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A MINI REVIEW ON THE NUTRITIONAL COMPOSITIONS AND PHARMACOLOGICAL PROPERTIES OF *Litsea garciae*

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ABSTRACT

Litsea garciae is an underutilized plant found in certain parts of South East Asia. The plant part has been traditionally used to treat, among others, skin infections, boil, rectal bleeding, muscular pain, and sprains. Besides its medicinal properties, its seasonal fruit is consumed for its avocado-like flavor. This article aims to provide information on what is known so far about the nutritional composition and pharmacological properties of *Litsea garciae*.

Key words: Antioxidant, *Litsea garciae*, pharmacological, phytochemical, underutilized fruit

INTRODUCTION

The Lauraceae or the laurel family contains 50 genera which include the genus *Litsea*. There are more than 400 species in the genus *Litsea,* and it is predominant in Asia, Australasia, and America (Sampson & Berry, 2019) with 50 species can be found in Malaysia (Mehat, 2008; Poli & Assim, 2019). The ethnopharmacological properties and medicinal uses of the genus *Litsea* have attracted much attention in researches (Wang & Liu, 2010; Kamle *et al*., 2019). A few species of *Litsea*, for example, *L. cubeba*, *L. japonica* and *L. salicifolia,* have been extensively studied and are shown to be sources of secondary metabolites with important chemical structures including alkaloids, lactones, sesquiterpenes, flavonoids, lignans, and essential oils. Extracts from different plant parts of *Litsea* such as bark, leaf, and root show significant pharmacological activities including anticancer, anti-inflammatory, antimicrobial, antioxidant, antidiabetic, anti-HIV, and insecticidal (Wang & Liu, 2010; Wang *et al*., 2016; Kamle *et al*., 2019).

This article is the first review paper that gathers the relevant literature to congregate the chemical and pharmacological properties of *Litsea garciae*. The common name of *L. garciae* is bagnolo/wuru lilin. In the Sarawak state of Malaysia, the common name differs according to the local languages: engkala as in Malay language, enkala/pedar as in Iban language, and ta'ang as in Bidayuh language (Poli & Assim, 2019). *Litsea garciae* originated from Borneo (Sabah and Sarawak in Malaysia, Indonesian Kalimantan, and Brunei), Indonesia (Java and Bangka), Taiwan, and the Philippines. It grows wild from seed and can be found in the inland riparian forest, secondary forest, and rarely in mixed dipterocarp. *Litsea garciae* is a sub-canopy, broadleaved evergreen tree that maintains its green leaves throughout the year and bears fruit once a year (Figure 1).

The edible part of *L. garciae* fruit includes the fleshy part and the thin peel (Figure 2). It has a flavor that is comparable to the Lauracea, *Persea americana* (common name, avocado), and has a nickname of "Borneo avocado". The literature search revealed only a few publications on *L. garciae*. Since there is a lack of findings and information on *L. garciae*, this literature review aims to reveal what is known so far on its nutritional compositions, medicinal uses, and other applications.

Nutritional compositions of *Litsea garciae*

Proximate and mineral compositions of Litsea garciae

The proximate and mineral composition data are obtained from Voon and Kueh (1999) and Husen (2015). There are different results obtained from both studies which are probably due to the different analyses used and sites of plant collection (Demir &

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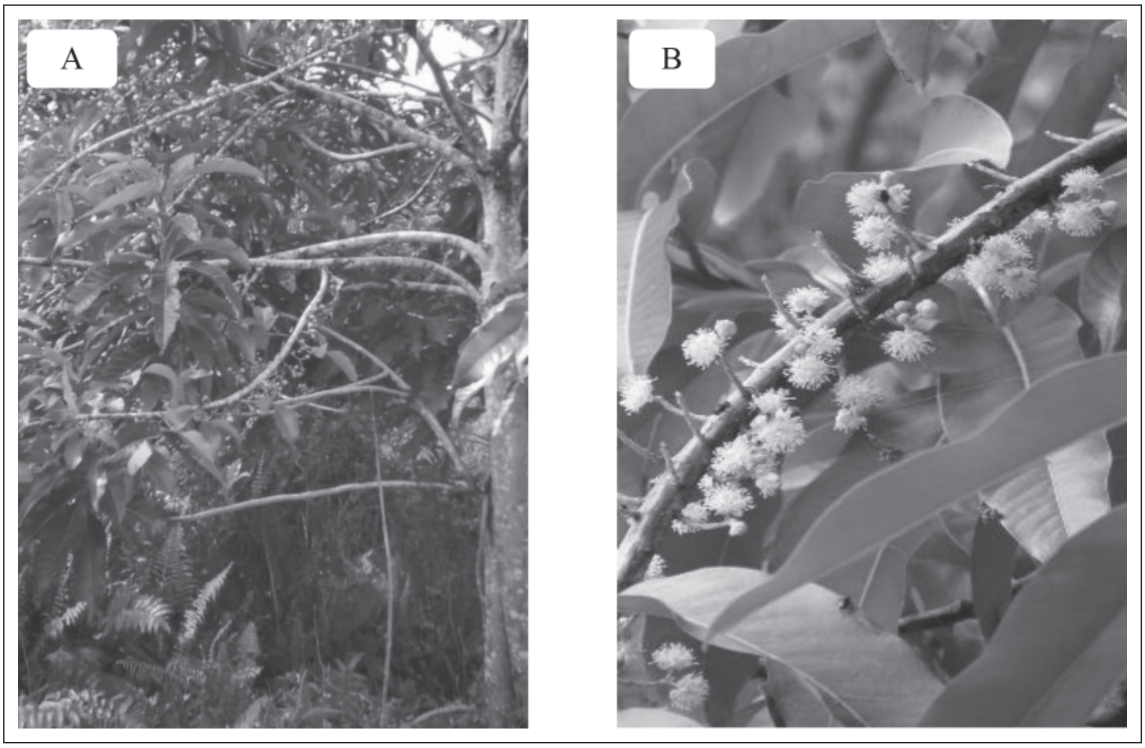

