



ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; SP-11(1): 1052-1060
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www.thepharmajournal.com
Received: 10-11-2021
Accepted: 12-12-2021

Gursimran Kaur
Department of Food Technology,
School of Agriculture, Lovely
Professional University,
Phagwara, Punjab, India

Muskaan
Department of Food Technology,
School of Agriculture, Lovely
Professional University,
Phagwara, Punjab, India

Nitish Chaudhary
Department of Food Technology,
School of Agriculture, Lovely
Professional University,
Phagwara, Punjab, India

Zorempuii
Department of Food Technology,
School of Agriculture, Lovely
Professional University,
Phagwara, Punjab, India

Corresponding Author
Gursimran Kaur
Department of Food Technology,
School of Agriculture, Lovely
Professional University,
Phagwara, Punjab, India

A review paper on rambutan

Gursimran Kaur, Muskaan, Nitish Chaudhary and Zorempuii

Abstract

Rambutan, or *Nephelium lappaceum*, is a fruit with a perplexing, sweet flavour that belongs to the Sapindaceae family and contains an astonishing range of bioactive chemicals. There has been various research held on Rambutan studying fruit's composition, biological and chemical properties, and health benefits others were based focusing on antioxidant, antimicrobial, antidiabetogenic, anti-obesogenic, other health benefits, and toxicological properties. Fruit peels were discovered to be an important part of the plant that is often overlooked, despite the fact that they contain a large number of phenolic compounds with nutraceutical and pharmacological potential. This report compiles information from these various studies into a review paper.

Keywords: tropical fruit, sapindaceae, fruit peels, larvicide, anti-microbial

Introduction

'Rambutan' (*Nephelium lappaceum* var. *lappaceum*) a tropical tree which belongs to sapindaceae family. The word "rambutan" comes from the Malay word "rambut," which means "hair". Rambutan is a tree native to the Malay Archipelago. Malay Archipelago also known as East Indies which covers mainland of Indonesia, Malaysia, and Southern Thailand, and Asia it is also cultivated in India and Sri Lanka. *Nephelium lappaceum* tree bears green leaves throughout the entire year with a height up to 25 meters. The tree needs humid surrounding with rainfall from 250 to 350 cm to flourish. The leaves of the plant are pinnately complex, with hairy midribs and oval leaflets that develop in pairs (Verheij and Coronel, 1991) ^[1]. The plant produces spheroid fruits with a thick layer of soft hair like spines on the rind. The fruit is initially green, but when ripens according to the variety the rind of the fruit turns red or yellow. The rambutan's sarcotesta, or edible interior part, is a single oval or round seed with white, firm, non-translucent flesh (Wong *et al.*, 1996) ^[2]. The meat (aril) is edible and white or rose-tinted. It has a good flavor and aroma and is sweet, juicy, and appetizing. The fruit has the appearance and texture of a litchi, but the peel has number of long, thick yellow or pink and red colored hairy growths. Fruit rind is soft, reddish, orange, or yellow in color, and covered with thick, soft hair. Fruits can be consumed raw or processed into dried fruit pulp, jams, jellies, fruit concentrates, and other items. The majority of rambutan varieties produce sweet fruits, but certain kinds produce sour ones. It is processed into juices, jams, and jellies, as well as pharmaceuticals, in major producing countries like Malaysia and Thailand. This fruit may be found in abundance throughout Asia, where it is consumed fresh, canned, or processed as a delectable fruit (Sun *et al.*, 2011) ^[3]. Tannins, saponins, flavonoids, geraniin, and other phytonutrients were discovered to be abundant in rambutan peel (Thitilertdecha *et al.*, 2008) ^[4].

Several phenolic chemicals, including as ellagic acid, corilagin, and geraniin, have also been discovered in the seeds (Palanisamy *et al.*, 2011a) ^[5], which may have health benefits. Rambutan's seed contemplated to be waste due to its taste (Kheir *et al.*, 1979). The bitter taste is due to alkaloids, tannins, saponins, and phenolic chemicals present in seed. This isn't unexpected, given that the Sapindaceae family is recognised for being saponin-rich. Minerals such as calcium, zinc, iron, magnesium, and manganese are also found in rambutan seeds. Rambutans are typically collected when they are fully mature as it is a non-climacteric fruit it would not be able to ripen more once removed from tree. Storage is a significant issue for the fruit since, owing to shrivelling and browning of the peel, the fruit rapidly loses its aesthetic quality. Furthermore, prolonged storage leads the fruit to soften and the pulp to become watery and leaky, lowering the fruit's quality and, as a result, the market price and customer acceptance (Supapvanich, 2015) ^[6]. To ensure freshness and great fruit quality, standard storage techniques must be strictly adhered.

