Research Journal of
Phytochemistry

ISSN 1819-3471

Academic
Journals Inc.

www.academicjournals.com

OPEN ACCESS Research Journal of Phytochemistry

ISSN 1819-3471
DOI: 10.3923/rjphyto.2017.66.73

Review Article
Physico-chemical Properties and Biological Activities of Rambutan (*Nephelium lappaceum* L.) Fruit

Abdul Rohman

Department of Pharmaceutical Chemistry, Faculty of Pharmacy and Research Center of Halal Products, Gadjah Mada University, 55281 Yogyakarta, Indonesia

Abstract

Rambutan (*Nephelium lappaceum* L.) is exotic fruit commonly found in South East Asia region such as Indonesia, Malaysia and Thailand. Some physico-chemical properties have been used to describe the characteristics of rambutan fruit, either edible part or nonedible one. The seed and peel of rambutan are considered as wastes, therefore, some scientists have attracted to investigate the biological activities of seed and peel to seek the possibility of both to be developed as functional food. Several biological activities, which are beneficial to human health are reported in rambutan fruit, namely antioxidant, antibacterial, antidiabetic and anticancer. The active components contained in rambutan such as ellagic acid, corilagin and geraniin are responsible for those activities. This review highlighted some physico-chemical properties and the active compounds present in the fruit, seed and peel of rambutan along with the biological activities supporting rambutan fruit as functional food.

Key words: Rambutan, rambutan seed fat, physico-chemical, biological activities

Received: November 08, 2016 Accepted: January 03, 2017 Published: March 15, 2017

Citation: Abdul Rohman, 2017. Physico-chemical properties and biological activities of rambutan (*Nephelium lappaceum* L.) fruit. Res. J. Phytochem., 11: 66-73.

Corresponding Author: Abdul Rohman, Department of Pharmaceutical Chemistry, Faculty of Pharmacy and Research Center of Halal Products, Gadjah Mada University, 55281 Yogyakarta, Indonesia

Competing Interest: The author has declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Rambutan (*Nephelium lappaceum* L.), family of Sapindaceae is important tropical fruit in Southeast Asian region, especially in Indonesia, Thailand and Malaysia. Rambutan is a tropical plant which grown in warm, humid and low evaporation rates with high rainfall. Rambutan fruit is ovoid with a red or yellow pericarp. It is covered with soft spines and varied in color from green, yellow and red[1]. In Indonesia, there are some cultivars of rambutan with different characteristics, namely Rapiah, Narmada, Sinyonya, Binjai, Garuda, Kapulasan, lebak bulus, Si Batuk Ganal, Antalagi, Tangkue Lebak, Simacan, Bahrang and Sibongkok. Commercially, rambutan fruit is available as fruit fresh, juice, jam, marmalades and jellies[2]. In Indonesia, rambutan has some local names, namely Rambot in Aceh, Barangkasa in Maluku, Buiuwan in Bali, Rambuta in West Nusa, Balatung, Boeol, Rambusa Bolotu and Wulangas in Sulawesi, Banamon, Beliti, Bengayu, Beriti, Kayokan, Maliti, Puson, rambutan, Sagalong, Sanggalong and Siban in Kalimantan, rambuten in Sumatra, as well as rambutan in Java, Minangkabau and Madurese[3].

The anatomical characteristics of whole rambutan fruit constitutes of 27.4% of weight, 13.2% peel, 11.7% pulp, 2.53% seed and 1.60% embryo[4]. Rambutan fruit is consumed freshly, consequently it produces huge amount of wastes from peel and seed. Therefore, it is important to take advantages of rambutan waste or underutilized part by exploring them for industrial purposes[5]. Besides nutritional aspects, rambutan may be contaminated with bacteria. Rambutan fruit cultivar Binjai is reported to contain endophytic bacteria from genus of *Corynebacterium*, *Bacillus*, *Chryseobacterium*, *Staphylococcus* and *Curtobacterium*. These bacteria are suspected to play as plant growth-promoting bacteria[6].

CHARACTERIZATION AND COMPOSITIONAL ANALYSIS OF RAMBUTAN FRUIT

Rambutan fruit is potential to be used as functional food due to its capability to provide beneficial health effects. Underutilized part of rambutan (peel and seed) contain some active components which are reported to prevent some diseases, therefore the compositional analysis and its characterization of rambutan are explored by some plant scientists.

Chemical composition of rambutan fruit: Ong *et al.*[7] have determined some volatile compounds (odor-active compounds) in rambutan fruit using gas chromatography-flactometry (GC/O) and gas chromatography-mass spectrometry (GC/MS). The extraction solvents used are ethyl acetate (semipolar) and Freon (nonpolar) to obtain polar and nonpolar fractions of volatile compounds. The polar fraction contained more odor-active compounds than nonpolar fraction.

