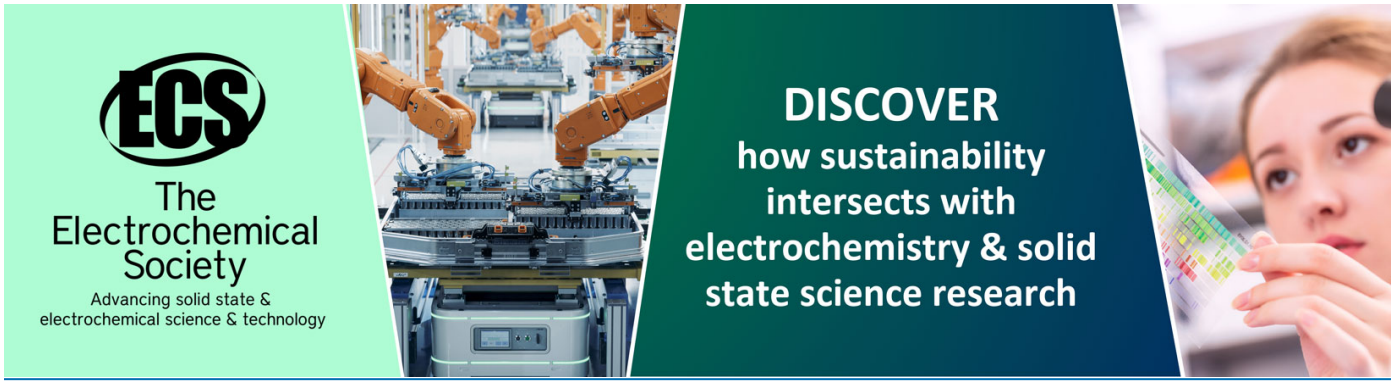
A review on benefits, potential and conservation of *Baccaurea lanceolata*



A review on benefits, potential and conservation of *Baccaurea lanceolata*

M B C Mojulat, N Surugau*

[1]Faculty of Science and Natural Resources, Universiti Malaysia Sabah, Malaysia,

*Corresponding author: lnoumie@ums.edu.my

Abstract. Malaysia has introduced the Plant Genetic Resources for food and agriculture (PGR) policy to further research and profile its wild crops to conserve and protect its rich biological diversity. There is an urge for relevant research to be conducted since it may also serve as an identifying accession of desirable traits for crop improvement. One such underutilised plant, *Baccaurea lanceolata* or locally known as "liposu" by the Dusun people has long played a traditional and cultural role for the local Bornean people. Unfortunately, although in recent years it has gained traction as a traditional food delicacy among the locals, it has remained underutilised and not commercially cultivated due to limited research and exposure. Despite that, limited studies on plants of Baccaurea species have been shown to contain various beneficial properties. The underutilised fruit of *Baccaurea lanceolata* has a high probability of containing a health beneficial, noteworthy amount of unique, uncovered phytochemicals. Research on this underutilised plant may also provide a path to road of commercialisation as well as preserving this tree from the danger of forest clearing. This review paper has therefore compiled information from available secondary literature on *Baccaurea lanceolata* in terms of its traditional knowledge, cultural usage as well as studies on its scientifically proven health benefits.

Keywords. *Baccaurea lanceolata*, phytochemical, underutilised plant, *liposu*

1. Introduction

Malaysia is one of the world's megadiverse countries, ranking at 12th in the world for its biodiversity richness, which takes into account on the estimates of country richness, endemism in vascular plants and four terrestrial vertebrate classes [1]. According to Mohd Shukor *et al.* [2], Malaysia harbours some 185,000 species of fauna and more than 15,000 species of flowering plants. The study by Abdul Shukor *et al*. [3] under MARDI agency further reported that among them, there are over 2,500 tree species, 3,000 species of orchids, 500 species of ferns, and 60 species of grasses and bamboos. The same study consequently stated that Malaysia houses more than 500 species of cultivated, underutilised and rare fruit species. Unfortunately, only a small percentage of this species have been utilised for food production and that only about 300 fruit species native to Malaysia had been exploited and utilised [3]. The remainder is still growing wild or semi-wild, and their economic potential has not been investigated thoroughly. In a global scale, FAO in its infographic report also stated that biodiversity, and in particular genetic diversity, is being lost at an alarming rate [4].

Forest is home to almost 80% of terrestrial biodiversity. They account for over 80,000 tree species. Nevertheless, less than 1% have been studied in any depth for their present and future potential. FAO further stated that plants account for over 80% of the human diet. While 30,000 terrestrial plants are

known to be edible, only 7000 are cultivated or collected by humans for food. Moreover, only 30 crops feed the world where five cereal crops (rice, wheat, maise, millet and sorghum) provide 60% energy intake of the world population [4]. One can only imagine the gradual loss of these undiscovered species (primarily through forest clearing) to make way for commercial crops to thrive, which, may dampen effort on diversifying species and varieties for the betterment of food security, livelihoods and to the supply of ecosystem services.