Rambutan cultivation

The tropical evergreen tree *Nephelium lappaceum* is primarily found in Thailand (Four lakhs thirty thousand tonnes), Indonesia (One lakh forty-eight thousand tonnes), Malaysia (Eighty thousand tonnes), and the Philippines (twenty tonnes) (Menzel, 2003) [7]. Thailand is the world's leading producer and exporter of rambutan, with the 'Rong-rien' variety being the most popular commercial variation (Supapvanich, 2015) [6]. The *Nephelium* genus contains 22 species, 16 of which are located in Indonesia and nine of which are edible rambutan species, namely *N. lappaceum*, *M. cuspidatum* var. *eripetalum*, *N. junglandifolium*, *N. maingayi*, *N. meduseum*, *N. ramboutan-ake*, *N. melanomiscum*, *N. reticulatum* and *N. uncimatum* (Windarsih and Efendi, 2019) [8]. Rambutan is well adopted to warm temperature. Temperatures between 22 and 30 degrees Celsius are ideal for tree growth. It can grow up to 700 meters above the sea level. Plant growth is considerably impeded at temperatures below 10 °C because it is particularly sensitive to cold temperatures. Cooler temperatures influence defoliation, panicle emergence, and fruiting. Fruit development is hampered by low humidity. The plant requires 200-500 cm of rain per year, evenly distributed throughout the year, however a brief dry phase is required for the beginning of flower buds. Fruit cracking occurs because of excessive rainfall during the maturation stage. The best soils for rambutan growth and yield are well-drained sandy-loam to clay-loam soils with organic content. It can be cultivated successfully in red laterite soil with the use of sufficient organic and inorganic fertilizers. The ideal pH range for soil is 4.5 to 6.5. Waterlogging is a problem for rambutan. The orchard on slightly sloppy terrain has shown to be more productive. If the soil is deficient in zinc and iron, yellowing of the leaves because of nutrient inadequacy is prevalent.

Important Varieties

Over 200 rambutan cultivars have been developed from selected clones and are now accessible throughout tropical Asia. Cultivars that are hermaphroditic account for the significant number of commercial cultivars. Indonesian cultivars include Lebakbulus, Binjai, Seematjan, and Rapiah; Malaysian varieties include R134, Gula Batu, Muar Gading, Khaw Tow Bak, Lee Long, and Daun Hijau; Singaporean cultivars include Deli Cheng and Jit Lee; Philippine cultivars include Seematjan, Seenjonja, and Mahalika; and Thai cultivars include Rongrien, Seechompoo, and Bang CHES (IIHR) has released two rambutan cultivars in India. The planters have planted seedlings grown from seeds collected from outside and within the country. After a comprehensive examination of Kerala, Karnataka, and Tamil Nadu, the Central Horticultural Experiment Station (IIHR) in Chettalli has a few other promising lines. Some nurseries have also discovered a few unique variations

The following are various important varieties

- Seematjan
- Lebakbulus
- Seenjonja
- Seelengkeng
- Seetangkooweh
- Seekonto
- Rogaine

- Seechompoo
- BR1(BotingRambutanNo.1)
- BR2
- RongRien
- Bangyeekhan
- Binjai
- Rapiah

Nutritional Composition

Rambutan (*Nephelium lappaceum*) fruit has abundant amount of carbohydrates, minerals (niacin, iron, calcium, copper), fiber and protein. Rambutan fruit is round to oval and can be utilized in raw form and cooked form as well. Rambutan comes in the category of non-climacteric fruit that is it do not ripe once removed from tree. The fruit is a good source of sugars and vitamin c and other minerals. The fruit grows in cluster groups of 10-13 in terminal. The edible portion is the pearly white translucent aril which is surrounded by red or yellow colored tubercle skin. The fruit Rambutan is of two types: sweet type and sour type. The former type that is sweet type is used as fresh fruit and the latter category that is sour category is canned, used in jams, jellies (Prakash, 2021) [9]. The seed has a bitter flavour and narcotic and poisonous effects. Nutritional composition of the fruit is given below in the table1 (composition value per 100g of edible portion of rambutan fruit.). The juicy fruit has moisture content ranging from 79.5 – 84.7gm, with protein up to 1gms. Fat content is the lowest among all the values i.e.,0.21gm. Fruit has an abundance of carbohydrates up to 20.87gm (as given in table). Fiber content of the fruit ranges from 0.3 gm to 2.8 gm according to the different varieties of the fruit. Minerals like Calcium is found in lesser amount accounting from 8 to 22 mg, Magnesium up to 10mg, Iron up to 2.5mg and Potassium 140mg.

Table 1: Composition value of edible portion per 100g rambutan fruit

Composition	Quantity
Moisture(g)	79.5 – 84.7
Protein(g)	0.65 – 1.05
Fats(g)	0.21
Carbohydrates(g)	13.9-20.87
Fiber(g)	0.3-2.8
Calcium(mg)	22
Magnesium(mg)	7-10
Potassium(mg)	140
Iron(mg)	0.1- 25
Phosphorus(mg)	9- 30
Ascorbic acid(mg)	38.6-70
Manganese(mg)	7
Sodium(mg)	11

Rambutan seed composition: Generally, the main component of fat and oil is triglycerides, and each fat/oil has a different fatty acid content. Table 2 summarizes the primary fatty acid makeup of rambutan seed fat Over 75% of the fat composition is made up of oleic and arachidic acids, with palmitic, stearic, gondoic, palmitoleic, and behenic acids also present. Around half of the fatty acids in rambutan seed fat are saturated, with a high percentage of arachidic acid, a long-chain fatty acid with a high melting point. Rambutan seed's percent weight and proximal analysis were also explored, yielding vital information.

