**Bioactive Compounds of Rambutan** (*Nephelium lappaceum* L.)

**Rajeev Bhat**

*ERA Chair for Food (By-) Products Valorisation Technologies,*

*Estonian University of Life Sciences, Fr.R.Kreutzwaldi 1, 51006 Tartu, Estonia*

Contact email: rajeev.bhat@emu.ee; Phone: +372 53560789 &+372 7313927



**Contents**:

**Abstract**

Rambutan, a widely popular tropical fruit encompasses rich amount of bioactive compounds. All parts of this plant (leaves, bark, root, fruits, fruit skin, pulp and seeds) finds traditional usage, and are linked with high therapeutic values. Rambutan fruits parts like that of peel, pulp and seeds have been scientifically investigated in-depth and is reported to encompass high amounts of bioactive compounds (such as polyphenol, flavonoid, alkaloid, essential mineral, dietary fiber). These compounds contribute towards antioxidant, antimicrobial, anticancer, antidiabetic and anti-obesity activities. However, literature pertaining towards potential industrial applications (food, cosmetics, pharmaceutical) of rambutan fruits are limited. In the present chapter, it is intended to document some of the interesting research themes published on rambutan fruits, and identify the existing gaps to open up arena for future research work.

**Keywords**: Bioactive compounds · Cultivars · Exotic fruits ·Rambutan · Therapeutic value

## 1 Introduction

Majority of the exotic fruits have been identified to possess rich nutraceutical values and are in high demand among local populations of the growing regions. Regular consumption of fresh fruits prevent cardiovascular diseases, cancer, and other neurodegenerative disease[1-3].Contribution of exotic and local fruits of a region can play a vital role in meeting the demands of health conscious consumers as well as assure food security and sustainable food production of the region[4]. Presence of bioactive compounds or phytochemicals (such as polyphenols, flavonoids, essential minerals and vitamins) and their bioactivity are reported in majority of the tropical fruits. Rambutan (**Fig. 1**) is one of the much-admired exotic tropical fruits, the taste of which is relished widely in the growing regions. Apart from their organoleptic qualities, these fruits are appreciated for nutritional and health benefits. Each part

of rambutan plant could be a good source of bioactive compounds due to its therapeutic value. With this background, in the present chapter, it is intended to document some of the interesting research themes published on rambutan fruits, and identify the existing gaps to open up arena for future research work.

## 2 Botanical description

Genus *Nephelium* has 3 major species viz., *Nephelium lappaceum* (Rambutan), *Nephelium mutable* (Pulasan) and *Nephelium philippinense* (Bushan). *Nephelium lappaceum* L. (family Sapindaceae), is a tropical non-climacteric fruit bearing tree with nearly 2000 sub-species type.Based on leaf characteristic features, rambutan is categorized into three botanical varieties *Nephelium lappaceum* var. *pallens*, var. *lappaceum* and var. *xanthiodes*. Rambutan tree is native to Southeast Asia (mainly in Malayan Archipelago), and as of today it is widely cultivated in Philippines, Thailand, Vietnam, Singapore, Australia, India, Mexico, Hawaii and in South Africa. The trees occur as a male, female or a hermaphrodite, and grows luxuriantly inwarm tropical weather (25-30 °C). The name 'rambutan' finds its origin from the Malay language wherein rambut means 'hair' that covers the fruit (**Fig. 1 A-E**). Fruits are considered as berries, are ovoid in shape, very juicy (pulp portion is up to 48%), slightly acidic (owed to high vitamin C) and are covered with thick elastic/stretchable skin (up to 4mm, app. 50% w/w) with soft hairs or the soft spines (**Fig. 1 C-E)**. The juicy fruits pulp are white coloured, translucent, sweet to tangy flavoured and encompasses a medium sized seed (**Fig. 1 E, F**) [5].To achieve marketable maturity, it is expected that the fruits should weigh a minimum of 30 grams with spine length not exceeding 1 cm. The aril is recommended to be firm and easily separable from the seed. Further, the total solid content in mature fruits is expected to range between 16-18% [6].Another variety is the yellow coloured ones referred to as 'wild Rambutan' which are much small in size [7].