The volatile compounds identified in rambutan fruit using GC/O are β-damascenone, (E)-4,5-epoxy-(E)-2-decenal, vanillin, (E)-2-nonenal, phenylacetic acid, cinnamic acid, ethyl 2-methylbutyrate, δ-decalactone, 3-phenylpropionic acid, 2,6-nonadienal, furaneol, 2-phenylethanol, m-cresol, maltol, heptanoic acid, nonanal, guaiacol, (Z)-2-nonenal and γ-nonalactone. Some other volatile compounds identified are (E,E)-2,4-decadienal, ethyl cinnamate, 2-acetyl-2-thiazoline, (E)-furan linalool oxide, carvone, (E,Z)-2,4-nonadienal, 1-octen-3-ol, γ-decalactone, (E,E)-2,4-nonadienal, furfural, benzothiazole, (E,Z)-2,4-decadienal, γ-undecalactone, 3-methyl(thio)propanol, endo-isocamphone, α-humulene, 2-heptanone, isoamyl acetate, 2-amylfuran, 2-methylbutyric acid, 2-acetylthiazole, ethyl butyrate, hexanal, hexanoic acid, hexyl acetate, 5-methylfurfural, isobutyl acetate, 1,2-dimethoxybenzene, isobutyric acid, octanoic acid, butyric acid, butyl acetate, ethyl crotonate, (E)-2-hexenal, (E)-2-hexen-1-ol, 1-hexanol, γ-butyrolactone, amyl acetate, ethyl 3-hydroxybutyrate, benzaldehyde, ethyl 3-hydroxy-3-methylbutyrate, ethyl hexanoate, benzyl alcohol, limonene, acetophenone, ethyl 2-hydroxycaporate, camphor-L, 2,3-dihydroxy-3,5-dihydroxy-6-methyl-4(H)-pyran-4-one, benzyl acetate, octyl acetate, ethyl benzoate, (Z)-pyran linalool oxide, nonyl alcohol, (E)-pyran linalool oxide, benzoic acid, ethyl phenyl acetate and phenyl ethyl acetate[3,7].

Chemical composition of rambutan seed: Rambutan seed is reported to contain proximate composition with moisture content of 9.6±3.52%, crude protein as determined using Kjeldahl of 7.6±0.14%, crude fiber 2.4±0.32%, lipid extracted using Soxhlet with petroleum ether as extracting solvent of 38.0±4.36%, carbohydrate (by difference) 28.7±0.43% and ash content of 1.22-2.26%[8,9]. Rambutan seed can produce a solid pleasant scented rambutan tallow which is similar to cocoa-butter. When heated, the fats obtained can be used as alternative sources in the cosmetics industry and biodiesels[3,10], as substitute for cocoa butter due to the similar physicochemical characteristics between rambutan fat and cocoa butter[11]. Rambutan Seed Fat (RSF) contained some minerals needed by human, namely chromium (0.55 mg/100 g), manganese (1.62 mg/100 g), nickel (0.24 mg/100 g), copper (0.83 mg/100 g), zinc (40.61 mg/100 g) and and iron (24.77 mg/100 g)[9].

Table 1: Physico-chemical properties of rambutan seed fat

Properties	Values by Lourith *et al.*[12]	Values By Augustin and Chua[14]	Values by Sirisompong *et al.*[2]	Values by Sonwai and Ponprachanuvut[15]	Values by Romain *et al.*[16]	Values by Manaf *et al.*[8]
Free fatty acids as oleic acid	-	-	-	-	-	6.1±2.33
Acid value (mg KOH g^{-1} fat)	4.35±0.00	-	-	-	-	-
Saponification value (mg KOH g^{-1} fat)	246.73±0.10	-	-	-	-	182.1±0.16
Iodine value (g I2/100 g fat)	44.17±0.30	-	-	-	-	50.3±1.24
Peroxide value (mEq kg^{-1})	1.00±0.00	-	-	-	-	
Unsaponified matters (%)	0.10±0.00	-	-	-	-	0.5±0.12
Fatty acid composition						
Palmitic acid (C16:0)	5.84±0.12%	4.61±0.25%	4.69±0.15	3.39±0.11	4.20±0.10%	4.60%
Palmitoleic acid (C16:1)	0.86±0.02%	1.08±0.19%	0.49±0.04	-	-	0.72%
Stearic acid (C18:0)	4.54±1.86%	6.53±0.84%	7.03±0.08	8.70±0.11	7.20±0.19%	7.88%
Oleic acid (C18:1)	31.08±0.75%	39.08±1.12%	36.79±0.16	33.13±0.58	36.60±0.95%	43.09%
Linoleic acid (C18:2)	2.40±0.07%	1.39±0.17%	1.37±0.02	0.03±0.00	1.80±0.05%	3.22%
Linolenic acid (C18:3)	-	-	-	-	-	0.74%
Arachidic acid (C20:0)	28.65±0.72%	36.46±0.32%	34.32±0.01	42.51±0.60	38.10±1.00%	31.53%
Gadoleic acid (C20: 1)	-	-	-	-	-	5.89%
Behenic acid (C22:0)	3.04±0.10%	2.60±0.095%	3.10±0.04	2.63±0.08	3.60±0.09%	2.10%