Table 2: Composition of Rambutan seed per 100g

Composition	Quantity
Calcium	9.58 mg/100g
Iron	0.34 mg/100g
Magnesium	12.3 mg/100g
Manganese	1.06 mg/100g
Potassium	84.1 mg/100g
Sodium	20.8 mg/100g
Zinc	0.17 mg/100g
Phosphorus	16.6 mg/100g
Vitamin A	< 40 IU/100 g
Vitamin C	59.4 mg/100 g
pH	4.66

Table 3: Percentage and weight of the constituent portions of rambutan fruit

Portion of fruit	Weight (g)	Percentage %
Whole fruit	27.4	100
Rind	13.2	45.7
Pulp	11.7	44.8
Seed	2.53	9.5
Embryo	1.60	6.1

Anti-nutritional factors

Antinutritional factors (ANFs) are Factors or biological components that are here in foods which can decrease nutrient utilization or food consumption, which heads to weakened gastrointestinal functions and metabolic execution. Factors that affect nutritional component of rambutan are:

- Saponin
- Alkaloid
- Tannin
- Phytate
- Phenol
- oxalate
- Flavonoid

Collection and treatment of samples

For the analysis of Anti-nutritional factors rambutan (*Nephelium lappaceum*) dried grounded samples of pulp, seed and rind of rambutan fruit is required. Fruits were washed before cutting into pieces and arranging separately parts (pulp, rind and seed) of the fruits. After separating fruit parts were washed and have done different operations on the different parts. Seeds were washed and after washing directly placed in the foil paper. Pulp is cut into the shreds and placed in foil after draining. Rind is cut into small pieces like tiny cubes and placed in the foil after draining of the water used for the washing. After all this, parts of the fruit were lay down for drying in the oven. After drying dry materials were separated and pulverised in the steel blade grinding mill at 30 mesh sieve. Fresh material utilised in fresh state but produced in the same way which is mentioned above. According to the evaluation:

Saponin

Saponin content in the fresh pulp of rambutan was (1.50 ± 0.00), in fresh seed it was (0.98 ± 0.01) and in fresh rambutan rind it was (0.52 ± 0.01) and on other hand in dry sample saponin content of dry rambutan pulp, dry rambutan seed and dry rambutan rind is (3.18 ± 0.21), (2.10 ± 0.05), (2.24 ± 0.57) respectively.

Alkaloid

(0.82 ± 0.01) at ($P < 0.05$) mg/100gm of Alkaloid was present in the fresh sample of seed of *Nephelium lappaceum* and in fresh rambutan rind It was (2.17 ± 0.07) and in dry sample it

was (4.41 ± 0.01) in dry rambutan rind and (1.95 ± 0.02) at ($P < 0.05$) dry rambutan seed and alkaloid was not detected in fresh rambutan pulp and dry rambutan pulp.

Tannin

Tannin content in fresh rambutan pulp, fresh rambutan seed and fresh rambutan rind was (0.12 ± 0.00) at ($P < 0.05$), (0.15 ± 0.00) and (1.35 ± 0.01) (mg/100gm) on other hand in dry rind of *Nephelium lappaceum* it was (1.72 ± 0.02) at ($P < 0.05$), (0.35 ± 0.01) was in the dry state of the rambutan pulp and in dry rambutan seed it was (0.28 ± 0.01) as shown in the table.

HCN

HCN content was not detected in the fresh and dry sample of rind, pulp and seed as shown in both tables.

Phytate

Phytate content in fresh rambutan pulp was (0.15 ± 0.01) and in fresh rambutan seed and fresh rambutan rind it was (0.40 ± 0.00) and (0.77 ± 0.00) at $P < 0.05$ Respectively and in dry rambutan pulp and in dry rambutan (seed and rind) it was (0.71 ± 0.00), (0.77 ± 0.03) and (0.40 ± 0.00) Respectively.

Phenol

Phenol content of fresh rambutan (*Nephelium lappaceum*) pulp (0.11 ± 0.00) at ($P < 0.05$), in fresh Rambutan rind (0.31 ± 0.01) and in seed it was (0.20 ± 0.00). on other hand in dry sample dry rambutan pulp was (0.36 ± 0.07), dry rambutan seed was (0.41 ± 0.09) and in rind of dry sample it was (0.68 ± 0.06) at ($P < 0.05$) (mg/100gm).

Oxalate

Oxalate content in fresh rambutan pulp was (0.11 ± 0.00) and in dry rambutan pulp it was (0.07 ± 0.00), fresh rambutan seed contain (0.26 ± 0.01) and in dry rambutan seed it was (0.19 ± 0.01) at ($P < 0.05$) of oxalate and oxalate content in fresh rambutan rind and dry rambutan rind was (0.12 ± 0.00) at ($P < 0.05$) and (0.10 ± 0.00) (mg/100gm). There was decreased in oxalate amount in pulp, seed and rind of the rambutan (*Nephelium lappaceum*) after the drying of the parts of fruit.