## 3General uses

Rambutan fruits are consumed fresh and excess of harvest are generally processed into juice, jam, jellies, chips, or are canned[8-10]. Rambutan fruits contain valuable bioactive and human health promoting components [11].Rambutan fruit is traditionally endorsed to treat diarrhoea, overcoming microbial infections and fever, enhance the digestion, induce weight loss, and treat hypertension and diabetes[12]. Further, Palanisamy et al. [13] reported rambutan trees bark usage as an astringent, leaves to relieve headache, and decoction of the roots for treating common fever. Honey obtained from rambutan flower nectar has been used as a traditional medicine for accelerating oral mucosa wounds [14].

## 4 Composition and bioactive compounds

A wide array of bioactive compounds has been isolated from the fruit pulp, peel/skin and seeds of rambutan fruit. In the preceding text, details on reported bioactive compounds and composition of the fruits parts (peel, pulp and seeds) are provided.

### 4.1 Fruit peel

#### 4.1.1 Nutrients and composition

Fruit peel forms the non-edible portion and is discarded as a waste. However, available reports indicate valorization of these wastes to produce bioactive compounds. Rambutan fruits peel has reported to contain the high carbohydrates (up to 21%), vitamin C and polyphenols, and protein (0.6%),dietary fiber (0.9%), and fat content (0.21%) in lower amount in dry matter[15-18].Rich antioxidant activity and presence of polyphenolic compounds have reported from the peel. Suhendi and Muhtadi [19] showed that fruit peel to encompass rich amounts of polyphenolic compounds (gallic, caffeic, coumaric, syringic, and ellagic acids), tannins,

flavonoids and saponin. In another study, Palanisamy et al. [20] reported polyphenolic content of 393 mg/g in the husk. Same authors have reported ethanolic extract of skin to contain epigallocatechin-3-gallate. Epigallocatechin-3-gallate present in the peel is envisaged to have anti-hyperglycemia activities. Several researchers have reported the variations in the polyphenol content from rambutanhusk.Maisuthisakul et al. [21] reported 203 mg/g of hydrolysable polyphenols, while Ling et al. [22] have reported polyphenolics content of 702 mg/g. Further, Maran et al. [23] reported 402 mg/g of hydrolysable phenolics. Mexican rambutan husk/peel indicated presence of high levels of polyphenolics (582 mg/g) with identification of nearly 13 compounds [24]. Further, the same authors were able to identify for the presence of flavonoids and seven ellagitannins types.Thitilertdecha and Rakariyatham [25] reported the accumulation of corilagin, ellagic acid and geraniin in the peels of Rongrien and Seechompoo cultivars of rambutan and increased with the maturity stages of fruit.

### 4.1.2 Biological activities

**Antioxidant activity**

Palanisamy et al. [13] have reported rind of rambutan to be a prospective source of natural antioxidant compounds exhibiting high activities. Further, Thitilertdecha et al. [26] showed methanolic fraction of the peel extracts to encompass high amounts of polyphenolic compounds (542.2 mg/g) which exhibited highest antioxidant activities (4.94 mg/ml; determined as 50% DPPH radical inhibition concentration).The phenolic acids and ellagitannins from the rambutan fruit peel exhibited the antioxidant potential [15].Further, Thitilertdecha and Rakariyatham[25] havereported accumulation of corilagin, geraniin and ellagic acid in the peels (Rongrien and Seechompoo cultivars of rambutan), which increased during maturity stages.

**Antimicrobial activity**

Different solvent (water, ether and methanol) extracts of rambutan peel exhibited the antibacterial activity againstpathogenic microorganisms, particularly for Gram-negative *Vibrio cholera* and *Gram*-positive *Staphylococcus epidermidis* [26]. Tadtong et al. [27] demonstrated the bactericidal activity against *Streptococcus mutans* ATCC25175T, *Staphylococcus aureus* ATCC6538 and methicillin-resistant *S. aureus* (MRSA) DMST20645 from the methanol-extract of fruit peels. Antiviral activity of geraniin (hydrolysable tannin)extracted from the fruit peel was revealed against dengue virus type-2 (DENV-2) [28].

**Anticancer and antidiabetic activities**

Methanol extract of peel induced cytotoxic effects in carcinoma cell lines in human mouth [29]. Okonogi et al. [30] detected anticancer activity of peels extracts to exhibit high $IC_{50}$ value (>100 μg/ml) against Caco-2 cell line and PBMC.