Fig. 1. *Litsea garciae* bearing fruits (A) and flowers (B) (adapted from (Bukbi, 2019)).

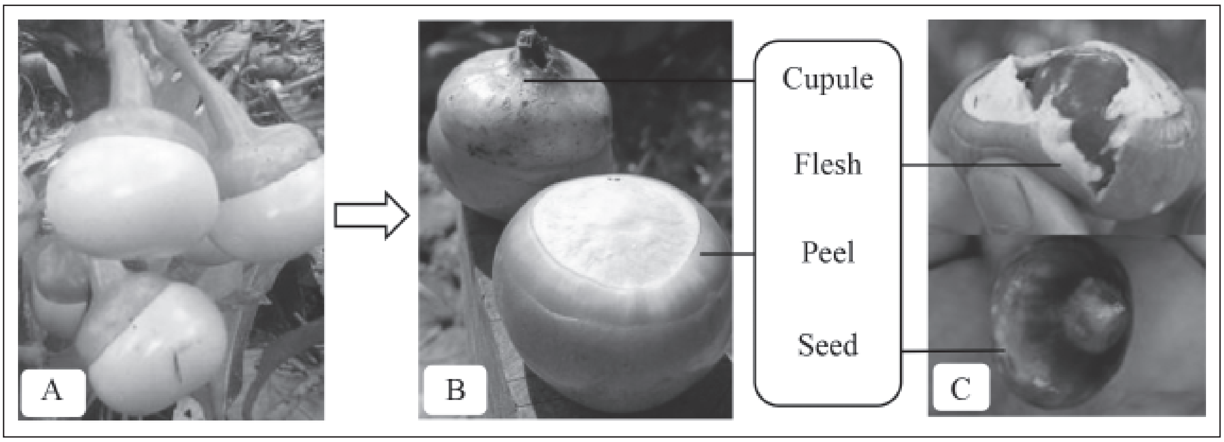

Fig. 2. Transformation of the white, unripe *L. garciae* fruit (A) into red, ripe fruit (B) with different parts of *L. garciae* fruit (C) (adapted from (Lim, 2012)).

Ozcan, 2001). *Litsea garciae* contains a substantial amount of energy with the flesh contains higher energy than the seed (Table 1). The energy content in *L. garciae* is lower than avocado (160 kcal) and durian (147 kcal) but higher than a banana (89 kcal) and papaya (43 kcal) (USDA, 2012). Voon and Kueh (1999) report that the flesh has a high moisture content (78.3%), which is in agreement with Husen (2015) (68.8% in flesh & 71.7% in seed). Moisture content is important as it affects the stability and quality of the fruit besides contributing to the refreshing character of the fruit. According to Voon and Kueh (1999), there is a higher percentage of fat (6.8%) compared to protein (1.4%) in the *L. garciae* flesh. The fat content gives *L. garciae* the creamy texture and buttermilk taste. Husen (2015) shows that *L. garciae* has a high content of carbohydrate (22.1% in the flesh and 18.6% in the seed) which probably account for its high energy content.

The ash content is the measure of the mineral contents present in this fruit. The ash content of the flesh is 2.5% while the seed has 1.4%. The findings of mineral contents by Voon and Kueh (1999) are lower than by Husen (2015) except for magnesium, copper, and zinc (Table 1). The flesh of *L. garciae* contains 652.9 mg of potassium and 91.5 mg of

Table 1. Nutrient contents of the flesh and seed of *L. garciae* fruit per 100 g of flesh/seed portion

