

Phenotypic evaluation of some promising rare fruit crops in the Philippines

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Six selected rare fruit species, two endemic and four introduced into the country, were evaluated phenotypically for tree and fruit characteristics. These species include: Cedar Bay Cherry (*Eugenia carissoides* F. Muell.), “Hunggo” (*Elaeocarpus calomala* Turcz.), “Katmon” or Elephant Apple (*Dillenia philippinensis* Rolfe), “Kepel” (*Stelechocarpus burahol*), “Lovi-lovi” or Governor’s Plum (*Flacourtia enermis* Roxb.), and Giant Soursop (*Annona montana* Macfayd.). The Cedar Bay Cherry from Australia is a shrub up to 2.0 m high; the fruits are globose to roundish (1.73 g) with shrimp red skin that are eaten fresh or made into jam or jelly. The “Hunggo”, an endemic species in the Philippines, is a very large tree up to 30 m high; the fruits are oblong (7.5 g) with dark purple red skin, sub-acid flesh and astringent taste that are usually eaten fresh mixed with a little salt. “Katmon”, another endemic species in the country, is a medium-sized tree up to 17 m high; the fruits are globose to ovoid (73.9 g) with yellowish green skin when ripe, and sour flesh that can be eaten raw, or made into souring agent, jam or jelly. The “Kepel” from Indonesia is a small tree, up to 5.50 m high; the fruits are ovoid (101.76 g) with Chinese yellow flesh, that is sweet (9.44 °Brix) and can be eaten raw or made into sherbet. The “Lovi-lovi”, also from Indonesia, is a small- to medium-sized tree up to 6.51 m high; the fruits are spheroid (4.35 g) with very dark purple peel and copper brown flesh that is sub-acid to sweet (12.0 °Brix) that can be eaten fresh or made into preserve. The Giant Soursop from Florida, USA is a medium-sized tree that grows up to 10.0 m high; the fruits weigh 1,550 g, are obovoid, and greenish when ripe, with sub-acid flesh that can be made into preserve.

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INTRODUCTION

The Philippines has 3,600 identified native trees, 67% of which are endemic or found only in our archipelago (GCSFHESE 2012). In terms of the fruit-bearing species, there are some 2,500 tropical fruits worldwide (Wolfgang and Kessler 2008) and out of those, more than 300 edible perennial plant species have been reported in the Philippines. However, only five are considered major fruits including banana, pineapple, mango, papaya, and citrus. About another 20 more species are economically important but are not fully utilized including avocado, breadfruit, caimito, canistel, cashew, ciruela, durian, guava, jackfruit, langsat, mandarin orange, mangosteen, pili, pummelo, rambutan, santol, sapodilla, soursop, sugarapple, and tamarind (Coronel 2011a). The other fruit species are considered rare but very promising since they have great potential for development of products both for the local and foreign markets. In addition, they have high nutritive value, have diversity of uses, have potential for domestic and export markets, have potential for primary and secondary processing, are high or prolific yielders, and should have potential for creating new employment for local residents (Coronel 1998).

Very recently, however, these rare fruit species caught a lot of attention among fruit enthusiasts and agricultural policy makers because of their potential as a new fruit for income generation especially those with processing and culinary potential. Processed fruits in the form of preserves, jam, jelly, marmalade, canned in syrup, and those that are dehydrated are now in demand in many supermarkets. In addition, with climate change being a worldwide problem, conservation agriculture that could prevent erosion and loss of ground water, improving soil fertility that can be achieved by planting trees (Smith et al. 2007), and

KEYWORDS

Cedar Bay Cherry, Giant Soursop, “Hunggo”, “Katmon” or Elephant Apple, “Kepel”, “Lovi-lovi” or Governor’s Plum

the growing of fruit-bearing species, can be regarded as a long-term solution for adaptation to this worldwide pressing problem.

Furthermore, many of the rare fruit crops are potential sources of phytochemicals, antioxidants, nutraceuticals, and other compounds for the promotion of beauty, health, and wellness (DA-BAR 2011). Fruits are known as “functional foods” because of the pharmacologically active phytochemicals and antioxidants that they contain. These have physiological benefits that can protect people from sickness or reduce the risk of developing chronic diseases (Galvez Tan and Maraña-Galvez Tan 2008). For instance, the mangosteen contains xanthone, an anti-tumor, anti-leukemic, and antiviral compound (Tan 1980), while the pomegranate or “granada” has pellertriene alkaloids, another anti-skin cancer natural compound (Pei 2000). In addition, the “duhat” possesses phenols, tannins, alkaloids, and triterpenoids, which are antibacterial and have hypoglycemic action (Chevalier 2001), while the papaya has chymopapain that is effective against prostatic inflammation (Balch 2002).

While perennial fruit crops need at least five to seven years before they produce fruits, the waiting time is very rewarding to any grower. This is probably even more exciting especially for rare species that are unfamiliar to many. A well-established fruit conservation farm called “RC Fruit Nursery” located in Mabacan, Calauan, Laguna owned by Dr. Roberto E. Coronel, an Emeritus Professor of the College of Agriculture, is a rich source of both endemic fruits in the Philippines and those that he introduced into the country several years ago (Coronel 2011b). Since these species have just fruited for the first time, it is necessary that they be evaluated for their fruit characteristics; hence, this study was conducted to: i) evaluate the tree and fruit characteristics of the newly fruiting fruit species, and ii) document the tree and fruits of these species.