Therefore, what makes a plant fall into the underutilised plant category? In an excerpt by Chakravarty *et al*. [5], the plant is categorised as underutilised if they have neither been cultivated nor domesticated. However, these plants are readily available in their wild natural habitat. Furthermore, these plants also have throughout the ages and globe played a significant role in the development and civilisation of human history. Without these underutilised plants, the cultural, belief system, social and religious aspects of the rural communities are considered incomplete.

An example of underutilised plant available in Borneo and some part of Southeast Asia is *Baccaurea lanceolata.* This review paper has therefore compiled information from available secondary literature on *Baccaurea lanceolata* in terms of its traditional knowledge, cultural usage as well as studies on its scientifically proven health benefits.

2. Literature Review

The genus Baccaurea was first described in 1790 [6]. In 1866, 31 species were included in the genus [7]. There were no changes in the classification of Baccaurea genus in subsequent publications in 1963 [8], 1973 [9], 1978 [10], 1979 [11], 1980 and 1981 [7, 8]. Following the year 2000, a study by [14] introduces a total of 43 species into the genus Baccaurea. Based on the previous classification system, the genus Baccaurea was included in the Euphorbiaceae family, but based on the APG II classification system, when taking into account on molecular evidence and morphology, the ovules were included in the Phyllanthaceae family [15].

Baccaurea lanceolata is one of the plants belonging to the genus Baccaurea. The information tabulated in Table 1 summarises the general information regarding *Baccaurea lanceolata,* from its scientific name to its natural habitat and ecology.

Table 1. General information regarding *Baccaurea lanceolata*

	Descriptions
Scientific name	*Baccaurea lanceolata* (Miq.) Muell. Arg.
Synonyms	*Adenocrepis lanceolatus* (Miq.) Müll.Arg., *Baccaurea glabriflora* Pax & K.Hoffm., *Baccaurea pyrrhodasya* (Miq.) Müll.Arg., *Hedycarpus lanceolatus* Miq. (basionym), *Pierardia pyrrhodasya* Miq.
Family	Phyllanthaceae, also placed in Euphorbiaceae
Common/English Names	Lampaong
Vernacular Names	***Borneo***: Limpasu (Banjarese; Bundu Tuhan) Ampusu' (Bidayuh) Buah Liposu, Lepasu, Lipasu, Nipassu (Dusun) Asam Pauh, Empaong, Lampaong Lampawong, Lampong (Iban) Kalampesu, Lempahong (In Kalimantan) Buah Lipauh (Kelabit) Kelepesoh (Kenyah) Buah Lepesuh (Punan) Empawang, Lapahung

	Lempawong, Paong ***Peninsular Malaysia***: Asam Pahong, Rambai Hutan, Medang Kelawar, Asam Pahung, Asam Paung, Limpanong, Pahu Asam, Pahu Temuangi ***Indonesia***: Tegeiluk (Mentawai) Peng (Sumatra) Lingsoe (Javanese) Kaloe Goegoer, Langsat Hutan, Lempaong, Lempaoe-Oeng ***Sarawak***: Pisau (Bidayuh) Limpa'ong (Iban) Bua'pau (Kelabit) Lepesu (Penan)
Origin/Distribution	The species is found in Borneo (Sarawak, Brunei, Sabah, West-, Central-, South- and East Kalimantan), Peninsular Malaysia, Philippines, Thailand and Sumatra. Rarely in cultivation in fruit gardens.
Habitat and Ecology	Usual sighting is in the primary and secondary tropical rain forest, growing on slopes and in the riverine forest, from sea level to 1,300m in its native range. It is, however, more common in the lowlands. The flowering period ranges from March to December while bearing fruit all throughout the year.

Source: Adapted from [14, 16]

Shown below in Table 2 are the tabulated botanical description of *Baccaurea lanceolata*, a dioecious, perennial tree.

Table 2. Botanical description of *Baccaurea lanceolata*

Part of plant	Description
Tree	• Medium-sized capable of reaching a height of 3–30 m. • Gnarled-shaped trunk diameter at breast height (dbh) of 5–60 cm. • Buttresses, mainly for stabilisation purpose, is absent. • (Sub)glabrous branchlets with green shoots when young, gradually turning grey-green to brownish when dry. • Generally has weak Terminalia branching pattern.
Indumentum	• Simple hair covering.
Bark	• Soft bark (0.2–3 mm thick) is smooth and scaly to the touch, occasionally peeling off. • Fresh bark turns grey to pale brown, consequently turning yellowish to whitish, then greenish when fresh. • Grey dry bark. • The inner bark (2–3.5 mm thick) turns pale brown to white, then grey to yellowish in the process of maturing.
Heartwood	• The dense inner part of the tree trunk is yellowish to brownish.