-: Indicated no reported data

Lourith *et al.*[12] have extracted fats from rambutan seed intended for industrial scale and found that maceration extraction technique using n-hexane for 1 h is the feasible means among other techniques. The extraction yield obtained is 30.12±0.04%. Re-use of n-hexane during maceration gave non-significantly different extractive yields ($p>0.05$). The main fatty acids present in RSF is oleic acid (C18:0) and arachidic acid (C20:0). Table 1 compiled fatty acid composition of RSF along with other physicochemical parameters. Rambutan seed is also potential source of flour which is rich in carbohydrate. The defatted rambutan seed flour can be obtained using supercritical extraction with CO_2 at 35 MPa and 45°C[13]. The seed flour is treated with alkaline solution and is compared with that of non-treated. During alkaline treatment, protein, fat and amylose contents are reduced with 9.1, 24.9 and 6.0%, respectively. The ash content of alkali-treated flour was higher than that of untreated flour ($p<0.05$).

Some chemical compounds are contained in rambutan seed. Ragasa *et al.*[17] reported that dichloromethane extracts of rambutan seed contained two new diastereomeric monoterpene lactones (1) and (2), the known butenolide siphonodin (3) and kaempferol 3-O-β-D-glucopyranoside-7-O-β-L-rhamnopyranoside (4). The chemical structures of (1)-(4) are shown in Fig. 1.

Physicochemical composition of rambutan peel: The ethanolic extract of Rambutan Peel (RP) is reported to contain ellagic acid, corilagin and geraniin which are responsible for some biological activities. The methanolic and ethanolic extract of RP contain geraniin constituting of 56.8 and 37.9 mg g^{-1}, respectively[18,19]. Liang *et al.*[20] have isolated five oleane-type triterpene oligoglycosides from RP, namely hederagenin 3-O-(3-O-acetyl-β-D-xylopyranosyl)-(1→3)-α-L-arabinopyranosidealong (new compound) with four known compounds of hederagenin, hederagenin 3-O-(4-O-acetyl-α-L-arabinopyranosyl)-(1→3)-α-L-rhamnopyranosyl-(1→2)-α-L-arabinopyranoside, hederagenin 3-O-α-L-arabinopyranosyl-(1→3)-α-L-rhamnopyranosyl-(1→2)-α-L-arabinopyranoside and hederagenin 3-O-β-D-glucopyranosyl-(1→3)-α-L-rhamnopyranosyl-(1→4)-β-D-xylopyranoside.

BIOLOGICAL ACTIVITIES OF RAMBUTAN FRUIT

Some biological activities of rambutan fruit along with its by-products (seed and peel) are reported such as antioxidant, antibacterial, antidiabetic and cytotoxic activity. These activities are deduced from several active compounds which include anthocyanins, phenolics and flavonoids. Some attempts have been made to isolate these bioactive compounds as much as possible, using experimental design approach. Maran *et al.*[21] used central composite design using 4 factors (extraction temperature, extraction time, power of ultrasound and solid-liquid ratio) each with three levels. The optimal conditions based on both individual and combination of factors are achieved using extraction temperature of 50°C, ultrasound power of 20 W, extraction time of 20 min and ratio solid-liquid of 1:18.6 g mL^{-1}.

The safety evaluation of rambutan peel extract in male Wistar rats through acute and sub-chronic toxicities has been reported by Thinkratok *et al.*[22]. The acute toxicity is monitored by giving rats with single doses of extract. During acute toxicity, the serum levels of triglyceride (TG), aspartate aminotransferase (AST) and alanine aminotransferase (ALT) remain constant. The LD_{50} was reported to be greater than 5000 mg kg^{-1} of extract. The sub chronic toxicity is evaluated

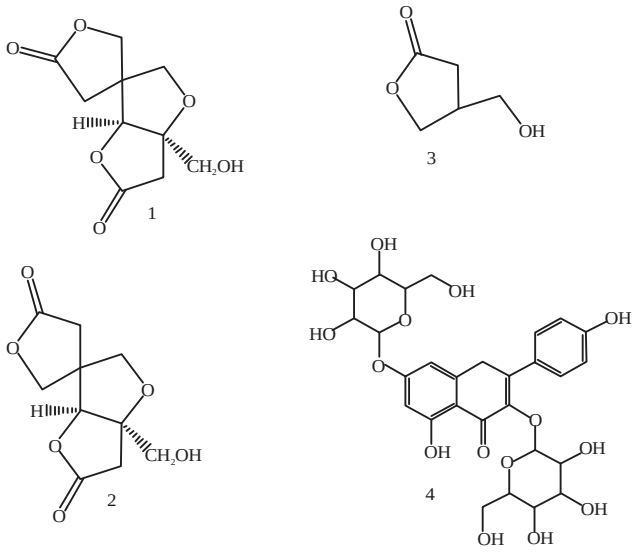

Fig. 1: Chemical structures of two new diastereomeric monoterpene lactones, 1 and 2 and the known butenolide siphonodin (3), kaempferol 3-O-β-D-glucopyranoside-7-O-β-L-rhamnopyranoside (4), contained in rambutan seed