MATERIALS AND METHODS

Fresh ripe fruit samples were obtained from the RC Fruit Nursery in Mabacan, Calauan, Laguna in coordination with Dr. Roberto E. Coronel. Twenty-five fruits per species were harvested at the ripe stage and taken to our laboratory at the Institute of Plant Breeding, College of Agriculture, University of the Philippines, Los Baños for evaluation of selected traits. Harvesting was done at different times when ripe fruits become available for each species being monitored. These species include: Cedar Bay Cherry (*Eugenia carissoides* F. Muell., Myrtaceae), “Hunggo” (*Elaeocarpus calomala* Turcz., Elaeocarpaceae), “Katmon” or Elephant Apple (*Dillenia philippinensis* Rolfe, Dilleniaceae), “Kepel” (*Stelechocarpus burahol*, Annonaceae), “Lovi-lovi” or Governor’s plum (*Flacourtia enermis* Roxb., Flacourtiaceae), and Giant Soursop (*Annona montana* Macfayd., Annonaceae).

The tree characters evaluated were height, canopy spread, trunk or girth diameter, number of years to first fruiting, harvest season, and yield. The leaf characters recorded were leaf blade length, width, color, shape, apex, base, texture, margin, and venation; and petiole length and width. The qualitative evaluation of the leaf shape, apex, margin, and venation were based on the standard descriptions and illustrations found in the book, “Vascular Plant Systematics” (Radford et al. 1976), while the

leaf color, petiole color, peel color, and seed color were described based on the Royal Horticulture Colour Chart (RHCC) published by the Royal Horticultural Society (RHS) of London (RHS 1966).

The fruits were characterized based on whole fruit shape, weight, length, and width; peel color, texture, and thickness; and flesh texture, flesh color, total soluble solids (TSS), edible portion, and titratable acidity (TA). The TSS was measured using a hand held refractometer, while the TA was determined using the titration method. In addition, the seeds were evaluated based on seed number per fruit and total seed weight per fruit; and weight of individual seeds, length, width, thickness, seed color, and shape.

STATISTICAL ANALYSIS

Twenty-five ripe fruit samples from the different rare fruit species evaluated were used for the assessment of the different fruit characters. Evaluation of all characters was conducted over three fruiting seasons. In assessing seed characters, 30 seed samples were used; while for leaf characters, 20 mature leaf samples were used. Since these tree species are rare in the country, purposive sampling involving three to five trees was used in the evaluation. The mean or average of all quantitative fruit characters was taken. These data are presented in tabular form.

RESULTS AND DISCUSSION

Phenotypic characteristics of “Lovi-lovi”

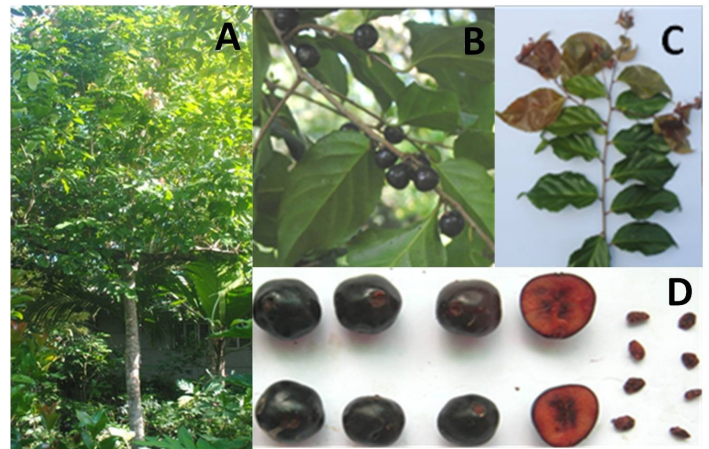


Figure 1. (A) A twenty-six year-old tree of “Lovi-lovi” grown from an open-pollinated seed, (B) its cauliflorous fruiting habit showing the clustered dark purple fruits borne on the leaf axils, (C) the alternate leaf arrangement, and (D) whole ripe fruits, longitudinal sections, and seeds.

Tree and leaf characteristics

The tree, leaf, and petiole characteristics of “Lovi-lovi” are shown in Table 1. The “Lovi-lovi” trees are medium-sized that can grow to an average height of 6.51 m with a canopy diameter that can reach 6.70 m. This fruit was introduced into the Philippines from Sumatra, Indonesia by Dr. Roberto E. Coronel in 1987. Attesting to this claim is the fact that “Lovi-lovi” is not included in Father Manuel Blanco’s list of tropical fruits introduced into the Philippines during the Spanish occupation

Table 1. Tree and leaf characteristics of “Lovi-lovi” (*Flacourtia inermis* Roxb.).

Main Character	Parameters Evaluated	Description
Tree	Height (m)	6.51
	Canopy spread (m)	6.70
	Trunk diameter (cm)	20.5
	Trunk color	Cinnamon purple (RHCC 165 C)
	Average number of years from planting to first fruiting	4.5
	Vigor	high
	Harvest season	June-July and October-November
	Yield (average number of fruits/year)	30,000
Leaf	Arrangement	Alternate
Leaf Blade	Color of mature leaf, adaxial side	Dark green (RHCC N137A)
	Color of mature leaf, abaxial side	Light green (RHCC 137 A)
	Color of young leaf, adaxial side	Chrysanthemum crimson (RHCC 185 A)
	Color of young leaf, abaxial side	Light purple (RHCC 178 A)
	Shape	Obovate
	Apex	Acuminate
	Base	Petiolate
	Texture	Smooth
	Margin	Slightly wavy
	Venation	Reticulate, distinct
	Length (cm)	14.57
	Width (cm)	7.37
	Petiole	Length (mm)
Width (mm)		2.60
Color		Brownish purple (RHCC 176 A)

Table 2. Fruit characteristics of “Lovi-lovi” (*Flacourtia inermis* Roxb.).