Flavonoids

Flavonoids content in fresh rambutan rind was (88.84 ± 0.02) and after drying of rind flavonoid content became (22.30 ± 0.30) and flavonoids content in fresh rambutan seed and fresh rambutan pulp was (16.00 ± 0.10) and (7.64 ± 0.01) at ($P < 0.05$) Respectively and in dry rambutan seed and pulp of dry sample of fruit it was (1.63 ± 0.32) at ($P < 0.05$), and (3.27 ± 0.67) Respectively. Fresh rambutan pulp, seed and rind contain more flavonoids as compared to the dried sample pulp, seed and rind of rambutan (*Nephelium lappaceum*) fruit.

Table 4: Anti-nutrient factors content of *Nephelium lappaceum* is shown based on mg/100g fresh matter

Components	FRP	FRS	FRR
Saponin	1.50 ± 0.00	0.98 ± 0.01	$0.53 \pm 0.01^*$
Alkaloid	0.00 ± 0.00	$0.82 \pm 0.01^*$	$2.17 \pm 0.07^*a$
HCN	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
Tannin	0.12 ± 0.00	0.15 ± 0.00	$1.35 \pm 0.01^* a$
Phytate	0.15 ± 0.01	$0.40 \pm 0.00^*$	$0.17 \pm 0.00a$
Phenol	0.11 ± 0.00	0.20 ± 0.00	$0.31 \pm 0.01^*$
Oxalate	0.11 ± 0.00	$0.26 \pm 0.01^*$	$0.12 \pm 0.00^*a$
Flavonoids	7.64 ± 0.01	$16.00 \pm 0.10^*$	$88.84 \pm 0.02^*a$

FRP = fresh rambutan pulp

FRS = fresh rambutan seed

FRR = fresh rambutan rind

Table 1: Assessment of Anti-nutrient contents of *Nephelium lappaceum* is presented based on mg/100g dried matter

Components	DRP	DRS	DRR
Saponin	3.18 ±0.21	2.10 ±0.05*	2.24 ±0.57
Alkaloid	0.00 ±0.00	1.95 ±0.02*	4.41 ±0.01*a
HCN	0.00 ±0.00	0.00 ±0.00	0.00 ±0.00
Tannin	0.35 ±0.01	0.28 ±0.01*	1.72 ±0.02*a
Phytate	0.71 ±0.00	0.77 ±0.03*	0.40 ±0.12*a
Phenol	0.36 ±0.07	0.41 ±0.09*	0.68 ±0.06*a
Oxalate	0.07 ±0.00	0.19 ±0.01*	0.10 ±0.00a
Flavonoids	3.27 ±0.67	1.63 ±0.32*	22.30 ±0.30*

DRP = dry rambutan pulp.

DRS = dry rambutan seed.

DPR = dry rambutan rind.

Bioactive compounds

The rambutan fruit possess rich nutraceutical values and is source of traditional medicines and value-added products for local regions. Rambutan fruit contains bioactive components in most part of fruit like pulp, seed and peel. Bioactive components are phytochemicals present in small amounts in plants and their by-products and promote health by regulating the body's metabolism. Different types of bioactive components are anthocyanins, polyphenols, saponins, flavonoids, tannins, carotenoids, phytosterols, etc. Phenolic compounds or polyphenols are generally present in all plants and in our diet and have antioxidant properties (Fornaciari S *et al.*, 2015) [10].

According to Suhendi (2015) [11], the fruit peel contains polyphenolic compounds like geraniin, syringic, corilagin, epigallocatechin-3-gallate, caffeic, saponins, coumaric, tannins, ellagic acids, flavonoids, gallic. Epigallocatechin-3-gallate demonstrate anti-hyperglycemia activities and is found in the rambutan peel (Palanisamy *et al.*, 2011) [12]. Rambutan fruit peel has antioxidant, antimicrobial, anticancer, antidiabetic and anti-obesity properties while seed has antioxidant, antidiabetic, antimicrobial, anticancer and natural larvicide properties. The fruit pulp is a good source of antioxidants.

Eteng (2012) [13] studied the seeds of rambutan fruit and deduced that fresh seeds of rambutan fruit have a lethal effect but after processing by drying or roasting of the seeds they can be consumed and utilized. To minimize the waste produced during food processing, many effective methods are being researched to for effective utilization of the waste by-products. Rambutan seeds contain high levels of alkaloids, flavonoids and polyphenols and reported to have antifungal, antioxidant and antibacterial activities when boiled, raw or roasted.