Nutrient Contents	Flesh	Flesh	Seed
Proximates			
Energy (kcal)	104	93.3	83.4
Moisture (%)	78.3	68.8	71.7
Protein (%)	1.4	2.5	3.3
Fat (%)	6.8	NA	NA
Carb (%)	10.0	22.1	18.6
Crude fibre (%)	1.0	4.0	5.0
Ash (%)	2.5	2.5	1.4
Minerals			
Phosphorus (mg)	26	NA	NA
Potassium (mg)	355	652.9	331.5
Calcium (mg)	7	7	2.4
Magnesium	17	3.7	1.8
Iron	0.5	4.9	1.1
Manganese (p.p.m)	5	NA	NA
Copper (p.p.m)	2.6	1.0	0.6
Zinc (p.p.m)	10.2	1.6	1.1
Sodium	NA	91.5	6.3
Vitamin C	3.4	11.8 (FD) 34.7 (SHSD)	4.8 (FD) 13 (SHSD)
Authors	Voon & Kueh (1999)	Husen (2015)	Husen (2015)

NA= Not available; FD = freeze dried; SHSD = superheated-stream dried.

sodium per 100 g of flesh part where both values are higher than the non-edible seed (Husen, 2015). Potassium and sodium are electrolytes that regulate the body fluid and blood volume. Adequate potassium and sodium intake may promote blood pressure control in adults. The United States Food and Drug Administration (FDA) (FDA, 2000) claims that food containing 350 mg of potassium and less than 140 mg of sodium has the medical benefit for blood pressure; thus, this suggests that *L. garciae* is healthy food to consume.

Husen (2015) reports a high content of vitamin C in the *L. garciae* flesh. Vitamin C is necessary for the growth, development, and repair of all body tissues in addition to its antioxidant properties. The vitamin C content of the flesh is 11.8 mg and 34.7 mg by using the freeze-drying (FD) method and superheated-steam drying (SHSD) method respectively. In the SHSD method, the time taken for the flesh to reach the final moisture of about 10% is three hours compared to several days when using the FD method. Hence, there is a possibility that the vitamin C content is affected during the lengthy time of drying the flesh samples. The vitamin content of *L. garciae* is similar to mango (36.4 mg/100 g) and higher than *Persea americana* flesh (8.0 mg/100 g) (Dreher & Davenport, 2013).

Fatty acid composition

There is a slight variation in the fatty acid compositions of *L. garciae* seed oils extracted from different districts in Sarawak, Malaysia (Poli & Assim, 2019). This is probably contributed by the environmental factors and growth conditions among the different districts (Sanchez-Martin *et al*., 2018). The seed oil of *L. garciae* is very rich in saturated fatty acids (SFA) (76.94 ± 1.50%), contains a moderate percentage of monounsaturated fatty acids (MUFA) (16.23 ± 1.20%), and a small percentage of polyunsaturated fatty acids (PUFA) (7.1 ± 0.79%) (Poli & Assim, 2019). The predominant component of SFA in *L. garciae* seed oil is lauric acid (40.73 ± 2.81%), followed by myristic acid (19.69 ± 0.52%), palmitic acid (7.2 ± 0.63%), and capric acid (6.07 ± 2.01%). The significant amount of MUFA and PUFA of *L. garciae* seed oil are contributed by oleic acid (14.98 ± 1.44%) and linoleic acid (7.10 ± 0.79%) respectively. *Litsea garciae* has a comparable amount of beneficial SFAs to coconut oil and palm oil (Poli & Assim, 2019), and it has more unsaturated fatty acids than coconut oil which suggests that it can be used as an alternative for coconut oil and palm oil. Currently, available data on the composition of fatty acid of *L. garciae* are only for the seed oil. It would be interesting to know the compositions of fatty acid from the flesh part of *L. garciae* too since this is the edible part of the plant.

Nevertheless, the *P. americana* kernel oil is loaded with good fat. It possesses a low proportion of SFA (32.50 ± 0.12%), with a predominance of palmitic acid at 20.85 ± 0.84%. There is a high proportion of unsaturated fatty acids accounting for approximately 67% of the total fatty acids. The MUFA content is 20.71 ± 0.14%, with a predominance

Table 2. Comparison of fatty acid composition between *L. garciae*, *P. americana*, *C. nucifera,* and *E. guineensis* kernel oils