by administraion of extract into rats orally at doses of 500, 1000 and 2000 mg kg^{-1} daily for 30 days. During sub-chronic toxicitytest, there are no mortal rats found up to 1000 mg kg^{-1} day^{-1} of extract, while rats treated with extract at dose 2000 mg kg^{-1} day^{-1} exhibited the rat's mortality of 12.5%. All the given doses of extract significantly decreased the levels of TG and blood urea nitrogen ($p<0.05$), but did not alter those of AST and ALT ($p>0.05$). The acute and sub-chronic toxicity studies of ethanolic extract of rambutan peel were also performed by Subramaniam *et al.*[23]. The results indicated that extract do not show rat's mortality and no significant adverse effects observed, as indicated by no significant difference of some biochemical parameters of serum urea, ALP, AST, protein and total protein. The lethal dose of extract reported is >2000 mg kg^{-1}, therefore, the ethanolic extract of rambutan peel is considered as not toxic. Rajasekaran *et al.*[24] reported that methanolic extracts of raw seed, boiled seed and roasted seed of rambutan are safe up to 2.5 g kg^{-1} dose during acutetoxicity study.

Antioxidant anti-inflammation activities: Antioxidant activities of Rambutan Peel (RP) and by products are reported using some mechanisms including antiradical, ferric reducing activity, chelating agent, beta-chelating agent and lipid peroxidation method *in vitro*, as reviewed by Carocho *et al.*[25] and Embuscado[26]. The antioxidant activities of rambutan are correlated with the presence of phytochemicals such as phenolics, flavonoids and carotenoids[27,28]. Permatasari and Rohman[29] reported that ethanolic extract of RP from cultivars Simacam and Lebak bolus revealed strong antiradical activities toward 2,2′-diphenil-1-picrylhydrazil radical (DPPH). Among extracts and fractions evaluated, ethyl acetate fraction of RP cult. Lebak bolus has the highest antiradical activity with IC_{50} value of 2.732 μg mL^{-1}, lower than that of positive control of vitamin C with IC_{50} of 1.998 μg mL^{-1}. The correlation between IC_{50} and phenolics content revealed R^2 of 0.594, while R^2 for the relationship between IC_{50} and flavonoid content is 0.323. These correlations indicated that phenolics and flavonoid contents contributed to 59.4 and 32.30% of antiradical scavenging activity of RP extracts, respectively. Rohman *et al.*[30] also investigated antiradical activities of extract and fractions of RP from two cultivars of Aceh and Binjai. Both cultivars revealed strong antiradical activities toward DPPH and 2,2-azinobis(3-ethylbenzo thiazoline-6-sulphonic acid) diammonium salt (ABTS). Thitilertdecha *et al.*[31] have investigated the extracts of ether, methanol and aqueous of RP using DPPH radicals and the IC_{50} values reported are 17.3±1.03, 4.94±0.26 and 9.67±0.87 μg mL^{-1}, repectively. The DPPH radical scavenging activity of the lyophilized water extract of peel, seed and pulp of rambutan cult. Seeechompoo and Rongrien revealed IC_{50} values in the range[32] of 1.42-4.75 mg mL^{-1}. Palanisamy *et al.*[33] have compared DPPH radical activities of fruit pulp, seed, rind and leaves of rambutan. The ethanolic extracts of rind and leaves of rambutan exhibited the highest DPPH radical-scavenging ability. Using ABTS radical assay, ethyl acetate extract of RP showed the highest radical capacity with Trolox Equivalent Antioxidant Capacity (TEAC)[34] of 23.0 mM mg^{-1}. While,

Tachakittirungrod *et al.*[35] reported that ethanolic crude extract of RP has TEAC of 3.07±0.003 mM mg^{-1}.

Using Ferric Reducing Assay Power (FRAP), the methanolic extract of RP revealed the highest activity with effective concentration (EC_{50}) value of 20.2 mM mg^{-1} among extracts and fractions evaluated. The FRAP activities are correlated with phenolic contents[34]. The FRAP method is also used to evaluate the antioxidant activities of hexane, ethyl acetate and ethanol extracts of RP from 4 cultivars (Lebak bulus, Rajah, Rapiah and Binjai). The ethyl acetate extract of RP cult. Binjai showed the highest FRAP capacity with EC_{50} value[36] of 77.1 μg mL^{-1}.

The binary extraction system using the mixture of ethanol and water of RP was investigated for antioxidant assay *in vivo*. The oral administration of RP extracts into Sprague Dawley rats for 14 and 30 days resulted in a significant increase of antioxidant enzymes (superoxide dismutase, glutathione reductase and catalase), compared with those in control group rats[37]. Chingsuwanrote *et al.*[38] have investigated antioxidant activity of rambutan cultivars Rongrien and Sichompu *in vivo*. The ethanolic extract of rambutan pulp cultivar Sichompu at 40 mg mL^{-1} is able to inhibit the formation of Reactive Oxygen Species (ROS) by 25% using pre-treatment of non-differentiated U937 cells, while rambutan cultivar Rongrien do not show significant antioxidant activity.