Properties of Bioactive Compounds

The studies reveal various properties of bioactive compounds as following:

Antidiabetic

Nephelium lappaceum L. exhibit anti-hyperglycemic effects and has antidiabetic properties. This was found by testing the rambutan leaf extract on a Swiss webster mice model induced with high glucose diet in a dose dependent manner. The extract lowered glucose level in blood and had a strong impact against diabetes. Diabetes mellitus or type 2 diabetes is a health condition where blood sugar levels reach 200 mg/dL or more. This is similar to the effect of metformin dose used as positive control (Suliska *et al.*, 2020) [14]. Similar effect was found in case of rambutan fruit peel extract to the rats fed with high fat diet and alloxan intra-peritoneal which

induces diabetes in lab rats and was found to reduce cholesterol levels and glucose levels (Muhtadi M. H. *et al.*, 2016) [15]. Subramaniam (2015) [16] reported that the anti-diabetic activity of rambutan rind extract was positive in a test model of diabetic rats fed a high fat diet. The rambutan seed infusion also reduced the blood glucose levels in mice (*Mus musculus*) as per the study by Rahayu (2013) [17].

Antimicrobial

Phuong (2020) [18] studied anti-microbial action of extract of rambutan peel to be effective against gram positive bacteria and gram-negative bacteria like *Staphylococcus aureus*, *Listeria monocytogenes*, *Escherichia coli*, etc. in invitro tests and also studied the in situ anti-microbial activity of the extract which inhibited *Salmonella enteritidis* in raw chicken breast and *Vibrio parahaemolyticus* in fish.

Natural Larvicide

According to Fajriansyah (2020) [19], to control mosquitoes, the most effective method is to terminate the life cycle of mosquitoes by eradicating the larval sodium called larvicides. Rambutan leaves contains saponins and tannin compounds. Saponins damage the red blood cells through the reaction of hemolysin and are lethal to cold-blooded animals and insects. The larvae of *Aedes aegypti* was treated with extract of rambutan leaf in varied dosage of 5%, 10% and 15% and was found to have an average death rate of 19.7%, 34.3% and 43.7% respectively.

Metabolic Dysfunction

Metabolic syndrome (MetS) refers to a group of conditions which co-occur and increase the chances of diabetes mellitus, stroke and cardiovascular disorder. Ellagitannin geraniin is a polyphenolic compound present in the rind of rambutan which is potentially effective against metabolic dysfunction and mitigated anomalies caused by high fat diet (Cheng H.S. *et al.*, 2020) [20].

Increases Sperm Count

Obesity can cause change in reproductive hormonal profile by reducing the semen quality due to high-fat diets. This can be overcome by antioxidant compounds present in tropical fruits like rambutan in which the fruit peel extract increased total sperm count in male wistar rats induced with high-fat feed with the highest efficacy on the dose of 15mg/kgBW (Sipahutar K *et al.*, 2020) [21].

Antioxidant

Geraniin is a polyphenol which is hydrolysable in nature and possess antioxidant properties and is from the rambutan fruit rind. Research explains the strong impact of geraniin in treating the metabolic dysfunction. Geraniin supplementation may restore biomarkers of oxidative stress, redox balance of glutathione, and serum antioxidants to levels similar to control. Geraniin primarily acts on pancreas of obese rats to provide safety against lipid toxicity and glucotoxicity and is non-toxic in rats on a high-fat diet. (Chung A. P. *et al.*, 2018) [22].

Increases number of Erythrocytes

Lisdiana *et al.*, (2017) [23] proved that rambutan peel extract increase and maintain red blood cell and hemoglobin counts in the blood of rats exposed to tobacco smoke at 45 mg/kgBW.

Anticancer

Rambutan peel extract can help treat cancer by ligating zinc ions and forms zinc oxide nanochains which is a biomimetic synthesis aiding in anti-cancer activity. When incubated with ZnO treated cells, it hinders the growth of cancer cells (Yuvakkumar *et al.*, 2015) [24].

Anti-obesity

Lipid accumulation causes liver damage due to high oxidative stress and is mainly caused due to obesity. Lipid peroxidation can be prevented with the help of antioxidants as it occurs due to oxidative stress in cells. The rambutan peel exhibited anti-obesogenic activity by reducing the triglycerides levels. The rambutan peel also reduced Malondialdehyde (MDA) levels, an oxidative stress biomarker in the body and found to have antioxidant property (Setyawati *et al.*, 2015) [25]. Geraniin at 50 mg/kg body weight can safely reduce metabolic dysfunction caused by obesity. (Chung A. P. *et al.*, 2014) [26].

Anti-hypercholesterolemia

Strong antioxidant activity was reported in the rind of

rambutan fruit (*Nephelium lappaceum* L.) with IC50 value of 7.74 $\mu\text{m} / \text{mL}$. Hypolipidemic effect was found in the extract of fruit containing polyphenolic components along with flavonoids. Hypercholesterolemia condition is induced by feeding a high cholesterol diet for weeks consisting of cooking oil, water, quail egg yolk, propylthiouracil (PTU) and feed consisting of margarine and standard feed (Muhtadi H. S. *et al.*, 2013) [27].

Wound Healing

Rambutan leaf extract has anti-inflammatory properties, wound healing and free radical scavenging properties. Rambutan leaf extracts tested for wound healing activity and showed positive outcome. In the 2,2-diphenyl-1-picrylhydrazyl (DPPH) mice excision model test, rambutan leaf extracts inhibited free radicals at all concentrations. The formalin induced paw licking test model was used to check the anti-inflammatory effects of rambutan in rat model (Subramanian *et al.*, 2018) [28].