Main Character	Parameters Evaluated	Description
Whole Fruit	Shape	Spheroid
	Weight (g)	4.35
	Length (cm)	1.79
	Width (cm)	1.88
Peel	Color	Very dark purple (RHCC N186A)
	Texture	Smooth
	Thickness (mm)	1.30
Seed	Color	Dark purple (RHCC 187A)
	Shape	Oblong
	Average seed number	9.5
	Weight, total (g)	0.69
	Weight, individual (g)	0.08
	Length (cm)	0.56
	Width (cm)	0.41
	Thickness (cm)	0.19
Flesh	Texture	Smooth
	Color	Copper brown (RHCC 175A)
	Total soluble solids (°Brix)	12.0
	Edible portion (%)	61.27
	Titration Value (meq/10ml)	0.09

(Blanco 1837). It is not also included in the enumeration of plants found in the book, "Food Plants of the Philippines" (Wester 1921), suggesting that it was not introduced during the American regime. Figure 1A shows a twenty-six year-old fruiting tree of "Lovi-lovi" grown from open-pollinated seeds. The trunk that is cinnamon purple (RHCC 165 C) has a diameter of 20.5 cm (Table 1). The tree bears fruit 4.5 years after planting a one-year old seedling. The flowering and fruiting of "Lovi-lovi" are seasonal. Fruits mature in about four months from flowering, while the next flowering and fruiting cycle starts immediately after the fruits mature. There are fruits on the tree almost all year round under Los Baños conditions. However, there are two peaks of fruiting season namely: from June to July and from October to November.

The fruits readily mature on the tree, but fruit maturity does not happen uniformly. Because of this manner of ripening, there are harvestable fruit each day on the tree. "Lovi-lovi" has a cauliflorous fruiting habit where the flowers and fruits clusters are borne all over the branches in leaf axils (Figure 1B). There are 1-4 fruits clustered in each leaf axil. The branches tend to bend downward due to a heavy load of fruits. A heavy-fruiting tree can yield an average of 30,000 fruits in two harvest seasons within one year.

The alternate leaf arrangement of the "Lovi-lovi" leaves is shown in Figure 1C. The leaves on average are 14.57 cm long, 7.37 cm wide, obovate, smooth with a reticulate and distinct venation. The apex is acuminate, the base is petiolate, while the margin is slightly wavy. The adaxial side of the mature leaf is dark green (RHCC N 137 A), while the abaxial side is light green (RHCC 137 A). On the other hand, the adaxial side of the young leaf is chrysanthemum crimson (RHCC 185 A), while the abaxial side is light purple (RHCC 178 A). The leaf petiole is brownish purple (RHCC 176 A) and measures 9.0 mm long and 2.60 mm wide.

Fruit characteristics

Figure 1D shows whole fruits of "Lovi-lovi" that are fully ripe with very dark purple color, the half-ripe with rhodonite red color, and the immature fruit with lettuce green color. The whole and longitudinal section of the fully ripe fruits and the seeds are shown in Figure 1D. The fruit is a berry, spheroid, and has an average weight of 4.35 g, 1.79 cm long and 1.88 cm wide (Table 2). The peel is smooth, shiny, and thin (1.30 mm). The peel is rhodonite red (RHCC 51A) when half-ripe, but turns to dark purple (RHCC N 186A) when fully ripe. The smooth, juicy, and copper brown (RHCC 175A) flesh accounts for 61.27% of the whole fruit. The flesh is sweet with TSS of 12.0 °Brix, but contains some acid with a total acidity of 0.09 meq/10 ml juice. The fruit juice obtained from the flesh is dark brown, but after titration became light brown.

A fruit contains an average of 9.5 dark purple (RHCC N 187 A) seeds that weigh 0.69 g. Each seed weighs on average 0.08 g, is oblong in shape, and measures 0.56 cm long, 0.41 cm wide, and 0.19 cm thick.

Phenotypic characteristics of "Kepel"



Figure 2. (A) A twenty-six year-old tree of "Kepel" showing the opposite branching pattern, the cauliflorous fruiting habit and, (B) whole ripe fruits.

Tree and leaf characteristics

The tree, leaf, and petiole characteristics of "Kepel" are shown in Table 3. The "Kepel" tree is medium-sized that can grow to an average height of 5.5 m, with a canopy diameter that can reach an average of 3.0 m. This fruit was first introduced into the Philippines from Indonesia by Roberto E. Coronel in 1987. To attest to this claim, "Kepel" is not found in Father Manuel Blanco's list of fruits introduced into the Philippines during the Spanish era (Blanco 1837), nor in the book, "Food Plants of the Philippines" (Wester 1921), indicating that it was not also introduced during the American regime. Figure 2A shows a twenty-six year-old fruiting tree of "Kepel" grown from an open-pollinated seed showing its opposite type of branching. The trunk that is light black (RHCC 202 B) has an average diameter of 10.0 cm (Table 3). The tree starts to flower 20 years after planting one-year old seedling, but it bears fruit for the first time 23 years after planting. The flowering and fruiting of "Kepel" are seasonal. Fruits mature in about four months from flowering. The peak of the fruiting season is August to September under Calauan, Laguna conditions.

The fruits readily mature on the tree, but fruit maturity does not happen uniformly. While many fruits are already ripe for harvesting with cinnamon color (RHCC 165 C), others are still half-ripe (light cinnamon). "Kepel" has a cauliflorous fruiting habit where the flowers and fruits clusters are borne on the trunk. There are 1-4 fruits clustered in each peduncle (Figure 2A).

"Kepel" has an alternate leaf arrangement. The leaves are 23.4 cm long, 9.27 cm wide, elliptic, smooth, has acute base, and reticulate venation. The apex is acuminate, the base is acute, while the margin is entire. The adaxial side of the mature leaf is arras green (RHCC 139 A), while the abaxial side is light green (RHCC 137 A). The leaf petiole is light green (RHCC 137 C) and measures 13.60 mm long and 2.20 mm wide.