The radical scavenging activities of hexane, ethyl acetate and ethanol extracts of Rambutan Leaves (RL) from five cultivars namely Rapiah, Rajah, Binjai, Lebak bulus and non-edible rambutan using DPPH and ABTS were reported by Fidrianny *et al.*[39]. The ethanolic extract of RL cultivar Rapiah had the highest antiradical activities with IC_{50} value of 14.66 μg mL^{-1} (using DPPH) and IC_{50} of 12.826 μg mL^{-1} (ABTS). A correlation between these antiradical activities of all extracts studied and phenolics contents resulted R^2 of >0.957. The un-blanched and blanched water extract of RL have similar antiradical activity toward DPPH radical with IC_{50} values of about[40] 1.00 μg mL^{-1}. The rind and leaves also revealed the antiradical activity toward ABTS radical with IC_{50} values of 1.7±0.1 and 12.2±0.2 μg mL^{-1}, respectively.

Chingsuwanrote *et al.*[38] have evaluated anti-inflammation activity of rambutan cultivars Rongrien and Sichompu *in vivo*. The ethanolic extract of both cultivars inhibited the secretion of TNF-α, but not IL-8. This activity is deduced due to antioxidant activity of active compounds contained in all parts of rambutan.

Antibacterial activity: The activity of ether, methanol and aqueous extracts of RP in inhibiting some bacteria is reported by Thitilertdecha *et al.*[31]. The methanolic extract revealed the antibacterial activity against five pathogenic bacteria, namely *Pseudomonas aeruginosa* with Minimum Inhibition Concentration (MIC) of 62.5 mg mL^{-1}, *Vibrio cholera* and *Enterococcus faecalis*, each with MIC of 15.6 mg mL^{-1}, *Staphylococcus aureus* with MIC of 31.2 mg mL^{-1} and *Staphylococcus epidermidis* with MIC of 2.0 mg mL^{-1}.

The water extract of rambutan seed is also tested for antibacterial activity using the disc diffusion method against pathogenic bacteria, namely *Staphylococcus aureus, Streptococcus pyogenes*, *Bacilllus subtillis* (representative Gram positive bacteria), as well as *Escherichia coli* and *Pseudomonas aeruginosa* (representative Gram negative bacteria). The inhibition zones of *S. pyogenes*, *B. subtilis, S. aureus, E. coli* and *P. aeruginosa* are 12±0.10, 12±0.40, 13±0.80, 6.5±0.66 and 10±0.55 mm, respectively. The positive control of antibiotics (Kanamycin) revealed inhibition zones on 28, 21, 26.5, 20 and 25 mm toward these five bacteria, respectively[41]. Rajasekaran *et al.*[24] reported that methanolic extracts of raw seed and boiled seed of rambutan are very sensitive toward *Staphylococcus epidermidis* with MIC value of 40 g mL^{-1}. Ragasa *et al.*[17] reported that dichloromethane extracts of rambutan seed contained two new diastereomeric monoterpene lactones, 1 and 2 which exhibited antibacterial activities.

Antidiabetic activity: Soeng *et al.*[42] have evaluated antidiabetic effect of ethanolic extract of RP and its fraction *in vitro* based on inhibition of α-glucosidase. Alpha-glucosidase is an enzyme involved in the digestion and absorption of carbohydrate. Among ethanolic extract and its fraction (n-hexane, water, ethyl acetate, butanol), ethanolic extract has the highest antidiabetic activity with IC_{50} 9.92 μg mL^{-1}. The ethanolic extract of RP is also reported to have antidiabetic activity on alloxan-induced diabetic male Albino rats with dose of 0.45 mg kg^{-1} b.wt. The highest percentage reduction in blood glucose levels were shown of rambutan fruit peels extract with dose 500 mg kg^{-1} b.wt. and the percentage reduction of glucose was 61.76±4.26%[43]. Geraniin, isolated from RP using HPLC is evaluated for its capability to reduce glucose levels in male Sprague Dawley (SD) rats given by high-fat diet pellets. There is a significant decrease in plasma glucose levels of rats treated with geraniin compared to high fat diet rats (rat controls). This result supported that RP has been potential to be used for antidiabetic patient[44].

Palanisamy *et al.*[45] reported that aqueous extract of RP has antidiabetic activity by regenerating functional pancreatic beta cells and consequently reducing the glucose levels (hypoglycemic activity). This extract showed the inhibition effect toward carbohydrate hydrolyzing enzymes, such as

α-glucosidase with EC_{50} (effective concentration capable of inhibiting 50% enzymes) of 2.7 μg mL^{-1} and α-amylase with EC_{50} of 70.8 μg mL^{-1}. While, positive control of acarbose has EC_{50} of 3500 μg mL^{-1}. Furthermore, the active component of geraniin contained in that extract is capable of inhibiting aldol reductase (EC_{50} of 0.04 μg mL^{-1}) and preventing glycation end-products formation by 43%. The ethanolic extract of RP using geraniin as marker compound is also evaluated for its antidiabetic activity on male Sprague Dawley rats fed with high fat diet followed by injection with nicotinamide and streptozotocin to induce type 2 diabetes. Metformin was used as positive control. The results showed that the glucose levels in the diabetic rats treated with RP is reduced and insulin levels are improved. These effects are comparable to those of metformin-treated groups. The RP revealed anti-hyperglycaemic activity without any major toxic effects in high-fat diet induced diabetic rats[46].