Table 6: Properties of Bioactive Compounds of Rambutan

S.no.	Property	Test Model	Dose/Concentration/Method	Mechanism of action and Potential findings	References
1.a.	Anti-diabetic	25 Swiss Webster male mice	Mice induced with 1g/kgBW glucose to each group and given metformin dose (65 mg/kgBW), extract dosage of 10 mg/kgBW, 25mg/kgBW and 50 mg/kgBW. Blood sugar levels checked randomly at 30, 60, 90 and 120 minutes.	Rambutan leaf extract at 50mg/kg body weight reported to have an impact of lowering glucose levels in the blood.	Suliska <i>et al.</i> , (2020) [14]
b.		Diabetic rats	Rats induced by alloxan intra-peritoneal at dose 150 mg/kgBW (oral administration) and 0.5% CMC-Na (negative control), positive control Glibenclamide 0.45 mg/kgBW taken and rambutan peel extract for eleven days. High fat fed diet (28 days) and treated with extracts (14 days) for reduction in cholesterol levels.	At a concentration of 500 mg rambutan peel extract / kgBW, there was a decrease in blood glucose and cholesterol levels, with reductions of $61.76 \pm 4.26\%$ and $60.75 \pm 8.26\%$.	Muhtadi M <i>et al.</i> , (2016) [15]
c.		Male Sprague Dawley rats	rambutan rind extract dose of 500 and 2000 mg (28 days), 210 mg/kg nicotinamide, 55 mg/kg streptozotocin and Positive control (200 mg) metformin.	Diabetic rats treated with 2000 mg rambutan rind extract showed anti-hyperglycemic activity by reduction in blood glucose level and improved insulin levels.	Subramaniam S <i>et al.</i> , (2015) [16]
d.		30mice (Mus musculus)	Rambutan seed infusion of 1.56, 2.34 and 3.12 g/kgBW and induced with alloxan 250 mg/kgBW (16 days)	High dose of rambutan seed infusion 3.12g/kgBW most effective in reducing the blood glucose levels in mice.	Rahayu L <i>et al.</i> , (2013) [17]
2.	Anti- microbial	in vitro (medium) in situ	The extract inhibited Salmonella enteritidis by 1.5 log CFU/g in raw chicken breast (14 days, 4 °C, situ) and reduced in situ V. parahaemolyticus levels of chilled panga fish fillets (10 days).	Methanolic extract of <i>Nephelium lappaceum</i> L. peel containing phenolic compounds effective against gram positive and gram-negative bacteria like V. parahaemolyticus, E. coli, etc. using in vitro tests.	Phuong N <i>et al.</i> , (2020) [18]
3.	Natural Larvicide	Aedes aegyptimosquito larvae	rambutan leaf extract administered at a dose level of 5%, 10% and 15%	Three treatment concentrations of rambutan leaf extract, 5% (mean 19.7 mortality), 10% (mean 34.3) and 15% (mean 43.7), were highly effective in killing Aedes aegypti larvae.	Fajriansyah F (2020) [19]
4.	Metabolic dysfunction	Sprague Dawley rats	Metabolic syndrome (MetS) induced rats on a high fat diet treated with geraniin (25 mg/kg) (4 weeks, daily oral). Positive control metformin daily basis (200 mg/kg).	Geraniin treatment mitigated metabolic anomalies of MetS in rats caused by high fat diet like lipid metabolism, hypertension and impaired glucose.	Cheng H <i>et al.</i> , (2020) [20]
5.	Increases Sperm Count	30 male Wistar rats	High fat diet (positive control) and 15 mg/kg body weight of rambutan fruit peel extract (control) and three treatment groups received	At a dosage of 15mg/kg body weight, rambutan peel extract significantly increased total	Sipahutar K <i>et al.</i> , (2020) [21]