Fruit characteristics

Figure 2B shows whole fruits of "Kepel" that are fully ripe with cinnamon color. The fruit is a berry, ovoid, has on average a weight of 101.76 g, and measures 6.57 cm long and 5.67 cm wide (Table 4). The peel is hairy and thin (1.3 mm), and cinnamon colored (RHCC 165 C) when fully ripe. The smooth, juicy, and Chinese yellow (RHCC 20 A) flesh accounts for 59.89% of

Table 3. Tree and leaf characteristics of “Kepel” (*Stelechocarpus burahol*).

Main Character	Parameters Evaluated	Description
Tree	Height (m)	5.5
	Average canopy spread (m)	3.0
	Number of years from planting to first fruiting	23
	Harvest season	August-September
	Yield (average number of fruits/year)	55
Leaf	Arrangement	Alternate
Leaf Blade	Color, adaxial side	Arras green (RHCC 139A)
	Shape	Elliptic
	Apex	Acuminate
	Base	Acute
	Texture	Smooth
	Margin	Entire
	Venation	Reticulate
	Length (cm)	23.4
	Width (cm)	9.27
Petiole	Length (mm)	13.60
	Width (mm)	2.20
	Color	Light green (RHCC 137C)

Table 4. Fruit characteristics of “Kepel” (*Stelechocarpus burahol*).

Main Character	Parameters Evaluated	Description
Whole Fruit	Shape	Ovoid
	Weight (g)	101.76
	Length (cm)	6.57
	Width (cm)	5.67
Peel	Color	Cinnamon (RHCC 165C)
	Texture	Hairy
	Thickness (mm)	1.3
Seed	Color	Dark violet (RHCC N186C)
	Shape	Oblong
	Average seed number	4
	Weight, total (g)	17.73
	Weight, individual (g)	4.2
	Length (cm)	2.97
	Width (cm)	1.82
Thickness (cm)	1.2	
Flesh	Texture	Smooth
	Color	Chinese yellow (RHCC 20A)
	Total soluble solids (°Brix)	9.44
	Edible portion (%)	59.89

Table 5. Tree and leaf characteristics of Cedar Bay Cherry (*Eugenia carissoides*).

Main Character	Parameters Evaluated	Description
Tree	Height (m)	2.0
	Diameter (cm)	4.0
	Canopy spread (m)	2.5
	Number of years from planting to first fruiting	2.5
	Harvest season	All year round but the peak is May - June
	Yield (number of fruits/year)	400
Leaf	Arrangement	Opposite
Leaf Blade	Color, adaxial side	Dark green (RHCC N137A)
	Shape	Elliptic
	Apex	Acuminate
	Base	Petiolate
	Texture	Smooth
	Margin	Entire
	Venation	Pinnate
	Length (cm)	8.5
	Width (cm)	5.3
	Petiole	Length (mm)
Width (mm)		1.7
Color		Light green (RHCC 137 C)

the whole fruit. The flesh is sweet and juicy with a TSS of 9.44 °Brix.

A fruit contains an average of four dark violet (RHCC N186 C) seeds that weigh 17.73 g. Each seed weighs on average 4.2 g, is slightly elongated oblong, and measures 2.97 cm long, 1.82 cm wide and 1.2 cm thick.

Phenotypic characteristics of Cedar Bay Cherry

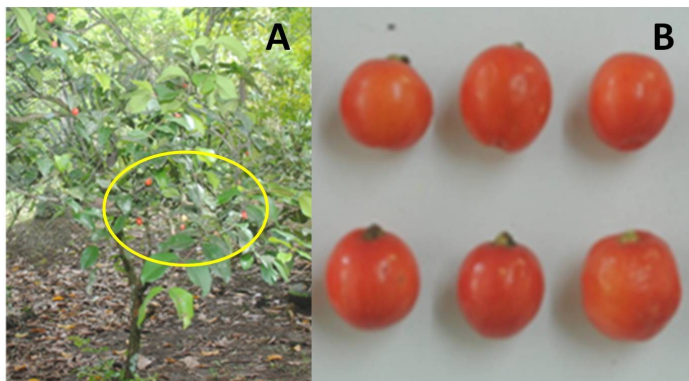


Figure 3. (A) A twenty-four year-old bush of Cedar Bay Cherry showing its fruiting habit, and (B) the ripe fruits.

Tree and leaf characteristics

The tree, leaf, and petiole characteristics of Cedar Bay Cherry are shown in Table 5. The Cedar Bay Cherry is a shrub that can grow up to 2.0 m tall with a canopy diameter that can reach 2.5 m. This fruit was originally introduced into the country from Queensland, Australia by Dr. Roberto E. Coronel in 1989. As proof to this claim, like “Lovi-lovi” and “Kepel”, the Cedar Bay Cherry was not previously found in the list of plants introduced during the Spanish regime (Blanco 1837), nor during the American regime (Wester 1921). Figure 3A shows a twenty-four year-old fruiting bush of Cedar Bay Cherry grown from an open-pollinated seed. The trunk that is light black (RHCC 202 A) has an average diameter of 4.0 cm (Table 3). The tree bears fruit 2.5 years after planting a one-year old seedling. The flowering and fruiting of Cedar Bay Cherry is all year round with a peak of fruiting from May to June under Calauan, Laguna conditions. Fruits mature in about two months from flowering.

The fruits readily mature on the tree, but fruit maturity does not happen uniformly. While many fruits are already ripe with shrimp red color (RHCC 34A) ready for harvesting, the others are still half-ripe with light red color. The fruits of Cedar Bay Cherry are borne on the uppermost leaf axils.

The Cedar Bay Cherry displays an opposite leaf arrangement. The adaxial side of the mature leaf is dark green (RHCC N 137A), while the abaxial side is light green (RHCC 137 C). The leaves are 8.5 cm long, 5.3 cm wide, elliptic, smooth, have petiolate base, thick, leathery, and have pinnate venation. The apex is acuminate, the base is petiolate, while the margin is entire. The leaf petiole is light green (RHCC 137 C) and measures 4.3 mm long and 1.7 mm wide.