Anticancer activity: Rambutan fruit is reported to have anticancer activities through some mechanisms including cytotoxic effect, anti-proliferative and anticancer. Khonkarn *et al.*[34] reported that hexane extract of RP has the cytotoxic activity toward KB cell line (human epidermal carcinoma of the mouth with HeLa contaminant) by MTT assay with IC_{50} of 7.7 mg mL^{-1} and no detectable cytotoxicity effects toward normal cells. The hexane fraction is supposed to contain novel active compounds with anticancer activity. However, the methanolic and water extracts of RP did not exhibit cytotoxic effects toward 4T1 (mouse breast cancer cell) and 3T3 cells (mouse embryonic fibroblasts cell) at doses[47] of 50 and 100 μg mL^{-1}.

The methanolic extracts of seeds and pericarps of rambutan are tested for cytotoxic activities against human mouth carcinoma (CLS-354) cells. Both extracts exhibited weak cytotoxicity against CLS-354 cells and reduced human Peripheral Blood Mononuclear Cells (PBMCs) viability. Due to its activities as antioxidant and cytotoxic effect, rambutan can be explored as chemo-preventive agents[48]. Hidayat *et al.*[49] reported that ethanolic extract of RP has *in vitro* activity against human osteosarcoma cancer cells and had no effect on normal cells. The extract induced G2/M arrest via inhibition of cancer cell cycle progression.

CONCLUSION

Rambutan is tropical fruit having some biological activities. All parts of rambutan either edible part or nonedible parts have been reported to contain some components beneficial to human health such as geraniin, ellagic acid and corrilagin. Several activities are reported for rambutan fruit including antioxidant and anti-inflammation, antibacterial, antidiabetic and anticancer.

SIGNIFICANT STATEMENTS

- Rambutan is important fruit in tropical countries
- The consumption of fresh rambutan fruit can produce huge amount of wastes from seed and peel
- Seed and peel rambutan are potential to be developed as functional food
- Some active components present in rambutan fruit like ellagic acid, corilagin and geraniin contribute to the beneficial biological activities toward human health

ACKNOWLEDGMENT

The authors thanks to Faculty of Pharmacy for financial support during conducting research activity via sheme English Thesis Scheme.

REFERENCES

1. Arenas, M.G.H., D.N. Angel, M.T.M. Damian, D.T. Ortiz, C.N. Diaz and N.B. Martinez, 2010. Characterization of rambutan (*Nephelium lappaceum*) fruits from outstanding Mexican selections. Revista Brasileira Fruticultura, 32: 1098-1104.
2. Sirisompong, W., W. Jirapakkul and U. Klinkesorn, 2011. Response surface optimization and characteristics of rambutan (*Nephelium lappaceum* L.) kernel fat by hexane extraction. LWT-Food Sci. Technol., 44: 1946-1951.
3. Lim, T.K., 2013. *Nephelium lappaceum*. In: Edible Medicinal and Non-Medicinal Plants, Volume 6: Fruits, Lim, T.K. (Ed.). Springer, Amsterdam, Netherlands, ISBN: 978-94-007-5627-4, pp: 62-71.
4. Solis-Fuentes, J.A., G. Camey-Ortiz, M.R. Hernandez-Medel, F. Perez-Mendoza and C. Duran-de-Bazua, 2010. Composition, phase behavior and thermal stability of natural edible fat from rambutan (*Nephelium lappaceum* L.) seed. J. Bioresour. Technol., 101: 799-803.
5. Santana-Meridas, O., A. Gonzalez-Coloma and R. Sanchez-Vioque, 2012. Agricultural residues as a source of bioactive natural products. Phytochem. Rev., 11: 447-466.
6. Suhandono, S., M.K. Kusumawardhani and P. Aditiawati, 2016. Isolation and molecular identification of endophytic bacteria from rambutan fruits (*Nephelium lappaceum* L.) cultivar binjai. HAYATI J. Biosci., 23: 39-44.
7. Ong, P.K.C., T.E. Acree and E.H. Lavin, 1998. Characterization of volatiles in rambutan fruit (*Nephelium lappaceum* L.). J. Agric. Food Chem., 46: 611-615.