			extract of rambutan skin at concentration of 15, 30, and 60 mg/kg bw (Eighty-one days).	sperm count due to antioxidant activity.	
6.	Antioxidant	High fat diet 6 weeks induced obesity	10 and 50 mg/kg bw oral supplementation of geraniin (Four weeks)	High fat diet rats confirmed diet-induced changes in pancreas, may restore biomarkers of oxidative stress, redox balance of glutathione and serum antioxidants to levels similar with that of the control.	Chung A <i>et al.</i> , (2018) ^[22]
7.	Increases number of erythrocytes	25 Male Wistar rats (180–200 g)	Dosage of 15, 30 and 45 mg/kg of body weight (30 days) exposed to tobacco smoke.	Extract of Rambutan fruit peel effective in maintaining and increasing the erythrocytes and hemoglobin count at a dose of 45 mg/kg body weight in the blood.	Lisdiana <i>et al.</i> , (2017) ^[23]
8.	Anticancer	Zinc oxide treated cancer cells	Approximately 40-60% of the cell viability was lost and 10-50% morphologic change was detected in four to seven days reared ZnO treated cells. Approximately 50% and 55% apoptosis were observed when the treated ZnO cells were incubated for 24-48 h for 7 days.	Rambutan peel ligates zinc ions forming zinc oxide nanochains is an example of biomimetic synthesis assisting in anti-cancer activity. Incubation with Zinc Oxide-treated cells obstructs the growth of cancer cells. Effective in liver cancer treatment.	Yuvakkumar R <i>et al.</i> , (2015) ^[24]
9.	Anti-obesity	Male post-weaning outbred Sprague Dawley rats	geraniin treatment at 10 and 50 mg/kg BW for ten weeks.	Treatment with geraniin 50 mg/kg bw (4 weeks) safely reduces metabolic dysfunction caused due to obesity.	Alexis Panny Y.S. Chung <i>et al.</i> , (2014) ^[26]
10.	Anti-hypercholesterolemia	25 Wistar Strain Male Rats fed high cholesterol diet for 4 weeks	Rats were fed high cholesterol diet for 4 weeks. 0.5% CMC-Na (negative control), 0.8 kg/kg of cholestyramine (positive control) and 96% ethanol extract of rambutan bark were administered at doses of 125, 250, 500 mg/kg (2 weeks).	Rambutan rind extract reported to have anti-hyper cholesterol activity 21.39 ± 6.61 percent for 125mg/kg, 31.15 ± 18.15 percent for 250mg/kg, and 60.75 ± 8.26percent for 500mg/kg.	Muhtadi <i>et al.</i> , (2013) ^[27]

Health benefits of Rambutan

Since the olden days, rambutan has been implemented to aid and treat diabetes and high blood pressure (Sukmandari *et al.*, 2017). Rambutan is historically renowned for its richness in antioxidants and has been employed to treat diabetes and bacterial infections, according to Chigurupati *et al.* (2019). Antioxidants have been shown to reduce cellular damage and potentially reduce the risk of cancer in many individuals. The rambutan fruit contributes to around 7.4 mg of vitamin C in 100 g, which makes it nutritious (Augustin and Chua, 1988). As mentioned, Vitamin C being antioxidant can fight against free radicals which may prevents cancer. Vitamin C abets in heme ions (iron). Dearth of vitamin C in men could spawn infertility. According to Akmal *et al.*, (2006) ^[29], vitamin C supplementation in infertile men may inflate sperm count, sperm movement, sperm structure, which increase the possibility of it being the cause of improvement to semen quality. Rambutan includes vitamin and niacin vitamin B3, which contribute in the better functioning of the human body by boosting the metabolic process as well as the defence systems. Fat-soluble vitamins (A, D, E, and K) are found to

be present in rambutan, which boost the immune system. Rambutan has a number of health advantages, one of which is that it strengthens our bones (Sabbe *et al.*, 2009). Vitamin D is widely known for its importance in bone development and strengthening. Rambutan is rich in antioxidant components. Flavonoids are claimed have effects in lowering cholesterol levels, as well as anticancer and anti-inflammatory (Zhuang *et al.*, 2017). The fruit, seed, and seed lipids of the rambutan provide tiny amounts of copper, which is essential for the production of more white and red blood cells. Vitamin C, according to scientists, may also help to fight ageing by keeping white blood cells healthy (Khalid Iqbal *et al.*, 2004) ^[30]. Because of the health benefits of N. lappaceum fruits and seed lipids, they have attracted a lot of interest (Febrianto *et al.*, 2012). Furthermore, these chemicals can protect cells and tissues in the human body from oxidative damage. Rambutan is a low-calorie fruit that is abundant in water and fibre. This combination may help you avoid overeating and feel fuller for longer, both of which can help you lose weight over time.

Table 7: Health benefits of respective part of fruit with supportive evidence

Part used	Utilization in Food	Effect on health	Supportive evidence
Fruit pulp	Raw fresh cut fruit	antioxidant, anti-cancer, Anti-inflammatory	Conforming to the studies of Augustin and Chua (1988), rambutan fruit disclose the sufficient amount of vitamin C, making it nutritious which contribute in fighting off free radicals. Vitamin C aids in the digestion of heme ions as well (iron). Rambutan has a number of health advantages, one of which is that it strengthens our bones (Sabbe <i>et al.</i> , 2009). Rambutan contains a lot of antioxidants. Conforming to the study conducted at the University of Chiang Mai in Thailand (Hunter 2014) ^[31] , delineate that the fount of antioxidants with flavonoids being the leading component of rambutan fruit, seeds and skin.