Fruit characteristics

Figure 3B shows whole fruits of Cedar Bay Cherry that are fully ripe with shrimp red color (RHCC 34 A). The fruit is a

fleshy berry, globose to roundish, and has an average weight of 1.73 g, and is 1.45 cm long and 1.25 cm wide on average (Table 6). The peel is smooth and thin (1.2 mm). The smooth, juicy, sub-acid, rather fibrous, and Chinese yellow (RHCC 20 B) flesh accounts for 81.0% of the whole fruit. The flesh had a TSS of 4.0 °Brix and titratable acidity of 1.41 meq/ml.

A fruit contains one greenish-grey (RHCC 191 B) seed. The seed weighs on average 0.34 g, is round, and measures 0.83 cm long, 0.74 cm wide, and 0.99 cm thick.

Phenotypic characteristics of “Hunggo”

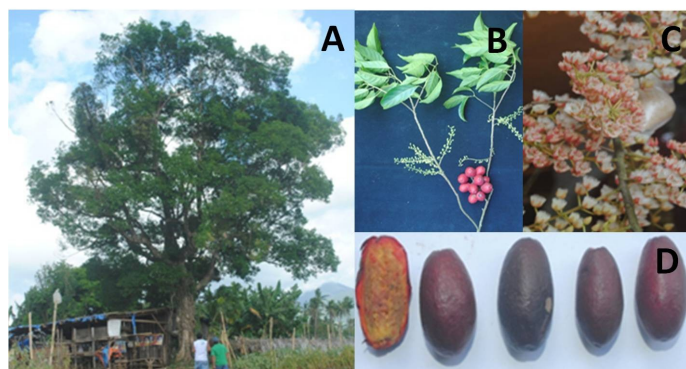


Figure 4. (A) A fifty- to sixty-year old tree of “Hunggo”, (B) the fruiting habit, (C) the inflorescence, and (D) ripe fruits and seed.

Tree and leaf characteristics

The tree, leaf, and petiole characteristics of “Hunggo” are shown in Table 7. The “Hunggo” is a large tree that can grow to a height of 30 m with a canopy diameter that can reach 17.50 m. This fruit is endemic to the Philippines and Indonesia (Coronel 2011b, Madulid 2001). Figure 4A shows a 50-60 year-old fruiting tree of “Hunggo” grown from an open-pollinated seed planted in Liliw, Laguna. The trunk of a fifty- to sixty-year old tree is light black (RHCC 202 C) and has an average diameter of 1.0 m (Table 3). The tree bears fruit six years after planting the seeds. The flowering and fruiting of “Hunggo” are seasonal. Fruits mature in about four months from flowering. The peak of fruiting season is from March to April under Liliw and Nagcarlan, Laguna conditions.

The fruits readily mature on the tree, but fruit maturity does not happen uniformly. While many fruits are already ripe for harvesting with dark purple red color (RHCC N 186 A), others are still half-ripe (chrysanthemum crimson RHCC 185 A). The fruits of “Hunggo” are borne on the branches and in clusters of up to 10 fruits per cluster (Figure 4B).

“Hunggo” has an alternate leaf arrangement. The adaxial side of the mature leaf is dark green (RHCC N 137 A), while the abaxial side is light green (RHCC 137 C). The leaves are 9.69 cm long, 4.89 cm wide; old leaves are oval, while young leaves are obovate, simple, smooth, have petiolate base and have reticulate venation, and are pointed at both ends. The apex is cuspidate, the base is petiolate, while the margin is serrate. The leaf petiole is light green (RHCC 137 C) and measures 22.2 mm long and 1.5 mm wide. The cherry-colored inflorescences are 12 cm long originating from the leaf axils. They are borne on slender spikes and are arranged oppositely on it (Figure 4C).

Table 6. Fruit characteristics of Cedar Bay Cherry (*Eugenia carissoides*).

Main Character	Parameters Evaluated	Description
Whole Fruit	Shape	Globose to roundish
	Weight (g)	1.73
	Length (cm)	1.45
	Width (cm)	1.25
Peel	Color	Shrimp red (RHCC 34A)
	Texture	Smooth
	Thickness (mm)	1.2
Seed	Color	Greenish-grey (RHCC 191 B)
	Shape	Round
	Seed number	1
	Weight , total (g)	0.34
	Weight, individual (g)	0.34
	Length (cm)	0.83
	Width (cm)	0.74
	Thickness (cm)	0.99
Flesh	Texture	Smooth
	Color	Chinese yellow (RHCC 20B)
	Total soluble solids (°Brix)	4.0
	Edible portion (%)	81.0
	Titration Value (meq/ml)	1.41

Table 7. Tree and leaf characteristics of “Hunggo” (*Elaeocarpus calomala* Turcz.).

Main Character	Parameters Evaluated	Description
Tree	Height (m)	30
	Trunk diameter (m)	1.0
	Canopy spread (m)	17.50
	Average number of years from planting to first fruiting	6
	Harvest season	March-April
	Yield (average number of fruits/year)	6,500 for mature trees
Leaf	Arrangement	Alternate
Leaf Blade	Color, adaxial side	Dark green (RHCC N137A)
	Shape	Oval-obovate
	Apex	Cuspidate
	Base	Petiolate
	Texture	Reticulate
	Margin	Serrate
	Venation	Reticulate
	Length (cm)	9.69
	Width (cm)	4.89
Petiole	Length (mm)	22.2
	Width (mm)	1.5
	Color	Light green (RHCC 137 C)

Table 8. Fruit characteristics of “Hunggo” (*Elaeocarpus calomala* Turcz.).