Leaves	• The petiole is 16–184 mm long. • Smooth, glabrous structure. • Pulvinate apically and slightly basally. • Green when fresh, gradually turning brown-green to grey when dry. • Raised glands are usually present. • The stipules are glabrous outside and inside, usually (3–)5–16 by 2–6 mm in length. It is caducous (to late caducous), where its midrib is often densely hairy above. Its margin is not ciliated and is usually hyaline. • The papery lamina is ovate to elliptic in shape, 9.2–45 by 3.7–26.5 cm, length to width (l/w) ratio of 1.7–3.4, attenuate to rounded base and acute to cuspidate apex, (0–)3–20 mm in length. • The upper surface of the leaf is glabrous, with the presence of raised glands, sometimes granulate, glossy dark green when fresh, and (grey to brown) to green when dry. • The lower surface is also glabrous, sometimes sparsely hairy at the midrib, raised glands present, discoid glands absent, (dull pale) green when fresh, (grey to brown) to green when dry with paler nervation. • Secondary veins 6–13 per side, closed at the margin to almost so, with reticulate nervation.
Staminate inflorescences	• Cauline, many clustered together, 3.5–18 cm long, 0.1–1 mm thick, glabrous to sparsely hairy, minute branching. • Flowers scattered along inflorescence are many-flowered, yellow to pink to cream-white. • Bracts 1 per branchlet, 0.4–1.5 mm long, densely hairy outside, (sub)glabrous inside, margin ciliate, hyaline. • Bracteoles 0.1–0.5 mm long, 2 per branchlet, glabrous outside, (sub)glabrous inside. • Branchlets absent, 3-flowered.
Staminate flowers	• Staminate flower reaches 2–7 mm diameter across, with yellow to pink to purple to cream-white colouring; (sub)glabrous, densely hairy at base. • Pedicel 1.8–7 mm long, upper part 1.7–7 mm long. • Has (3 or) 4 or 5 sepals, obovate to spatulate, often variable in size and shape, measuring ranges from 1.1–5.5 by 0.6–2.7 mm. The apex is slightly recurved or straight, glabrous outside, sparsely to densely hairy inside. • Rudimentary petals (3–5) are often present. • Staminodes (3–5); stamens (3 or) 4 or 5, 0.4–0.6 mm long, glabrous; 0.1–0.3 mm long straight filaments; anthers are 0.2–0.35 by 0.2–0.4 by 0.15–0.2 mm. • Absent disc. • Pistillode globose to cylindrical, velutinous, solid and 0.2–0.7 mm in height.
Pistillate inflorescences	• Cauline, few clustered together, 8–33(–50) cm long, 1–5 mm thick, subglabrous to sparsely hairy. • Yellowish-brown to reddish, 20–25-flowered. • Subglabrous to densely hairy pedicel is 0.8–4.5 mm long, pink in

	colour, thickened at abscission zone, and an upper part measuring 0.1–1.5 mm long. • Bracts 3 per branchlet, (sub)glabrous outside, glabrous inside, ciliate margin.
Pistillate flowers	• Diameter measures 3.5–10 mm. • Colouring ranges from yellow to orange, then to purple before consequently changing to reddish cream then whitish. • Has 4 or 5 sepals, ovate to obovate, measuring ranges from 1–6 by 0.9–3.2 mm. Densely hairy outside, (sub)glabrous inside, caducous; 2–8 reduced petals. • The globose ovary is purple to green in colour, 1.5–3.2 by 1.5–3.2 mm, 3- or 4-locular, sparsely to densely hairy. While its wings are usually absent, rare 3 or 4 wings are poorly developed. • Absent style, stigmas 0.7–1 mm long, cleft for upper 10–90%, reddish to ochre, persistent to caducous. • Lobes measure 0.7–1 by 0.2–0.6 mm, glabrous and ruminate above, glabrous to densely hairy below.
Fruits	• Globose to ellipsoid in shape. • Develops 1–4-seeded berries, 24–54 by 16.5–41 by 16.5–41 mm when dry, 38 by 60 mm when fresh. • Raised glands are present, ruminate when dry, glabrous outside and inside. • Purple or green when young, green to yellow to whitish to greyish to brownish when mature. • The pericarp is 1–10 mm thick; column c. 32 mm long. • Pedicel (1–)2.5–17 mm long, upper part 0.5–11 mm long.
Seeds	• Ellipsoid, laterally flattened, 12.2–26 by 8–15 by 4.8–9 mm. • Translucent arillode is white to grey. • Testa yellow to whitish. • Cotyledons 10–11.5 by 8.9–13 by c. 0.1 mm; radicle 1–2.2 mm long. • Endosperm 1–2 mm thick.
Propagation	• They are readily propagated through seeds.