			<p>Flavonoids helps in receding cholesterol levels with anticancer and anti-inflammatory effects. (Zhuang <i>et al.</i> 2017).</p> <p>Rambutan is rich in iron, which aid to fend off anaemia (Vaughan and Geissler, 2009)</p> <p>Vitamin C, according to scientists, may also help to fight ageing by keeping white blood cells healthy (Khalid Iqbal <i>et al.</i> 2004) ^[30].</p> <p>Natural antioxidants in lipid-containing and lipid-based goods like oil, fat, and butter can make these ingredients excellent for moisturising creams and other skin care products (Febrianto <i>et al.</i> 2012).</p> <p>In alloxan-induced diabetic rats and high-calorie-fed obese rats, <i>Nephelium lappaceum</i> inhibits hypoglycaemia rise and has anti-obesogenic properties. (Muhtadi <i>et al.</i>, 2015) ^[32].</p> <p>Chigurupati <i>et al.</i>, (2019) proclaimed the conventional use of rambutan in the treatment of diabetes and bacterial infections and antecedent of antioxidants.</p>
Seeds	Whole seeds or crushed seeds/ powder	Antioxidant, hypoglycaemic activity, anti-microbial activity	<p>Rambutan seeds were incorporated with phenolic components encompassing ellagic acid, corilagin, and geraniin (Palanisamy <i>et al.</i>, 2011a) ^[5].</p> <p>Furthermore, encloses minerals namely calcium, zinc, iron, magnesium, and manganese. To make the seeds available as a useful source of nourishment, they must now be appropriately processed (Olaniyi and Mehdizadeh, 2013).</p> <p>Ex vivo, the seed extract shows the decline in the rush of glucose-6-phosphate dehydrogenase (G6PDH), -glucosidase, and triglyceride in the 3T3-L1 cell line (Soeng <i>et al.</i>, 2015).</p> <p>The seed extract shows inclination in inhibitory action to <i>Escherichia coli</i> and <i>Pseudomonas aeruginosa</i>, along with Gram-positive bacteria <i>Streptococcus pyogenes</i>, <i>Staphylococcus aureus</i>, and <i>Bacillus subtilis</i> (Bhat and Aldaihan, 2014)</p> <p>Soeng <i>et al.</i> (2015) found that rambutans' seed (NLS) extract and fractions showed high superoxide dismutase value (SOD) but low 1,1-diphenyl-2-picryl-hydrazyl (DPPH) scavenging activity and might be used as a potential hypoglycemic agent with antioxidant and hypoglycemic activity.</p> <p><i>Nephelium lappaceum</i> seed infusion lowers the glycemic index and body weight of mice when treated with alloxan tetrahydrate. Rahayu <i>et al.</i> (2013) ^[17].</p>
Peel extract	Dried, grinded peels crushed into powder.	Antioxidant, anti-diabetic activity, anti-microbial	<p>(Nurhuda <i>et al.</i>, 2013; Widowati <i>et al.</i>, 2015) reports that inclusive of all the bioassays conducted on varieties of extracts, it has been divulged the presence of antioxidant activity to be the loftiest. In the 2,2-diphenyl-1-picrylhydrazyl (DPPH) free radical scavenging activity experiment, the aqueous and methanolic extracts show strong antioxidant activity with butylated hydroxytoluene (BHT) and vitamin c, the two positive requirements for antioxidant activity.</p> <p>The carbohydrate hydrolysing enzymes -glucosidase and -amylase are blocked at a substantial degree by <i>Nephelium lappaceum</i> rind extract in the form of tannin and geraniin. Acarbose, an anti-diabetic drug, is connected to acarbose. Thinkratok <i>et al.</i>, 2014; Palanisamy <i>et al.</i>, 2011a, 2011b) ^[33].</p> <p>The antimicrobial activity of methanolic rind extract against Gram-positive bacterial strains <i>Streptococcus pyogenes</i>, <i>Staphylococcus aureus</i>, and <i>Streptococcus mutans</i> (ATCC25175T) was demonstrated using the agar disc diffusion method, whereas dormant Gram-negative strains <i>Escherichia coli</i> and <i>Pseudomonas aeruginosa</i> or the fungus <i>Candida alb</i> (Sekar and colleagues, 2014).</p> <p>Mistriyani <i>et al.</i> (2018) ^[34] reveals bustle of phenolics and flavonoid as evince of anti - oxidants on rambutan peel and is potential to be high dietary food.</p> <p>According to Lestati <i>et al.</i>, polyphenols present in rambutan peel extract (RPE) can be employed as anti-obesity agents.</p> <p>According to Ma <i>et al.</i>, (2017), rambutan peel phenolic (RPP) efficiently maintained the tissue structure of the liver, kidney, and pancreas, as well as lowering the mesangial index and inhibiting TGF- expression in diabetic mice's kidneys.</p> <p>The peel of the rambutan fruit provides biological benefits such as antioxidant, antibacterial, antidiabetic, and cytotoxic properties, among others (Rehman <i>et al.</i>, 2016).</p>

Conclusion

Rambutan is a tropical tree which grows well at an optimum temperature of 22 to 30 degrees Celsius. The pulp of fruit is rich in minerals, seed is rich in fatty acids and the peel is rich in bio active compounds, but there is also presence of antinutritional factors such as saponin, tannin, oxalate etc. Major bio active compound in rambutan is Geraniin having anti-diabetic and anti-hyperglycemic effect. It is evident from research that rambutan is used in medicine for centuries that defines it has a lot of health benefits. It is a great source of antioxidants, improves immune system and enhances bones. there are other benefits including prevention from anemia. the presence of high water and high fiber in rambutan prevents overeating and eventually lead to loss in weight.

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