Main Character	Parameters Evaluated	Description
Whole Fruit	Shape	Oblong
	Weight (g)	7.5
	Length (cm)	2.7
	Width (cm)	1.9
Peel	Color	Dark purple red (RHCC N186A)
	Texture	Smooth
	Thickness (mm)	5.0
Seed	Color	Copper brown (RHCC 177B)
	Shape	Oblong
	Number	1
	Weight , total (g)	2.7
	Weight, individual (g)	2.7
	Length (cm)	2.4
	Width (cm)	1.3
	Thickness (cm)	1.82
Flesh	Texture	firm
	Color	Light purple red
	Total soluble solids (°Brix)	6.4
	Edible portion (%)	45.27

Fruit characteristics

The whole fruits and the flesh of “Hunggo” that are fully ripe have dark purple red color (RHCC N186 A), while the flesh is light purple red (Figure 4D). The fruit is a drupe, oblong, has an average weight of 7.5 g, and is 2.7 cm long and 1.9 cm wide (Table 8). The peel is smooth and thick (5.0 mm). The soft, dry, somewhat astringent, juicy, and purple flesh accounts for 45.27% of the whole fruit. The flesh is a bit sweet with a TSS of 6.4 °Brix.

A fruit contains one copper-brown (RHCC 177 B) oblong seed (Figure 4D). A seed that weighs 2.7 g measures 2.4 cm long, 1.3 cm wide, and 1.82 cm thick.

Phenotypic characteristics of Giant Soursop

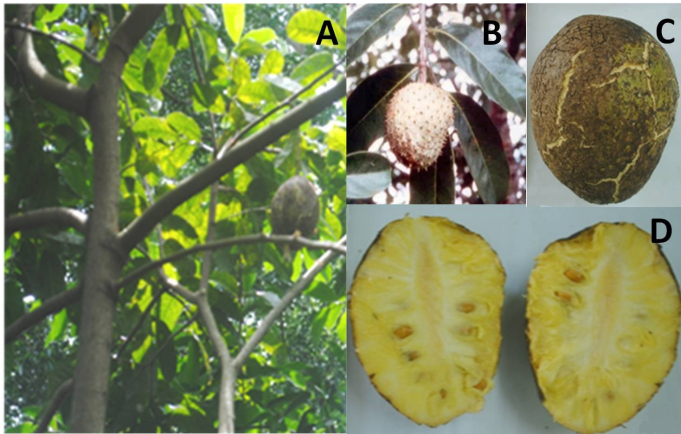


Figure 5. (A) A thirteen year-old tree of Giant Soursop, (B) its fruiting habit, (C) a whole ripe fruit, and (D) the longitudinal section of the fruit showing the yellowish flesh.

Tree and leaf characteristics

The tree, leaf and petiole characteristics of the Giant Soursop are shown in Table 9. The Giant Soursop is a semi-deciduous small- to medium-sized tree that can grow up to 10.0 m tall with a canopy diameter that can reach 2.0 m. This fruit was first introduced into the country from Florida, USA by Dr. Roberto E. Coronel in 2000. Attesting to this claim, is the fact that the Giant Soursop is not included in the list of fruits that were introduced during the Spanish, nor the American regime (Blanco 1837, Wester 1921). Figure 5A shows a seven-year old fruiting tree of Giant Soursop grown from an open-pollinated seed planted in the RC Fruit Nursery in Mabacan, Calauan, Laguna. The trunk that is dark brown (RHCC 200 A) has an average diameter of 12.0 cm (Table 9). The tree bears fruit 4-6 years after planting a one-year old seedling. The flowering and fruiting of the Giant Soursop is all year round, but the peak is from July to August under Calauan, Laguna conditions. The flowers are large and solitary on the leaf axil. Fruits mature in about four months from flowering.

The fruits readily mature on the tree, but fruit maturity does not happen uniformly. While a few fruits are already ripe with yellowish green (RHCC N 199B) peel and ready for harvesting, the others are still unripe with light green peel. The Giant Soursop has a cauliflorous fruiting habit where the flowers and fruits are borne on the trunk and on the branches (Figure 5B).

The Giant Soursop has an alternate leaf arrangement. The adaxial side of the mature leaf is dark green (RHCC N 137 A), while the abaxial side is light green (RHCC 137 C). The leaves are on average 17.16 cm long and 7.6 cm wide, malodorous, oval, broad but pointed, smooth, have petiolate base, and elliptic. The apex is mucronate while the margin is entire. The leaf petiole is dark green (RHCC N137 A) and measures 13.50 mm long and 2.60 mm wide.

Fruit characteristics

The whole fruit and the flesh of the Giant Soursop that are fully ripe had yellowish green color (RHCC N 199 B) (Figure 5C). The spines are short and sparse. The fruit is a fleshy, obovoid and has an average weight of 1,555 g, 19.0 cm long and 13.2 cm wide (Table 10). The peel is rough, and thick (5.1 mm). The slightly fibrous, juicy flesh accounts for 84.58% of the whole fruit. The flesh is yellowish (RHCC 160C), sub-acid and juicy with titratable acidity of 0.0614 meq/ml, and TSS of 5.0 °Brix (Figure 5D). While the fruit is not delicious, it is graft compatible with the soursop, hence, it could be used as a rootstock for grafting.

A fruit contains a total of 71 greyed-brown (RHCC N199 C) to black spheroid seeds that weigh a total of 59.1 g. A seed on average weighs 4.5 g, and measures 1.4 cm long, 1.2 cm wide and 1.82 cm thick.