Source: Adapted from [14, 16]

Figure 1 and 2 shows the tree and close up picture of the bark of *Baccaurea lanceolata*. Meanwhile, Figure 3 and 4 captured the long-shot image and preserved *Baccaurea lanceolata* leaves respectively. Accordingly, Figure 5 and 6 depict the inflorescence stage of *Baccaurea lanceolata* (yellow to reddish-white). Consequently, Figure 7-10 corresponds to the three different stages of *Baccaurea lanceolata* fruit (young, maturing and mature). Figure 9 and 10 show an in-depth mature stage of *Baccaurea lanceolata* fruit.

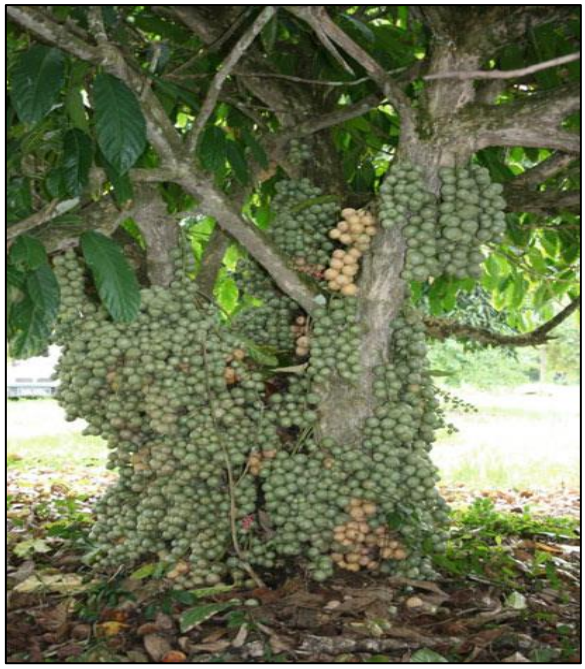


Figure 1. Much-branched tree with clusters of fruit [16]

Figure 2. Bark of *Baccaurea lanceolata.* [17]

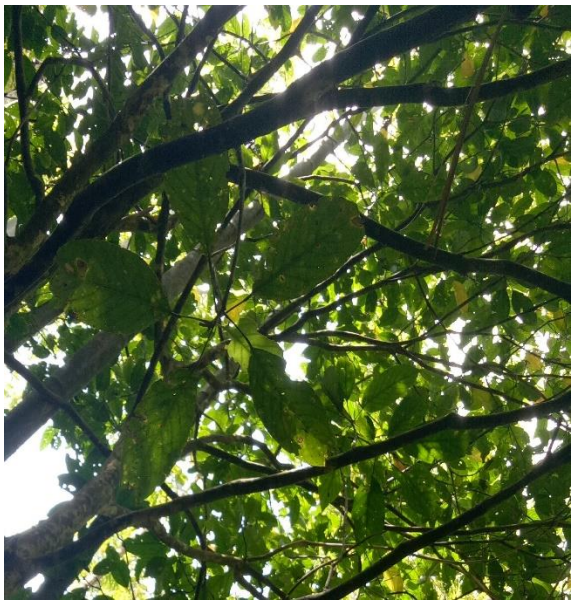


Figure 3. Long shot of the leaves

Figure 4. Preserved leaves [18]

Figure 5. Yellow flower inflorescence [19]

Figure 6. Reddish white flower inflorescence [20]

Figure 7. Young, purple fruit of the plant

Figure 8. Mid-developing green pendant clusters of subglobose fruit

Figure 9. Close up of the newly matured creamy-white fruit [16]

Figure 10. Fully matured brown fruit [21]

2.1. Cultural usages and ecological values

Baccaurea lanceolata as study object is more social-economically determined. While it is less commonly cultivated, a survey study conducted by Khadijah *et al*. [22] in 2018 determined that there are fifteen *Baccaurea lanceolata* trees planted in home gardens or orchards in Malaysia; fourteen trees in Sabah and one tree in Sarawak. The previous study conducted in 2014 [23] also confirmed the cultivation status of *Baccaurea lanceolata* with medium economic status. *Baccaurea lanceolata* tree is harvested for its timber [24] and is known to be rather hard and durable [14]. Hence, the timber is also used for house construction [16].

Other than that, the Iban uses the fruit of *Baccaurea lanceolata* as protection against charms and first consumed before paying house visits during Gawai, the harvest festival [16]. Culturally, when hunting, the Dayak depend on a few types of fruit as an indicator for the presence of pig or *duk* (*Macaca nemestrina*). *Baccaurea lanceolata* fruit is one of them. Where the fruits are found abundantly, in time the Dayak realised that the pig and *duk* are always around. The *duk* will eat the fruits on top of the trees while the pig will eat the leftover thrown by the *duk* [25].

The fruits are also consumed by many bird species, deer, monkeys, rodents, and also the Orangutan [26]. Therefore, even though *Baccaurea lanceolata* contributes only marginally to the local economics, their ecological values are more apparent.