Fatty acids		% of fatty acids			
		Engkala (*L. garciae*) (Poli & Assim, 2019)	Avocado (*P. americana Mill*) (Bora *et al*., 2001)	Coconut (*C. nucifera*) (Chowdhury *et al*., 2007)	Palm (*E. guineensis* (Chowdhury *et al*., 2007)
C6:0	Caproic acid	–	0.80 ± 0.05	–	–
C7:0	Enanthic acid	–	0.29 ± 0.10	–	–
C8:0	Caprylic acid	–	0.28 ± 0.05	6.21 ± 0.34	–
C9:0	Pelargonic acid	–	0.22 ± 0.01	–	–
C10:0	Capric acid	6.07 ± 2.01	–	6.15 ± 0.21	–
C11:0	Undecylic acid	0.64 ± 0.02	–	–	–
C12:0	Lauric acid	40.73 ± 2.81	0.28 ± 0.05	51.02 ± 0.71	–
C13:0	Tridecylic acid	0.58 ± 0.10	0.17 ± 0.01	–	–
C14:0	Myristic acid	19.69 ± 0.52	0.54 ± 0.05	18.94 ± 0.63	1.23 ± 0.28
C15:0	–	–	2.33 ± 0.11	–	–
C16:0	Palmitic acid	7.23 ± 0.63	20.85 ± 0.84	8.62 ± 0.50	41.78 ± 1.27
C18:0	Stearic acid	2.01 ± 1.48	1.73 ± 0.02	1.94 ± 0.17	3.39 ± 0.65
C19:0	Nonadecylic acid	–	1.19 ± 0.01	–	–
C20:0	Arachidic acid	–	0.61 ± 0.34	–	–
C22:0	Behenic acid	–	0.04 ± 0.02	–	–
C24:0	Lignoceric acid	–	1.11 ± 0.02	–	–
Total SFA[a]		**76.94 ± 1.50**	**32.50 ± 0.12**	**92.92 ± 0.56**	**46.34 ± 0.40**
C14:1	Myristoleic acid	–	0.25 ± 0.00	–	–
C15:1	–	–	0.32 ± 0.16	–	–
C16:1	Palmitoleic acid	0.63 ± 0.02	1.79 ± 0.33	–	–
C17:1	–	–	0.37 ± 0.08	–	–
C18:1	Oleic acid	14.98 ± 1.44	17.41 ± 0.06	5.84 ± 0.50	41.90 ± 1.20
C20:1	Gondoic acid	0.62 ± 0.01	0.45 ± 0.28	–	–
C22:1	Erucic acid	–	0.12 ± 0.04	–	–
Total MUFA[b]		**16.23 ± 1.20**	**20.71 ± 0.14**	**5.84 ± 0.46**	**41.46 ± 0.56**
C18:2	Linoleic acid	7.10 ± 0.79	38.89 ± 0.59	1.28 ± 0.18	11.03 ± 0.02
C18:3	α-Linolenic acid	–	6.58 ± 0.03	–	–
C20:3	–	–	1.26 ± 0.03	–	–
Total PUFA[c]		**7.10 ± 0.79**	**46.73 ± 0.22**	**1.28 ± 0.17**	**11.84 ± 0.92**

[a]SFA, Saturated Fatty Acid; [b]MUFA, Monounsaturated Fatty Acid; [c]PUFA, Polyunsaturated Fatty Acid.

of oleic acid at 17.41 ± 0.06%. The PUFA content is 46.73 ± 0.22%, with a predominance of linoleic acid at 38.89 ± 0.59% (Dubois *et al*., 2007). Estruch *et al*. (2013) show that a diet supplemented with foods rich in unsaturated fatty acids reduces the incidence of cardiovascular events by 30% after a follow-up of about 5 years in subjects at high risk for cardiovascular disease.

Phytochemicals

There are about 63 alkaloid compounds that have been identified in the genus *Litsea* (Kamle *et al*., 2019). A study by Lee *et al*. (1995) obtained a few alkaloids from *L. garciae* which are actinodaphnine, boldine, isodomesticine, laurolitsine, and reticuline. Then, Wulandari *et al*. (2018) showed that all the extracts from branch, bark, and leaf of *L. garciae*, formed using hexane, ethyl acetate, and ethanol contain alkaloid and carotenoids (Table 3). Coumarin is only absent in the ethyl acetate leaf extract but present in all of the other extracts, while triterpenoid and steroid are absent in n-hexane extract and ethanol extract respectively. Saponins are absent in all of the extracts from the three solvents. Saponins are glycosides of triterpenes and steroids (Mugford & Osbourn, 2012). The absence of saponins in this study is probably because triterpenes and steroids are not detected together in all of the samples (Table 3), hence no formation of saponin in the plants. These results can also indicate that the different solvents due to the differences in polarity will selectively extract different compounds. The

Table 3. Phytochemical screening of *L. garciae* (adapted from Wulandari *et al*., 2018)

Solvent	Part	Alk	Flav	Sap	Tan	Triter	Ste	Car	Cou	Caro
n-hexane	Branch	+	–	–	+	–	–	+	+	–
	Bark	+	+	–	–	–	+	+	+	–
	Leaf	+	+	–	+	–	–	+	+	–
Ethyl acetate	Branch	+	+	–	+	+	–	+	+	–
	Bark	+	–	–	–	+	–	+	+	+
	Leaf	+	–	–	+	–	+	+	-	+
Ethanol	Branch	+	+	–	+	+	–	+	+	–
	Bark	+	+	–	+	+	–	+	+	+
	Leaf	+	+	–	–	+	–	+	+	–

Remarks: (+) Present, (–) Absent, Alk; Alkaloids, Flav; Flavonoids, Sap; Saponins, Tan; Tannins, Triter; Triterpenoid, Ste; Steroid, Car; Carbohydrate, Cou; Coumarin, Caro; Carotenoids.

phytochemicals that are detected in *L. garciae* are also present in the other *Litsea* species, and they are shown to have antioxidant, antiplatelet, antitumour, anticonvulsant, antibacterial, antiviral, and anti-plasmodial effects (Othman *et al*., 2019; Kamle *et al*., 2019).