Phenotypic characteristics of “Katmon” or Elephant Apple

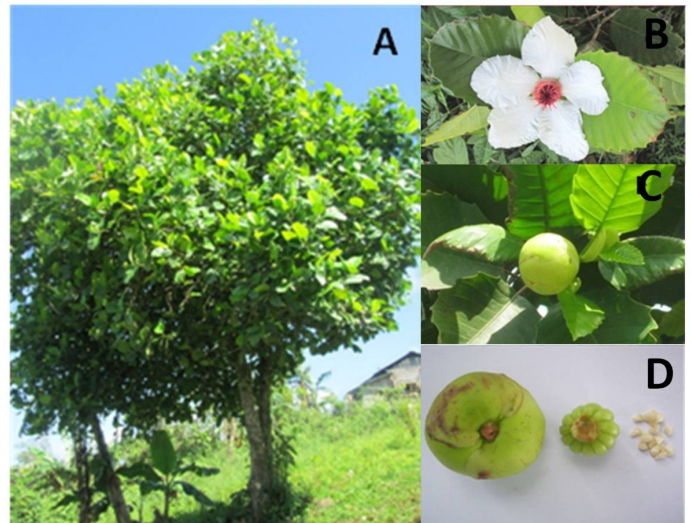


Figure 6. (A) A seven year-old tree of “Katmon”, (B) its ornamental-like flower, (C) the fruiting habit, and (D) the greenish ripe fruit enclosed by persistent fleshy sepals, and the seeds.

Tree and leaf characteristics

The tree, leaf, and petiole characteristics of “Katmon” are shown in Table 11. The “Katmon” is a medium-sized tree that can grow to a height of 17 m, with a canopy diameter that can reach 4.0 m. The “Katmon” is endemic to the Philippines (Madulid 2001) and can be found throughout the country. It is an evergreen flowering tree that grows in the slopes of Laguna, Quezon, Samar, Babuyan Islands, Cagayan, Sorsogon, Mindoro, Pulilio, Masbate, Leyte, Guimaras, Negros, Cebu, and throughout Mindanao (Soliven 2012). Figure 6A shows a seven year-

Table 9. Tree and leaf characteristics of Giant Soursop (*Annona montana* Macfayd.).

Main Character	Parameters Evaluated	Description
Tree	Height (m)	10.0
	Trunk diameter (cm)	12.0
	Canopy spread (m)	2.0
	Average number of years from planting to first fruiting	4-6
	Harvest season	All year round but peak is from July to August
	Yield (number of fruits/year)	4.0
Leaf	Arrangement	Alternate
Leaf Blade	Color, adaxial side	Dark green (RHCC N137A)
	Shape	Oval and broad but pointed
	Apex	Mucronate
	Base	Petiolate
	Texture	Smooth
	Margin	Entire
	Venation	Elliptic
	Length (cm)	17.16
Petiole	Width (cm)	7.6
	Length (mm)	13.50
	Width (mm)	2.60
	Color	Dark green (RHCC N137 A)

Table 10. Fruit characteristics of Giant Soursop (*Annona montana* Macfayd.)

Main Character	Parameters Evaluated	Description
Whole Fruit	Shape	Obovoid
	Weight (g)	1,555
	Length (cm)	19.0
	Width (cm)	13.2
Peel	Color	Yellowish green (RHCC N199B)
	Texture	Rough
	Thickness (mm)	5.1
Seed	Color	Greyed-brown (RHCC N199 C) to black
	Shape	Spheroid
	Number	71
	Weight , total (g)	59.1
	Weight, individual (g)	4.5
	Length (cm)	1.4
	Width (cm)	1.2
	Thickness (cm)	1.82
Flesh	Texture	Slightly fibrous
	Color	Yellowish (RHCC 160 C)
	Total soluble solids (°Brix)	5.0
	Edible portion (%)	84.58
	Titration Value (meq/ml)	0.0614

Table 11. Tree and leaf characteristics of “Katmon” or Elephant Apple (*Dillenia philippinensis* Rolfe).

Main Character	Parameters Evaluated	Description
Tree	Height (m)	17
	Trunk diameter (cm)	15.0
	Canopy spread (m)	4.0
	Number of years from planting to first fruiting	5.5
	Harvest season	April-May
	Yield (average number of fruits/year)	1,250 for mature trees
	Leaf	Arrangement
Leaf Blade	Color, adaxial side	Dark green (RHCC N137 A)
	Shape	Oblanceolate-Elliptic
	Apex	Acuminate
	Base	Acute
	Texture	Smooth
	Margin	Serrate
	Venation	Pinnate
	Length (cm)	18.78
	Width (cm)	13.26
	Petiole	Length (cm)
Width (cm)		0.23
Color		Light green (RHCC 137 C)

Table 12. Fruit characteristics of “Katmon” or Elephant Apple (*Dillenia philippinensis* Rolfe).

Main Character	Parameters Evaluated	Description
Whole Fruit	Shape	Globose to Ovoid
	Weight (g)	73.9
	Length (cm)	4.72
	Width (cm)	5.73
Peel	Color	Yellowish green (RHCC 145 B)
	Texture	Smooth
	Thickness (cm)	0.55
Seed	Color	White (RHCC N155 A)
	Shape	Ovoid
	Number	22.5
	Weight, individual (g)	0.56
	Length (cm)	0.47
	Width (cm)	0.36
	Thickness (cm)	1.80
Flesh	Texture	firm
	Color	Greenish (RHCC 149C)
	Total soluble solids (°Brix)	4.70
	Thickness (cm)	3.46
	Edible portion (%)	40.40

old fruiting tree of “Katmon” grown from an open-pollinated seed. The trunk that is greyish-brown (RHCC 199 A) has a diameter of 15.0 cm (Table 11). The tree bears fruit 5.5 years after planting a one-year old seedling. The flowering and fruiting of “Katmon” are seasonal. Usually the peak of fruiting season is from April to May under Cavinti and Kaliraya, Laguna conditions. The white flowers (RHCC N155 A) that are borne on the terminal portion of the branches, are large and about 15.0 cm in diameter (Figure 6B). Fruits mature in about four months from flowering.