2.2. Food

In most Baccaurea species, only the arillode is eaten. However, the pericarp of *Baccaurea lanceolata* is edible as well [14]. The fruits are very sour; thus, it is usually eaten by dipping it into sugar or salt [14]. The local Sabahan, especially the Dusun, also enjoy the fruit juice and are known to sun-dry the fruit slices, which are used in the cooking process. Figure 11 shows the image of *Baccaurea lanceolata* juice, while Figure 12 illustrates the sun-drying process of the fruit slices.

While it is true that *Baccaurea lanceolata* is rarely cultivated, a survey in Sabah by Kodoh *et al*. [27] found out that its fruit is traded locally in *tamu* (open market). Ten most common *tamu* was covered in that particular survey, as well as major ethnic groups in Sabah, mainly Kadazandusun,

Rungus and Murut. *Baccaurea lanceolata* fruit is also occasionally traded at the traditional market in some subdistrict in South Aceh region [28]. The Dayak is also recorded to enjoy the fruit [25].

Consequently, in Sarawak, it is usually served together with chicken rice and is also used during the cooking process [14]. The fruiting season of *Baccaurea lanceolata* is year-round. Therefore, not only the fruit can constitute a vital nutrient source [14], it provides possible benefits and boosting household incomes [28].

Figure 11. Fresh fruit juice

Figure 12. Sun-dried fruit slices

2.3. Cosmetic and skincare

In Indonesia, *Baccaurea lanceolata* fruit is traditionally used as an acne remedy [25]. The skincare products sold are usually in the form of face mask and powder. The fruit is also used as natural sunscreen [25, 28] by the tribal hamlets in Kalimantan, where the fruits are processed into powder form and applied to skin prone to sunlight exposure [29].

2.4. Traditional medicine

Several parts of *Baccaurea lanceolata* has been traditionally and culturally used to treat illnesses ranging from body pain, headaches, diarrhoea and reducing drunkenness. Table 3 hence shows the ethnomedicinal properties of different parts of *Baccaurea lanceolata*.

Table 3. Reported traditional properties of different parts of *Baccaurea lanceolata*

References	Parts Used	Reported traditional properties	Preparation	Ethnic group
Haegens, (2000)	Leaves	To relief stomach ache	Consuming decoction made from pounding the leaves in bamboo and mixed with water	Kelabit
Julius Kulip, (2003)	Fruit	To relieve abdomen pain	Pounded into a paste, and applied onto the abdomen	Murut
	Leaf	To mitigate stomach ache	Pound the leaves well, add a little water and drink the decoction.	Bidayuh
Lim T K, (2012)	Fruit	To reduce swellings on the body	A poultice made from the fruit	Bidayuh
	Bark	To reduce drunkenness	Tree bark is pounded,	Penan

			and the sap is drunk before consuming alcohol	
Galappathie *et al.* (2014)	Fruit shell	To cure diarrhoea	The shell of the fruit is eaten.	Kelabit
	Fruit	To cure headaches	The fruits are pounded with the fruits of *Etlingera elatior* and boiled. Leaves from *Begonia* spp. may also be added. The head is bathed in the solution when it has cooled.	Iban

Source: Adapted from [14, 16, 30-31]

3. Phytochemical study

To date, only one paper written by Abu Bakar *et al*. [32] that reported on the phytochemicals contents of *Baccaurea lanceolata* through several tests- total phenolic content (TPC), total flavonoid content (TFC), total anthocyanin content (TAC) and total carotenoid content (TCC). The data from the study are tabulated in Table 4, respectively, as shown below:

Table 4. Phytochemicals contents of *Baccaurea lanceolata*

Samples	TPC[a]	TFC[b]	TAC[c]	TCC[d]
Pericarp	3.31± 0.48	2.29 ± 0.01	0.50 ± 0.13	0.75 ±0.00
Flesh	4.81± 0.14	4.73 ± 0.27	0.37 ± 0.08	0.67 ±0.15
Seed	3.29 ± 0.33	1.97 ± 0.19	0.07 ± 0.00	0.64 ± 0.28

[a]TPC was expressed as mg gallic acid equivalent (mg GAE) in 1 g of dry sample;
[b]TFC was expressed as mg catechin equivalent (mg CE) in 1 g of dry sample;
[c]TAC was expressed as mg of cyanidin-3-glucoside equivalents (mg c-3-gE) in 100 g of dry sample;
[d]TCC was expressed as mg beta carotene equivalents (mg BCE) in 1 g of dry sample.
Source: Adapted from [32]

TPC of the fruit extracts ranged from 3.29 to 4.81 mg GAE/g for *Baccaurea lanceolata*. TAC and TCC content of *Baccaurea lanceolata* was on the lower side where TAC content ranged from 0.07±0.00 to 0.50±0.13mg c-3-gE whereas TCC was valued from 0.64±0.28 to 0.75±0.00 mg BCE. Low TAC content may be contributed to the fact that high TAC content is usually associated to dark-red colour fruit (i.e., cherry) as compared to pale-yellow colour fruit (i.e., plum) [33]. Table 5, on the other hand, summarise the antioxidant activity of different parts of *Baccaurea lanceolata* (pericarp, flesh and seed), also from the same authors [32].