8. Manaf, Y.N.A., J.M.N. Marikkar, K. Long and H.M. Ghazali, 2013. Physico-chemical characterisation of the fat from red-skin rambutan (*Nephellium lappaceum* L.) seed. J. Oleo Sci., 62: 335-343.
9. Harahap, S.N., N. Ramli, N. Vafaei and M. Said, 2012. Physicochemical and nutritional composition of rambutan anak sekolah (*Nephelium lappaceum* L.) seed and seed oil. Pak. J. Nutr., 11: 1073-1077.
10. Nguyen, H.D., M.H.T. Nguyen, T.D. Nguyen and P.T. Nguyen, 2016. *Nephelium lappaceum* oil: A low-cost alternative feedstock for sustainable biodiesel production using magnetic solid acids. Environ. Progress Sust. Energy, 35: 603-610.
11. Issara, U., W. Zaman and T.A. Yang, 2014. Rambutan seed fat as a potential source of cocoa butter substitute in confectionary product. Int. Food Res. J., 21: 25-31.
12. Lourith, N., M. Kanlayavattanakul, K. Mongkonpaibool, T. Butsaratrakool and T. Chinmuang, 2016. *Rambutan* seed as a new promising unconventional source of specialty fat for cosmetics. Ind. Crops Prod., 83: 149-154.
13. Eiamwat, J., S. Wanlapa and S. Kampruengdet, 2016. Physicochemical properties of defatted rambutan (*Nephelium lappaceum*) seed flour after alkaline treatment. Molecules, 21: 364-364.
14. Augustin, M.A. and B.C. Chua, 1998. Composition of rambutan seeds. Pertanika, 11: 211-215.
15. Sonwai, S. and P. Ponprachanuvut, 2012. Characterization of physicochemical and thermal properties and crystallization behavior of krabok (*Irvingia malayana*) and rambutan seed fats. J. Oleo Sci., 61: 671-679.
16. Romain, V., A.C. Ngakegni-Limbili, Z. Mouloungui and J.M. Ouamba, 2013. Thermal properties of monoglycerides from *Nephelium lappaceum* L. oil, as a natural source of saturated and monounsaturated fatty acids. Ind. Eng. Chem. Res., 52: 14089-14098.
17. Ragasa, C.Y., R.D. de Luna, W.C. Cruz and J.A. Rideout, 2005. Monoterpene lactones from the seeds of *Nephelium lappaceum*. J. Nat. Prod., 68: 1394-1396.
18. Thitilertdecha, N., A. Teerawutgulrag, J.D. Kilburn and N. Rakariyatham, 2010. Identification of major phenolic compounds from *Nephelium lappaceum* L. and their antioxidant activities. Molecules, 15: 1453-1465.
19. Palanisamy, U.D., L.T. Ling, T. Manaharan and D. Appleton, 2011. Rapid isolation of geraniin from *Nephelium lappaceum* rind waste and its anti-hyperglycemic activity. Food Chem., 127: 21-27.
20. Liang, W.J., Q.Y. Ma, H.Z. Jiang, J. Zhou, J. Pang and Y.X. Zhao, 2012. A new hederagenin glycoside from *Nephelium lappaceum*. Chem. Nat. Compd., 47: 935-939.
21. Maran, J.P., S. Manikandan, C.V. Nivetha and R. Dinesh, 2013. Ultrasound assisted extraction of bioactive compounds from *Nephelium lappaceum* L. fruit peel using central composite face centered response surface design. Arabian J. Chem., 1: 1-10.
22. Thinkratok, A., P. Suwannaprapha and R. Srisawat, 2014. Safety assessment of hydroethanolic rambutan rind extract: Acute and sub-chronic toxicity studies. Indian J. Exp. Biol., 52: 989-995.
23. Subramaniam, S., S. Chakravarthi, U.D. Palanisamy, A. Radhakrishnan and N. Haleagrahara, 2012. Acute and sub chronic oral toxicity assessment of the Ethanolic extract from the rind of *Nephelium lappaceum* in rats. J. Pharmacol. Toxicol., 7: 378-385.
24. Rajasekaran, A., S. Ganesan, N. Kamini, C. Lavanya, L.L. Yoon and H.S. Oh, 2013. Anti-nociceptive, CNS, antibacterial and antifungal activities of methanol seed extracts of *Nephelium lappaceum* L. Orient. Pharm. Exp. Med., 13: 149-157.
25. Carocho, M. and I.C.F.R. Ferreira, 2013. A review on antioxidants, prooxidants and related controversy: Natural and synthetic compounds, screening and analysis methodologies and future perspectives. Food Chem. Toxicol., 51: 15-25.
26. Embuscado, M.E., 2015. Spices and herbs: Natural sources of antioxidants-a mini review. J. Funct. Foods, 18: 811-819.
27. Javanmardi, J., C. Stushnoff, E. Locke and J.M. Vivanco, 2003. Antioxidant activity and total phenolic content of Iranian *Ocimum* accessions. Food Chem., 83: 547-550.
28. Rohman, A., S. Riyanto and D. Utari, 2006. Antioxidant activities, total phenolic and flavonoid contents of ethyl acetate extract of Mengkudu (*Morinda citrifolia* L.) fruit and its fractions. Indonesian J. Pharm., 17: 136-142.
29. Permatasari, L. and A. Rohman, 2016. 2,2'-diphenil-1-picrylhydrazil (DPPH) radical scavenging activity of extracts and fractions of rambutan (*Nephelium lappaceum* L.) peel. Res. J. Phytochem., (In Press).
30. Rohman, A., S. Riyanto, Mistriyani, Shuhaira and A.E. Nugroho, 2016. Antiradical activities of rambutan peel: Study from two cultivars. Res. J. Phytochem., 11: 42-47.
31. Thitilertdecha, N., A. Teerawutgulrag and N. Rakariyatham, 2008. Antioxidant and antibacterial activities of *Nephelium lappaceum* L. extracts. LWT-Food Sci. Technol., 41: 2029-2035.
32. Thitilertdecha, N. and N. Rakariyatham, 2011. Phenolic content and free radical scavenging activities in rambutan during fruit maturation. Scientia Horticulturae, 129: 247-252.
33. Palanisamy, U., H.M. Cheng, T. Masilamani, T. Subramaniam, L.T. Ling and A.K. Radhakrishnan, 2008. Rind of the rambutan, *Nephelium lappaceum*, a potential source of natural antioxidants. Food Chem., 109: 54-63.
34. Khonkarn, R., S. Okonogi, C. Ampasavate and S. Anuchapreeda, 2010. Investigation of fruit peel extracts as sources for compounds with antioxidant and antiproliferative activities against human cell lines. Food Chem. Toxicol., 48: 2122-2129.
35. Tachakittirungrod, S., S. Okonogi and S. Chowwanapoonpohn, 2007. Study on antioxidant activity of certain plants in Thailand: Mechanism of antioxidant action of guava leaf extract. Food Chem., 103: 381-388.