Phenolic and flavonoid content

Plant parts and fruits have been shown by many epidemiological studies to be great sources of natural antioxidants. Phenolic compounds are abundant structures in plants, and antioxidant compounds are usually in the phenolic form. Phenol compounds can destroy radicals because they contain hydroxyl groups. The hydrogen atom from the hydroxyl groups is abstracted by the hydroxyl radical resulting in phenol being converted to stable phenoxyl radicals. Therefore, the determination of the quantity of phenolic compounds is very important to ascertain the antioxidant capacity of plant extracts (Aksoy *et al*., 2013). The most important single group of phenolics in food are flavonoids which consist mainly of catechins, proanthocyanins, anthocyanidins, flavones, flavonols, and their glycosides (Tungmunnithum *et al*., 2018). Flavonoids are crucial antioxidants since they have redox potential, which allows them to act as a reducing agent, hydrogen donors, and singlet oxygen quenchers (Panche *et al*., 2016). The presence of flavonoids is an indication that the plant could have anti-inflammatory, anti-allergic, and antithrombotic or vasoprotective effects (Panche *et al*., 2016).

A study by Wulandari *et al*. (2018) shows that all the plant parts of *L. garciae* contain a significant level of total phenolic, total flavonoid, and total anthocyanin. The ethanol extract has the highest total phenolic and flavonoid contents in all the plant parts as compared to n-hexane and ethyl acetate extracts. This can suggest that ethanol is the solvent of choice for total phenolic and flavonoid extraction (Table 4). About 39 compounds of flavonoids have been recognized in *Litsea* species which are primarily flavones, flavanols, flavanones, flavanonols, anthocyanidins, chalcones, and flavan-3-ols (Wang *et al*., 2016). Both flavonoid and phenolic compounds are known to have multiple biological effects including antioxidant and anti-inflammatory properties.

For the fruit part (Table 5), the total phenolic content is highest in the cupule and seed, followed by the flesh from both the 80% methanol and aqueous extracts. The same trend is also observed for flavonoid contents where flavonoid content is highest in the cupule and seed followed by the flesh from both 80% methanol and aqueous extracts. On the other hand, the flesh recorded the highest content of anthocyanin, followed by the seed and then cupule for both the 80% methanol and aqueous extracts. Anthocyanin is naturally occurring pigments in fruits and vegetables belonging to the group of flavonoids. There are a few studies regarding the positive association of their intake with healthy biological effects such as reducing the risk of coronary heart disease, acting as antioxidants, improving visual acuity, and having anticancer properties (Mukherjee, 2019).

Pharmacological properties of *Litsea garciae*

Traditional use of L. garciae

In Borneo, the indigenous people use some parts of the *L. garciae* plants such as the leaves and barks for traditional medicinal uses. In Sarawak, the Ibans use the ground bark of *L. garciae* as a dressing for the treatment of caterpillar stings and boils (Mirfat *et al*., 2018). The bark is also used to make a decoction for the treatment of rectal bleeding. The Selako people use a poultice of leaves and young shoots of *L. garciae* with the combination of shallot and fennel seeds for the treatment of skin infections, diseases, and burns. The Kayan people treat beriberi by applying a warm poultice of *L. garciae* leaves,

Table 4. Total phenolic and flavonoid content of *L. garciae* (adapted from Wulandari *et al*., 2018)

Solvent	Part	Phenolic (µg GAE/mg extract)	Flavonoid (µg GAE/mg extract)
n-hexane	Branch	30 ± 0.002	190 ± 0.004
	Bark	40 ± 0.002	170 ± 0.003
	Leaf	30 ± 0.001	110 ± 0.002
Ethyl acetate	Branch	30 ± 0.002	140 ± 0.005
	Bark	40 ± 0.004	160 ± 0.005
	Leaf	40 ± 0.004	210 ± 0.004
Ethanol	Branch	100 ± 0.001	1010 ± 0.002
	Bark	90 ± 0.009	800 ± 0.001
	Leaf	100 ± 0.001	240 ± 0.001

Table 5. The total phenolic, flavonoid, and anthocyanin contents of different parts of *L. garciae* fruit extracts (adapted from Hassan *et al*., 2013)

Chemical content	80% methanol extract			Aqueous extract		
	Cupule	Seed	Flesh	Cupule	Seed	Flesh
Total phenolic (mg GAE/g)	8.29 ± 0.70	8.09 ± 0.60	2.65 ± 0.11	3.71 ± 0.24	3.54 ± 0.17	2.01 ± 0.07
Total flavonoid (mg RE/g)	6.90 ± 0.61	5.73 ± 1.39	2.05 ± 0.21	2.88 ± 0.23	2.63 ± 0.29	1.46 ± 0.15
Total anthocyanin (mg CE/100g)	0.35 ± 0.00	2.11 ± 0.03	4.12 ± 0.10	0.22 ± 0.03	1.42 ± 0.10	2.83 ± 0.23