Table 5. Antioxidants activity of *Baccaurea lanceolata*

Samples	DPPH[a]	ABTS[b]	FRAP[c]
Pericarp	48.93 ± 0.02	2.16 ± 0.11	2.29 ± 0.12
Flesh	94.36 ± 0.02	2.99 ± 0.12	2.81 ± 0.23
Seed	85.06 ± 3.15	3.03 ± 0.11	1.93 ± 0.17

[a]DPPH free radical scavenging was expressed as mg ascorbic acid equivalent antioxidant capacity (AEAC) in 1 g of dry sample;
[b]ABTS decolourisation assay was expressed as mg ascorbic acid equivalent antioxidant capacity (AEAC) in 1 g of dry sample;
[c]FRAP was expressed as mM ferric reduction to ferrous in 1 g of dry sample.
Source: Adapted from [32]

A study by Abu Bakar *et al*. [32] incorporated three methods to analyse the antioxidant capacity of *Baccaurea lanceolata* fruit which were DPPH (2,2-diphenyl-1-picryl-hydrazyl-hydrate), ABTS and also FRAP (Ferric Reducing/Antioxidant Power) assays. In DPPH assay, the flesh of *Baccaurea lanceolata* fruit had the highest scavenging activity. The lowest scavenging assay was observed on the pericarp of *Baccaurea lanceolata* pericarp while the seed displayed the lowest reducing effects in FRAP assay. The study further reported that there was a strong positive correlation ($r2 = 0.999$, $p < 0.01$) between TPC and reducing the power of extracts, which suggested that the powerful reducing agent in *Baccaurea* might be due to its phenolic compounds. Finally, the same study summarised that highest phytochemical content observed in *Baccaurea lanceolata* was its edible part (flesh). Generally, consumption of edible parts of the fruit is regarded as safer and suitable for direct human consumption, since damage via oxidation of free radicals and reactive oxygen species that contributes to human chronic diseases are reduced [32].

Another study by Hadi *et al*. [34] determined the IC_{50} value in *Baccaurea lanceolata* through DPPH assay. Table 6 tabulated the data obtained from the study, which was expressed in ppm.

Table 6. Antioxidants activity of *Baccaurea lanceolata* through DPPH assay

Sample	Extract		Fraction		
	Ethanol	Hexane	Ether	Ethyl acetate	Methanol
IC_{50} value (ppm)	450	530	280	230	270

Source: Adapted from [34]

Antioxidant activity obtained through DPPH assay was used as a guide to trace the most active fraction. From the results of fractionation using a separating funnel, ethyl acetate fraction had the highest antioxidant activity with IC_{50} values of 230 ppm. This fraction was further fractionated by column gravity, thus obtaining 18 fractions. Out of all of these fractions, fraction No. 16 displayed the highest activity with an IC_{50} value of 142 ppm. Meanwhile, fraction No. 1 has the lowest activity with an IC_{50} value of 675 ppm [34].

4. Pharmacological study

Two studies regarding the antimicrobial activity of *Baccaurea lanceolata* was found. The study by Galappathie *et al*. [31] tested the leaves and stems of *Baccaurea lanceolata,* tabulated, as shown in Table 7. *Baccaurea lanceolata* shows medium to potent inhibition against selected bacterial strains, with the highest inhibition being *Moraxella catarrhalis*. It, however, does not exhibit any inhibition against fungal strains of *Candida albicans.*

Table 7. Antimicrobial and antifungal activity of *Baccaurea lanceolata* extracts based on the disc diffusion assay

Plant name	Plant extract mass (µg) per disc	Zone of inhibition diameter (mm)*							
		Escherichia coli	*Pseudomonas aeruginosa*	*Salmonella enterica*	*Moraxella catarrhalis*	*Streptococcus pyogenes*	*Bacillus cereus*	*Staphylococcus aureus*	*Candida albicans*
B.lanceolata[a]	400	7.0	8.3	7.3	12.0	7.6	12.0	8.0	0.0
B.lanceolata[b]	400	7.0	8.3	7.0	10.6	7.0	9.6	7.0	0.0

[a,b] Where plant names are listed twice; it indicates that separate samples of Baccaurea lanceolata were collected from the same location during different months.
[1ab] Study by
* Zone of inhibition diameter ≤7 mm, weak; 7–8 mm, medium; ≥8 mm, strong

Source: Adapted from [31]

Consequently, another study by Fitriansyah *et al*. [35] proves that there is an antibacterial activity in other parts of *Baccaurea lanceolata* (fruit, leaf and bark). It was further reported that out of the three, the ethanol extract of *Baccaurea lanceolata* fruit shows the most active activity against gram-positive bacteria (*Bacillus subtilis, Staphylococcus aureus*), gram-negative bacteria (*Pseudomonas aeruginosa, Escherichia coli*) and gram-positive, acne-causing bacteria (*Cutibacterium acnes*, *Staphylococcus epidermidis*).

