main cultivated species is the mango (*Mangifera indica* L.). Fruit is a drupe. Beside *Mangifera indica*, there are many species which have a potential but are under-utilized.

Mangifera caesia Jack.

Known as the "binjai" or "beluno". Fruit oval to pyriform drupe, 12-15cm × 6-7cm. Two fruit forms have been reported in Sabah (Wong, 1993). Unlike the ordinary mango, the aroma is unique, so is the flavor. The form with a coarse, more brownish yellow colored skin is known as the "beluno". Mesocarp is white and has a sourish sweet taste, sometimes astringent in nature. This is a variety not good for eating. The "binjai", on the other hand, has a smoother, green-colored skin. Mesocarp is white and is usually sweet and less fibrous than the "beluno". This variety has a potential for becoming a fruit for fresh consumption, though selection for varieties with a better quality and less fibrous should be considered.

Mangifera laurina Blume

Known as "mempalam" or "mangga air". Tree is 20-30 m in height and a heavy bearer. Fruit is an obliquely oval or ellipsoidal drupe of average size. When ripe, the skin remains light green. Pulp yellow, juicy and sweet though fibrous. Offers a potential as a source of juice.

Mangifera odorata Griff.

Known as "kuini". Tree, 10-15m in height. Fruit is an oval to obliquely broad drupe, 10-13cm × 6-9 cm, with yellowish green skin. Strong aroma when ripe. Mesocarp yellow to orange, very sweet and relatively fibrous. Potential as fruit in its own right through selection of sweet varieties.

Mangifera pajang Kost.

Known as "embang" or "bambagan". Tree, 15-33m in height. Fruit is a large and globular drupe, up to 20cm in diameter, with coarse, pale-brownish skin which can be peeled off easily. Pulp is yellowish with a sweet to sour taste. There are smaller fruit forms with a much sweeter taste. Immature fruit is used for preservation of raw meat in Sabah. Potential as a fruit for fresh consumption.

10. Genus *Nephelium* (Family Sapindaceae)

The species best known under this genus is the rambutan (*Nephelium lappaceum* L.). Fruit is a drupe with inedible seed bearing fleshy sarcotesta. Beside the rambutan, the under-utilized species which can be developed into new fruit crops are listed below.

Nephelium cuspidatum Blume

Known as "lotong" or "meritam" or giant rambutan, this species consists of many varieties such as var.*eriopetalum* (Miq.) Leenh., var. *ophiods* (Radlk.) Leenh. and var. *robustum* (Radlk.) Leenh. The var. *robustum* has a larger leaflet and fruit size than the other varieties. Tree up to 40m in height, sometimes with buttresses. Fruit ellipsoid to globular drupe, 2-4cm × 2-3cm, with dull red rind which is densely set with soft spintern. Sarcotesta opaque white and generally sourish though sweeter forms have been identified among var.*robustum* in Sabah (Wong and Lamb, 1988).

Nephelium maingayi Hiern.

Known as "redan" or "mujau" or "serait". Tree up to 40m in height, sometimes with buttresses. Fruit small, about 3 × 1.6cm, flattened ellipsoidal drupe with a persistent style. Rind smooth to slightly warty turning bright red when ripe. Sarcotesta is thin though sweet in taste.

Nephelium ramboutan-ake (Labill.) Leenh.

Resembling closely the rambutan, this species is known as "pulasan." Tree, up to 15m or more in height. Fruit, ellipsoid to subglobular, 4-6.5cm × 2.5-5cm, bears short, stubby spines instead of long spintern as in rambutan. Like the rambutan, the edible part of pulasan is also the white sarcotesta. Many va-

rieties are found with a rind color ranging from green, yellow and purplish black. In Sabah, a local selection among the purple-black variety has been reported to show a very thick aril which is sweet, with good flavor and crunchy texture (Wong, 1993). It has a total soluble solids content of 22.3% and Vitamin C content of 23.5 mg/100g.

11. Genus *Salacca* (Family Palmae)

Salacca zalacca (Gaertner) Voss (syn. *Salacca edulis* Reinw.)

Known locally as "salak". This species is becoming popular. A relatively small, usually dioecious, very spiny, creeping and tillering palm, growing in compact clumps due to successive branching at the base. Fruit globose to ellipsoid, about 5-7 cm × 5 cm, tapering towards the base and rounded at top, each spadix contains 15-40 fruits. Fruit rind comprises numerous yellow to brown, united, imbricate scales, each scale ending in a fragile prickle. Sarcotesta cream-colored, fleshy, with total soluble solids content of 17.7% and Vitamin C content of 5.4 mg/100 g.

12. Genus *Syzygium* (Family Myrtaceae)

Some of the introduced species having a potential for larger scale cultivation are outlined below.

Syzygium malaccense (L) Merr. & Perry

Known as "jambu bol", "jambu merah" or Malay apple. Tree low to medium-sized, up to 20m in height and a heavy bearer. Fruit is an ellipsoid-globose berry, pear-shaped, flattened at the apex, crowned by much enlarged, thick, fleshy calyx segments, 5-6cm in diameter, white splashed or striped with crimson -pink, or wholly pale crimson to purplish, rather dull. Flesh white, pithy, juicy, with a low total soluble solids content of 7.0% and high Vitamin C content of 40 mg/100g.

Syzygium samarangense (Bl.) Merr. & Perry

Known as "jambu semarang" or "jambu air mawar". Tree low, 5-15m in height. Fruit is a broadly pyriform berry, 3.0-4.5cm long and 5cm in diameter, shiny, flattened at the apex, crowned by thick calyx segments which are incurved over the markedly dilated disk, skin thin, smooth, light green or white with some red color. Flesh greenish or white, spongy, with a low soluble solids content of 8.5% and Vitamin C content of 24.8 mg/100g.

Conclusions

Under-utilized fruit tree genetic resources in Malaysia remain relatively unexploited. The foregoing review has revealed a promising array of these species which show a potential either for developing into new commercial fruit crops or improving fruit crops already under cultivation. This review is in no way comprehensive and has covered only a very small section of the diverse under-utilized fruit tree species in Malaysia. Many of these fruits are unknown outside the areas where they are found. The wild fruit tree species found in the Malaysian rain forests may be facing the threat of erosion as a result of activities such as logging and other developments. Thus collection and conservation of these materials in the various arboreta in the country is a step in the right direction. It is hoped that through selection and improvement, more of the under-utilized fruit tree species can be brought into cultivation, thus expanding the choice of tropical and subtropical fruits available to consumers. Of particular interest is the presence of diverse wild relatives of species already cultivated. This obviously provides the plant breeders with ample resources of genetic material for improvement programs of the Malaysian fruit tree species.

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