Table 6. The antioxidant properties of *L. garciae* fruit extracts from different parts using three different assays (adapted from Hassan *et al*., 2013)

Assays	80% methanol extract			Aqueous extract		
	Cupule	Seed	Flesh	Cupule	Seed	Flesh
[1]DPPH assay	16.7 ± 0.6	17.3 ± 2.3	60.0 ± 3.5	20.0 ± 0.0	22.7 ± 2.3	62.7 ± 4.6
[2]FRAP assay	2,050.0 ± 28.5	1,910.0 ± 59.2	410.0 ± 54.1	1,650.0 ± 29.7	690.0 ± 17.0	210.0 ± 9.7
[3]ABTS assay	25.05 ± 1.7	19.14 ± 1.7	4.05 ± 0.1	16.47 ± 2.0	6.86 ± 0.6	2.14 ± 1.0

1. 2,2-Diphenyl-1-picryl-hydrazyl-hydrate assay (DPPH assay)
   DPPH free radical scavenging activity was expressed as IC_{50} (mg/mL).
2. Ferric reducing/antioxidant power (FRAP assay)
   FRAP has expressed as µM ferric reduction to ferrous in 1 g of dry sample. 3)2,2'-3. Azino-bis (3-ethylbenzothiazoline-6-sulphonic acid)
3. 2,2'-Azino-bis (3-ethylbenzothiazoline-6-sulfonic acid
   ABTS assay free radical scavenging activity was expressed as mg ascorbic acid equivalent antioxidant capacity (AEAC) in 1 g of dry sample.
4. Values are presented as mean ± SD (*n*=3) which, with different letters (within the column), are significantly different at α=0.05.

while the Kelabits make a cataplasm using the root bark to cure the sprains. In addition to that, the Penans use the pounded and warmed bark for the treatment of muscular aches and sprains, and the combination of *L. garciae* and durian bark is used as an antidote for snake bites (Lim, 2012).

Besides medicinal purposes, the extraction of oil from the *L. garciae* seeds is used in the manufacturing of candles and soaps. *Litsea garciae* woods have also been used as timbers in the construction field (Lim, 2012). It is also suitable for plywood production and interior decoration such as flooring materials, furniture, and paneling.

Antioxidants

Hassan *et al*. (2013) demonstrated the potent antioxidant activity of methanol and aqueous extracts of *L. garciae* using three different assay systems (DPPH assay, FRAP assay, and ABTS assay) (Table 6). The FRAP and ABTS assays show that the non-edible part of *L. garciae* displays the highest antioxidant activity in comparison to the edible part for both the methanol and aqueous extracts in the order of cupule > seed > flesh (Hassan *et al*., 2013). This is in agreement with the DPPH assay where the lower the IC_{50}, which is the concentration to deplete the DPPH, the better the antioxidant activity displayed by the substance. The IC_{50} values are in the order of cupule < seed < flesh. A previous study by Soong and Barlow (2004) also showed that the total antioxidant activity of the seeds from avocado, jackfruit, longan, mango, and tamarind are also higher compared to the edible portions.

The scavenging activity of *L. garciae* fruit parts shows a similar trend as portrayed by the total phenolic and total flavonoid contents (Table 5) where the cupule has the highest level of total phenolic and flavonoid contents followed by the seed and the flesh. In addition, the detection of alkaloids, flavonoids, tannins, coumarin, and carotenoids (Table 3) in *L. garciae* suggests that *L. garciae* is a rich source of natural antioxidants and therefore of potential therapeutic agents in preventing oxidative-stress related diseases.

Antimicrobial and antifungal properties

The branch, bark, and leaf from n-hexane, ethyl acetate, and ethanol solvent extracts of *L. garciae* with concentrations of 1250, 625, and 312.5 p.p.m were tested for their antibacterial activity against *Propionibacterium acnes* using micro broth dilution test (Wulandari *et al*., 2018). All the samples inhibit bacterial growth. The n-hexane and ethanol extracts of the branch and ethyl acetate extract of the leaf have a minimum inhibitory concentration (MIC) at 312.5 p.p.m (Table 7). The study of Wulandari *et al*. (2018) did not show a strong antibacterial activity probably because it used a higher concentration of *L. garciae* (312.5 to 1250 p.p.m), and besides, the active compound(s) may be present in insufficient quantities to show activity with the dose employed.

The crude extract of *L. garciae* leaf show some antifungal activities (Table 8) (Johnny *et al*., 2010; Johnny *et al*., 2011). The methanol extract exhibits higher antifungal activities against *C. capsici* than towards *C. gloeosporioides*. On the other hand, the chloroform extract shows a higher percentage of radial growth inhibition on *C. gloeosporioides* than towards *C. capsici*. The acetone extracts show approximately a similar percentage of inhibition on *C. gloeosporioides* and *C. capsici* at concentrations of 1.00 and 10.00 μg/mL respectively.