5. Nutritional value

A study on determining proximate composition (Table 8) and minerals value (Table 9) was conducted in 1999 [36]. The nutritional composition data tabulated were based on 100 g edible portion of *Baccaurea lanceolata* fruit.

Table 8. Proximate composition of *Baccaurea lanceolata* fruit

Nutritional composition per 100 g edible portion						
Energy (kcal)	Moisture (%)	Protein (%)	Fat (%)	CHO	Crude (%)	Ash (%)
18	92.4	0.2	0.2	3.7	2.2	0.8

Source: Adapted from [36]

The moisture content in *Baccaurea lanceolata* fruit analysed in the study was high (92.4%) with comparatively low protein and fat, both at 0.2%. Compared to the other food item studied in the same study [36], the overall proximate composition of *Baccaurea lanceolata* fruit is on the lower side.

Table 9. Minerals value of *Baccaurea lanceolata* fruit

Nutritional composition per 100 g edible portion								
P (mg)	K (mg)	Ca (mg)	Mg (mg)	Fe (Mg)	Mn (ppm)	Cu (ppm)	Zn (ppm)	Vit C (mg)
6	126	35	11	0.3	2	1.5	6.3	0.6

Source: Adapted from [36]

As tabulated in table 9, highest mineral value in *Baccaurea lanceolata* fruit is potassium (126 mg per 100 g edible portion) while vitamin C in the fruit is considered low at only 0.6 mg per 100 g edible portion. Except for Kepayang (*Pangium edule*), a fruit that was also analysed in the study, a low level of vitamin C is detected in all types of indigenous fruit and wild vegetable [36].

6. Potential Industrial Commercialisation

Lately, *Baccaurea lanceolata* fruit is gaining traction yet again, especially among the Sabahan local (Dusun local predominantly). The fruit commercially sold are either fresh, pickled or often made into *sambal* (a type of side dish), where it is cooked together with anchovies or salted fish, *Capsicum annum* (cili padi) and crushed shallot, garlic and ginger. The seasonings are usually made up of a combination of sugar and salt and other preferred condiments. Other possible commercialisation includes mass-producing the fruit beverages and dried fruit slices. The following Figure 13 shows the *sambal* of *Baccaurea lanceolata* fruit.

On the other hand, a 2014 Indonesian study [37] explored the potential of *Baccaurea lanceolata* as an alternative material for latex coagulant by studying the effect of the fruit extract on dry rubber content. An alternative natural latex thickener is preferred to reduce reliance on chemical, as well as to minimise cost and chemical exposure. Fully matured *Baccaurea lanceolata* fruit was chosen as it is readily available all year round, free or very cheap to purchase. The identification of the use of fruit extract as a latex thickener includes the duration of freezing, calculation of dry rubber content, and analysis of ash content. The results showed that the *Baccaurea lanceolata* extract had a density of 0.947g/mL, acetic acid content of 2.79%, and the resulting yield of 48.77%. This study also showed that the time needed for latex freezing was 3 minutes on average with the following conditions- using *Baccaurea lanceolata* fruit extract as a coagulant, dry rubber content of 30%, and the ash content of 0.86%.

Figure 13. *Sambal* of *Baccaurea lanceolata*

7. Conservation effort

Malaysia is recognised as a mega biodiversity country which holds different varieties or diversity of genetic resources. Therefore, efforts to conserve and utilise these resources, which are endemic and localised in distribution, are continued to be enhanced. One such effort by the government was to introduce the National Strategies and Actions Plan on Agrobiodiversity Conservation and Sustainable Utilization (2011- 2020). *In situ* and *ex situ* conservations are one of the critical aspects highlighted in

the policy. Hence, the efforts have been taken by several agencies in Malaysia such as the Department of Agriculture (DOA), FRIM, MARDI, Sarawak Biodiversity Centre, Sabah Biodiversity Centre and local universities [38].

In the case of Baccaurea species, due to the very declining area of tropical lowland rain forests, local extinctions of said species occur all the time [14]. Hence, in one of an *ex* situ conservation (located in MARDI germplasm at Jelebu, Negeri Sembilan), MARDI had taken an effort to collect and conserve the genetic resources of the Baccaurea species, which includes *Baccaurea lanceolata* species [22]. Example of *in situ* conservation done in Malaysia is the 50-ha plot in Pasoh Forest Reserve, a lowland Dipterocarp forest, in which a total of 820 species in 294 genera and 78 families of trees measuring more than 1 cm diameter at breast height were enumerated. Generally, the most common fruit tree genera found in the forests comprise of Artocarpus, Baccaurea, Durio, Garcinia, Lansium, Sandoricum, Bouea, Mangifera, Cynometra, Dialium, Parkia, Nephelium and Xerospermum [39].