36. Fidrianny, I., P.I. Sari and K.R. Wirasutisna, 2015. Antioxidant activities in various peel extracts of four varieties rambutan (*Nephelium lappaceum*) using DPPH, FRAP assays. Int. J. Pharmacog. Phytochem. Res., 7: 280-285.
37. Samuagam, L., C.M. Sia, G.A. Akowuah, P.N. Okechukwu and H.S. Yim, 2015. *In vivo* antioxidant potentials of rambutan, mangosteen and langsat peel extracts and effects on liver enzymes in experimental rats. Food Sci. Biotechnol., 24: 191-198.
38. Chingsuwanrote, P., C. Muangnoi, K. Parengam and S. Tuntipopipat, 2016. Antioxidant and anti-inflammatory activities of durian and rambutan pulp extract. Int. Food Res. J., 23: 939-947.
39. Fidrianny, I., A. Sukowati and Sukrasno, 2015. *In vitro* antioxidant activities of various leaves extracts from five varieties of rambutan (*Nephelium lappaceum*) and it's correlation with total flavonoid, phenolic, carotenoid content. Asian J. Pharmaceut. Clin. Res., 8: 139-143.
40. Nurhuda, H.H., M.Y. Maskat, S. Mamot, J. Afiq and A. Aminah, 2013. Effect of blanching on enzyme and antioxidant activities of rambutan (*Nephelium lappaceum*) peel. Int. Food Res. J., 20: 1725-1730.
41. Bhat, R.S. and S. Al-Daihan, 2014. Antimicrobial activity of *Litchi chinensis* and *Nephelium lappaceum* aqueous seed extracts against some pathogenic bacterial strains. J. King Saud Univ. Sci., 26: 79-82.
42. Soeng, S., E. Evacuasiany, W. Widowati and N. Fauziah, 2015. Antioxidant and hypoglycemic activities of extract and fractions of Rambutan seeds (*Nephelium lappaceum* L.). Biomed. Eng., 1: 13-18.
43. Muhtadi, A.U. Primarianti and T.A. Sujono, 2015. Antidiabetic activity of durian (*Durio zibethinus* Murr.) and rambutan (*Nephelium lappaceum* L.) fruit peels in alloxan diabetic rats. Procedia Food Sci., 3: 255-261.
44. Chung, A.P.Y., S.H. Ton, S. Gurtu and U.D. Palanisamy, 2014. Ellagitannin geraniin supplementation ameliorates metabolic risks in high-fat diet-induced obese Sprague Dawley rats. J. Funct. Foods, 9: 173-182.
45. Palanisamy, U., T. Manaharan, L.L. Teng, A.K.C. Radhakrishnan, T. Subramaniam and M. Masilamani, 2011. Rambutan rind in the management of hyperglycemia. Food Res. Int., 44: 2278-2282.
46. Subramania, S., A. Radhakrish, S. Chakravart, U.D. Palanisamy and N. Haleagraha, 2015. Antihyperglycemic effects of nephelium lappaceum rind extract in high fat-induced diabetic rats. Int. J. Pharmacol., 11: 542-551.
47. Ling, L.T., A.K. Radhakrishnan, T. Subramaniam, H.M. Cheng and U.D. Palanisamy, 2010. Assessment of antioxidant capacity and cytotoxicity of selected Malaysian plants. Molecules, 15: 2139-2151.
48. Chunglok, W., T. Utaipan, N. Somchit, M. Lertcanawanichakul and Y. Sudjaroen, 2014. Antioxidant and antiproliferative activities of non-edible parts of selected tropical fruits. Sains Malaysiana, 43: 689-696.
49. Hidayat, W.N.W.S., A.W. Ridhwan and S. Azamn, 2011. Promising effect of *Nephelium lappaceum* rind extract as cancer chemopreventive agent through apoptosis and cell cycle arrest mechanisms on human osteosarcoma cells. Proceedings of the Universiti Malaysia Terengganu 10th International Annual Symposium UMTAS 2011: Empowering Science, Technology and Innovation Towards a Better Tomorrow, July 11-13, 2011, University Malaysia, pp: 163-169.