The *Litsea* species have demonstrated anti-microbial and antifungal activities against numerous pathogenic strains. The essential oil of *Litsea* species has been extensively studied for its antimicrobial activities. For example, essential oil from *L. cubeba* has marked antimicrobial effects on *Vibrio parahaemolyticus, Listeria monocytogenes, Lactobacillus plantarum, and Hansenula anomala in vitro,* and in food products (Liu & Yang, 2012). *Staphylococcus aureus, Listeria monocytogenes, Escherichia coli, Pseudomonas aeruginosa, Candida albicans,* and *Aspergillus niger* are also sensitive to the cytotoxic activity of the *L. cubeba* essential oils (Saikia *et al*., 2013). The presence of aldehydes (Li *et al*., 2014) and alkaloids (Zhang *et al*., 2012) in the essential oil probably accounts for its antimicrobial effects. The methanol extract of *L. glutinosa* exhibits antibacterial activity comparable to chloramphenicol (Mandal *et al*., 2000) while the essential oil of *L. laevigata* (Muhammed *et al*., 2008) and *L. acuminata* (Su & Ho, 2013) have great activity against gram-positive bacteria and fungus. The essential oil from the root of *L. resinosa*

Table 7. Minimal Inhibitory Concentration (MIC) of *L. garciae* using antibacterial assay (adapted from Wulandari *et al*., 2018)

Solvent	Part	MIC (p.p.m)
n-hexane	Branch	625
	Bark	312.5
	Leaf	625
Ethyl acetate	Branch	625
	Bark	1250
	Leaf	312.5
Ethanol	Branch	625
	Bark	312.5
	Leaf	625

Table 8. The percentage reduction of radial growth (mm) of *Colletotrichum gloeosporioides (Cg)* and *Colletotrichum capsici (Cc)* by varying concentrations of *L. garciae* leaf extracts in different solvents using antifungal assay (adapted from Johnny *et al*., 2010 and Johnny *et al*., 2011)

Solvent	Mean ± S.E of % of Inhibition of Radial Growth (mm)				Fungus
	0.01 μg/mL	0.10 μg/mL	1.00 μg/mL	10.00 μg/mL	
Methanol	13.31 ± 0.49	15.17 ± 0.55	15.26 ± 0.58	17.22 ± 0.78	*Cg*
	13.59 ± 0.59	31.08 ± 0.77	33.77 ± 0.78	36.71 ± 1.41	*Cc*
Chloroform	14.24 ± 0.51	15.74 ± 0.67	17.73 ± 0.78	19.38 ± 0.48	*Cg*
	1.94 ± 1.70	5.84 ± 1.26	8.85 ± 1.99	9.68 ± 1.53	*Cc*
Acetone	18.88 ± 0.69	21.16 ± 0.50	21.78 ± 0.63	22.68 ± 0.56	*Cg*
	NI	NI	24.48 ± 1.38	25.48 ± 1.26	*Cc*

All the values represented the mean ± standard error. NI = no inhibition.

and *L. elliptica* shows significant antifungal activities with inhibition rates of 80.11% and 66.85% respectively (Wong *et al*., 2014). Thus, the essential oil of *L. garciae* can be explored further for its potential as a natural antimicrobial source.

Anticancer activities

The anticancer activity of *L. garciae* on human cell lines was investigated using MTT (3-(4,5-Dimethylthiazol-2-yl)-2,5-diphenyltetrazolium) method. *Litsea garciae* has moderate cytotoxic activities against three types of cell lines (Table 9) (Kutoi *et al*., 2012). The methanolic bark extract of *L. garciae* has moderate cytotoxic activities against human breast cancer (MCF-7) cell lines and human colorectal cancer (HT-29) cell lines with the IC_{50} values of 66 and 77 µg/mL respectively, and weak cytotoxic activity against cervical cancer (HeLa) cell lines with IC_{50} value of 117 µg/mL. On the other hand, the methanolic leaf extract has no activity against HeLa cell lines, weak towards MCF-7 cell lines (IC_{50} = 104 µg/mL), and has moderate cytotoxicity against HT-29 cell lines (IC_{50} = 73 µg/mL).