The policy stated previously are in line with the study of the underutilised plant (in this case, *Baccaurea lanceolata*). The sustainable effort under sector Plant Genetic Resources for food and agriculture (PGR) contained in NSAP calls for further utilisation, characterisation and evaluation of wild crop relatives and wild plants for food and agriculture. Relevant research will provide insight into these wild, underutilised plant species, and it may also serve as an identifying accession of desirable traits for crop improvement. Therefore, characterisations of Malaysia's biodiversity, primarily through agriculture, is crucial since it plays an essential component in food security since species diversity provides the genetic material for food and crops. The NSAP policies that were integrated into the new National Policy on Biological Diversity 2016-2025 (NBSAP) encompassed every aspect of sustainable development of biodiversity in the country, which subsequently shows Malaysia's commitment in conserving its biological diversity [38].

8. Future study

An extensive botanical study on *Baccaurea lanceolata* by Haegens [14] noted that the type specimen of *Baccaurea lanceolata* is a mixtum, where its leaves share similar characteristics to that of *Terminalia* sp. The leaves and bark of plants categorised in Terminalia genus are well known for their medicinal potential [40]. Consequently, a 2018 study [41] focusing on determining the antifilarial activities in the leaves of three plants belonging to the Terminalia genus (*Terminalia bellerica, Terminalia chebula* and *Terminalia catappa*) were done to explore the potential of the plants as an alternative medicine against filariasis. The study target was *Setaria cervi*, a bovine filarial parasite. Interestingly, all of the plants show antifilarial potential with *Terminalia bellerica* exhibiting significant antifilarial potential. Suffice to say; it would be interesting to replicate the same study using a different part of *Baccaurea lanceolata* (the leaves especially).

Accordingly, although *Baccaurea lanceolata* fruit has potential as a natural coagulant, more studies on its development should be done until it complies with the national standard set by the government. The same study by Purnomo *et al*. [37] stated that while rubber treated with *Baccaurea lanceolata* extract coagulant experienced perfect clotting and has a yellowish-white hue, after the third day, there are drastic changes of colour (brownish to yellow). Finally, on the sixth and seventh day, the rubber was observed to have small bubbles and mottled texture. Its elasticity properties still maintain, however. Going by Standard Nasional Indonesia (SNI) 2000, the quality of rubber will be higher if the surface is uniform, no bubbles, stretches, nor dirt and possess firm texture.

Consequently, the seeds of *Baccaurea lanceolata* is treated as a waste since it is not consumed. Hence, a study should be done to determine the potential of the seeds in various industrial application such as for cosmetic or bio-stimulant purposes since the study by Abu Bakar *et al*. [32] shows good antioxidant activity.

The study by Van der Ent *et al*. [42] through an intensive screening has found out that *Baccaurea lanceolata* plant (habitat: lowlands, mixed Dipterocarp forest with maximum foliar Ni of 1450μg g^{-1}) is a Nickel hyperaccumulator. It was stated in the same study that there was a predisposition for the Phyllanthaceae to accumulate not only Ni but also other trace elements such as Co, Cr, Mn and Zn,

which was proven when the specimen unexpectedly contained 179μg^{-1} Co, 143μg^{-1} Cr, 1451μg^{-1} Ni and 1450μg^{-1} Zn. Manganese concentrations were also reported to be relatively high but varied widely. Hence, it is imperative to conduct an extensive analysis to study its impact on human consumption. Confirmation of Nickel hyperaccumulators is also vital in order to better facilitate its conservation as well as potential future utilisation in Ni phytomining.

Apart from that, extensive analyses focusing on (not limited to) phytochemical, antioxidant, pharmaceutical, nutrient and metabolite compounds profiling should be conducted in order to contribute more to the available information on *Baccaurea lanceolata*. Apart from focusing on researching its fruits in different stages (young, developing, fully matured), other parts of the plant (leaves and bark) should be given attention as well.

9. Conclusion

Based on the compiled reports on *Baccaurea lanceolata*, it is clear that it has substantial commercial potential, especially in the food industry, which will benefit the local people. Consequently, phytochemical and antimicrobial studies conducted on the fruit shows that it has enormous benefits health-wise when consumed. Conservation of *Baccaurea lanceolata* plant is essential not only to preserve the plant for diversity sake but also to conserve its cultural value. It is also noted that there is minimal literature on *Baccaurea lanceolata*, possibly because it is endemic only to Borneo and particular part in Southeast Asia, and not cultivated commercially. Therefore, more research on *Baccaurea lanceolata* should be conducted to explore its maximum prospective, encompassing a different area of study.

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