The fruits readily mature on the tree, but fruit maturity does not happen uniformly. While a few fruits are already ripe with yellowish green (RHCC 145 B) peel ready for harvesting, the others are still unripe with light green peel. The fruits are borne on the terminal portion of the secondary branches (Figure 6C).

The “Katmon” has a whorled leaf arrangement. The adaxial side of the mature leaf is dark green (RHCC N 137 A), while the abaxial side is light green (RHCC 137 C). The leaves are 18.78 cm long, 13.26 cm wide, oblanceolate to elliptic, a bit rough and leathery, have acute base and pinnate venation with serrated or toothed margins. The apex is acuminate, the base is acute, while the margin is serrate. The leaf petiole is light green (RHCC 137 C), and measures 36.2 cm long and 0.23 cm wide.

Fruit characteristics

The whole fruit and the flesh of “Katmon” that are fully ripe had yellowish green color (RHCC 145 B) while the flesh is greenish (Figure 6D). The fruit is a fleshy, globose and has an average weight of 73.9 g, 4.72 cm long and 5.73 cm wide (Table 12). The peel is smooth, and 0.55 cm thick. The soft, acidic flesh enclosed by persistent fleshy and sticky sepals accounts for 40.40% of the whole fruit.

A fruit contains on average 22.5 white (RHCC N 155 A) seeds (Figure 6D). Each seed weighs on average 0.56 g, is ovoid in shape, and measures 0.47 cm long, 0.36 cm wide, and 1.80 cm thick.

SUMMARY AND RECOMMENDATION

The phenotypic characteristics of the different rare fruit species and the recommendations for the uses of the ripe fruits are:

The “Lovi-lovi” from Indonesia is a small to medium-sized tree, 6.51 m high with a canopy spread of 6.70 m and a trunk diameter of 20.5 cm. Fruits are spheroid berry, small (4.35 g) with very dark purple (RHCC N 186 A) and thin peel, copper brown flesh (RHCC 175 A) that is sub-acid to sweet (12.0 °Brix), has relatively moderate edible portion (61.27%), and has many but small, dark purple seeds. Ripe fruits are recommended to be eaten fresh or made into preserve.

The “Kepel”, also from Indonesia, is a small tree, 5.5 m high with a canopy spread of 3.0 m. Fruits are ovoid berry, medium sized (101.76 g) with cinnamon color (RHCC 165 C) and thin peel (1.3 mm), Chinese yellow flesh (RHCC 20 A) that is sweet (9.44 °Brix), and has relatively moderate edible portion (59.89%). A fruit contains an average of 4 seeds. A seed weighs 4.2 g and is dark violet (RHCC N 186 C). It is recommended that ripe fruits be eaten raw, or processed into sherbet.

The Cedar Bay Cherry from Queensland, Australia is a shrub up to 2.0 m high with a canopy diameter of 2.5 m. Fruits are globose to roundish, medium-sized (1.73 g) with shrimp red peel and Chinese yellow flesh with a TSS of 4.0 °Brix, and has a relatively high edible portion of 81.0%. A fruit has one large, round seed. The ripe fruits are recommended to be eaten fresh, or processed into jam or jelly.

The “Hunggo”, an endemic species to the Philippines, is a large tree that grows up to 30 m high with an average canopy diameter of 17.50 m. Fruits are oblong, medium-sized (7.5 g) with dark purple red peel, and dry sub-acid flesh that is somewhat astringent, and with a moderate edible portion of 45.27%. A fruit has one large oblong seed. Ripe fruits can be eaten fresh mixed with a little salt, or processed into preserve.

Another endemic species to the Philippines is “Katmon” or Elephant Apple, a medium-sized tree that grows up to 17 m high with a canopy diameter of 4.0 m. Fruits are globose to ovoid, medium-sized (73.9 g) with yellowish green peel when ripe. The greenish acidic flesh is soft and enclosed by persistent fleshy sepals. A fruit contains an average of 22.5 seeds. Ripe fruits are recommended to be eaten raw, or processed into jam and jelly, or made into a souring agent.

The Giant Soursop from Miami, Florida, USA is a small- to medium-sized tree that grows up to 10.0 m high with a canopy diameter of 2.0 m. The fruits are obovoid, big (1,555 g), yellowish green when ripe, has a high edible portion of 84.58% with sub-acidic flesh, and a TSS of 5.0 °Brix. It is recommended that ripe fruits be eaten raw, or made into preserve.

Since the uses of these rare fruits are still unknown to many in the Philippines, it is recommended that the fruits' potentials for processing into food products such as jam, jelly and whole fruit preserve, and their possible use as a souring agent (*e.g.*, “Katmon”), or as a coloring agent (*e.g.*, “Hunggo”), as well as their acceptability in the market be investigated. The medicinal properties and other possible uses of the fruits must also be studied. The chemical composition of the fruit should also be analyzed. Further, an efficient asexual propagation method should be developed for use in the mass propagation of these promising fruit species.

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CONFLICTS OF INTEREST

There is no conflict of interest in this article, or in the project on which this article is based or any other research work in the University. To the best of our knowledge, there are no other existing breeding and selection researches in the University on the rare fruit species used in this study.

CONTRIBUTION OF INDIVIDUAL AUTHORS

Dr. Pablito M. Magdalita is the leader of the project, “Breeding and Selection of Hardy Fruit Crops for Climate Change Adaptation and Health and Wellness”, wherein these rare fruit species are included. He conceptualized, planned, and directed this research, and further wrote the article. Dr. Roberto E. Coronel owns the fruit conservation farm from where the Cedar Bay Cherry, “Kepel”, Giant Soursop, and “Lovi-lovi” were obtained. Ms. Maria Ivana Kay M. Abrigo conducted a portion of the fruit evaluation.

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