Other species of *Litsea* also demonstrate high anticancer activities against numerous cell lines. Among the studies, the alkaloids isolated from the bark of *L. cubeba* exhibit very potent cytotoxic effect on several cancer cell lines such as BGC-823 cells (human gastric carcinoma), HepG2 cells (human hepatocellular carcinoma), MCF-7 cells (human breast cancer), SGC-7901 cells (human gastric adenocarcinoma), SK-MEL-2 (human skin cancer), and SK-OV-3 (ovarian cancer) with IC_{50} values ranging from 9.54–12.22 µM (Zhang *et al*., 2012). In addition, the butenolide isolated from the leaves of *Litsea lii* var. *nunkao tahangensis* have high cytotoxicity against MCF 7, NCI H460 (non-small lung cancer), and SF 268 (glioblastoma cells) lines in vitro (Wang *et al*., 2008). Two novel flavonoids with chalcone skeleton isolated from the stem barks of *Litsea rubescens* and *Litsea pedunculata* have cytotoxic activities against myeloid leukemia (HL-60) and carcinoma (A431) cell lines and more active than cisplatin (DDP) (Li *et al*., 2011). The alkaloids, such as boldine, are cytotoxic and induce apoptosis in breast cancer cells (Pydar *et al*., 2014) as shown by an increase in the release of lactate dehydrogenase, membrane permeability, and DNA fragmentation. Thus, more studies should be carried out to explore the potential of different parts of *L. garciae* as an anticancer agent.

Anti-inflammatory activity

Different parts of *L. garciae* have been used in folk medicine for treatments of muscular aches, sprained ankles and knees, skin disease, rectal bleeding, boil, and snakebite, and caterpillar stings (Mirfat *et al*., 2018). To date, only one study was done to show the anti-inflammatory activity of *L. garciae*. A study by Kutoi *et al*. (2012) shows the methanolic crude extracts of barks, leaves, and fruits of *L. garciae* exhibit some anti-inflammatory properties (Table 10). The bark, leaf, and fruit extracts inhibit lipoxygenase activity by 1.20%, 3.85%, and 9.42% respectively. There is a slightly higher inhibition of hyaluronidase activity with inhibition of 11.3%, 9.51%, and 27.7% for the barks, leaves, and fruits respectively. In addition, the bark and leaf extracts inhibit xanthine oxidase activity by 2.19% and 2.26% respectively.

Other species of *Litsea* have been assessed for their anti-inflammatory effects, for example, the methanol extract of *L. cubeba* inhibits nitric oxide (NO) and prostaglandin E2 (PGE2) production in lipopolysaccharide (LPS)-RAW-264.7 macrophages (Choi & Hwang, 2004). The ethanol and water root extracts of *L. cubeba* can reduce adjuvant arthritis and decrease the expression levels of cyclooxygenase-2 (COX-2) and 5-lipoxygenase in rats with Freund's complete adjuvant-induced arthritis (Lin *et al*., 2013). The methanol extracts of *L. akoensis* have significant anti-inflammatory activity by inhibiting the production of nitric oxide by 81.07% in LPS-induced macrophage at a dose of 25 µg/ml (Lin *et al*., 2007). The ethanol and chloroform extracts of *L. japonica* fruit significantly inhibit the production of COX-2/PGE2 and NO/iNOS, and pro-inflammatory cytokines by inhibiting the NF-κB and JNK/p38 MAPK signaling in LPS-induced macrophages (Koo *et al*., 2014).

Table 9. Inhibitory concentration of barks and leaves methanolic extract on HeLa, MCF-7, and HT-29 (adapted from Kutoi *et al*., 2012)

Part	Cytotoxicity activities against cell lines, IC_{50}		
	HeLa	*MCF-7*	*HT-29*
Barks (µg/mL)	117	66	77
Leaves (µg/mL)	N/A	104	73

Table 10. Lipoxygenase (LO), Hyaluronidase (HO), and Xanthine Oxidase (XO) inhibitory activities (adapted from Kutoi *et al*., 2012)

Part	Anti-Inflammatory Assay (% of inhibition)		
	LO Assay	*HO Assay*	*XO Assay*
Barks	1.20	11.30	2.19
Leaves	3.85	9.51	2.26
Fruits	9.42	27.70	Not Active

CONCLUSION

Litsea garciae has the potential to be promoted as a healthy food since its fruit is rich in nutritional components, and several studies had shown that the plant parts contained some pharmacological activities. However, the electronic data search revealed extremely scarce data on *L. garciae.* More studies should be done to identify the chemical constituents, for example, the types of alkaloids, butenolide, terpenes, flavonoids, amides, lignans, steroids, and fatty acids of *L. garciae*. To unravel the full therapeutic potential of the *L. garciae* plant, more pharmacological investigations should be performed. So far only antioxidants, antimicrobial, antifungal, anti-inflammatory, and anticancer studies were done for *L. garciae,* and the studies are far from complete. The use of *L. garciae* bark as an antidote for snakebite and dressing for caterpillar stings and a treatment for boils and other skin diseases as claimed by the locals should be explored. Other pharmacological studies on plant parts of *L. garciae* extracted with different solvent systems should be done, for example, the antinociceptive effects, antidiabetic activity, activity on the cardiovascular system, antidiarrheal activity, aphrodisiac, and hepatoprotective.

The authors are currently investigating the lipid composition of *L. garciae* fruit extracted with two solvent systems, which are petroleum ether and chloroform: methanol (1:2). In addition, the authors are also investigating the wound healing potentials of the *L. garciae* fruit on the fibroblasts cell line. The results from this study will become important contributions and can fill up the gaps in the knowledge on *L. garciae*.

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