Available research publications have indicated antidiabetic activities of rambutan peel extract. Suhendi and Muhtadi [19] have reported ethanolic extract of fruit peels to lower blood glucose levels in alloxan induced mice at the dose of 125, 250, and 500 mg/kg b.w. recorded with 22.65%, 49.05%, and 61.76%, activity respectively. At the same dose, anti-hypercholesterolemia activity was also recorded which was 21.39, 31.15, and 60.75, respectively.

The main component of the peel identified is the 'geraniin' whichis a potent compound inhibiting α-amylase and α-glucosidase activities (Thinkratok et al. 2014;Palanisamy et al. 2011) [20, 31].High reduction in the blood glucose levels was reported from extracts of rambutan fruit peels with dose of 500 mg/kg with percentage reduction being 61.76% (Muhtadi et al. 2015) [32]. Further, ethanol extract of peel was confirmed to exhibit α-glucosidase-

inhibitory and β-glucosidase inhibitory activities ($IC_{50}$ values of 0.106 and 7.02 µg ml/L, respectively) [33].

**Anti-obesity activity**

Results of animal experimentation in obese rats have revealed the effectiveness of rambutan peel extract in reducing the bodyweight, lowering of serum lipids and visceral tissue protein [34]. Water extract of fruit peel was described to reduce PPARγ expressions in obese rats [35]. Ethnaol extract of peels has been linked with *in-vitro* inhibition of fatty acid synthase wherein $IC_{50}$ was in the range of 6.69 to 204.4 µM [36] and activity was due to the flavonoids present in the peel.

Overall, safety and bioactivity of rambutan peels in pharmaceutical usage is well established via *in vivo* and *in vitro* studies [13, 26, 33, 37,38]. Formulation and sunscreen protection activities of gel nano-emulsion of fruit peel extracts is also reported [39].

**4.2Fruit pulp**

**4.2.1 Nutrients and composition**

Edible part or the fruit pulphas higher amounts of organic acids, sugars and ascorbic acid [40-41]. Wall [5] showedseven cultivars of rambutan from Hawaii to have ascorbic acid and soluble solid content ranging between 22 to 39% and 16 to 18% respectively. Rambutan fruit cultivars contained majority of the essential macro and micro-minerals and the pulp was a good source of copper, potassium, and manganese [5].

Rambutan fruits from Mexico (five regional selections) contained higher amounts of vitamin C (between 37.9 to 69.1%), total soluble solids (17.8 to 20.4 ºBrix), total sugars (211to 242%) with pH being 5.0 and titratable acidity of 0.20 to 0.28% [6]. Fresh and dried rambutan pulp has been compared for vitamin content [42]. Accordingly, in fresh pulp vitamin C was

58.29, Niacin 0.78, Riboflavin, 0.06 and Thiamine 0.02 mg/100g. Whereas in dry pulp contained vitamin C 52.35, Niacin 0.56, Riboflavin 0.05 and Thiamine 0.01 mg/100g. Supapvanich [43] reported glucose, fructose and sucrose were in the range of 14, 22 and 23 mg/g, respectively. Small amount of anti-nutritional compoundslikephytates (0.15%), saponin (1.50%) and oxalates (0.11%) were also reported [7].The volatile compounds contributing to rambutanfruits have unique aroma because of cinnamic acid, vanillin, beta-damascenone and phenylacetic acid [10].

### 4.2.2 Biological activities

**Antioxidant activity**

Total antioxidant capacity of 71.5% is reported in the pulp portion, which was assessed via ascorbic acid equivalent antioxidant capacity assay [44].The major compounds contributing to bioactivity (as antioxidants) in rambutan are geraniin, ellagic acid and corilagin [15,25].Enhanced phenolics and ellagitannins during fruit development of Rongrien and Seechompoo cultivars of rambutani s reported to contribute for the radical scavenging activities [25].The $IC_{50}$ values recorded for radical scavenging activity were initially low and it markedly enhanced during fruit maturation stages until harvest (4.87 to >1000 µg/mL). Further, 181.3% of anthocyanin (a coloured pigment exhibiting bioactivity) is reported from a study by Sun et al. [16].

### 4.3Seeds

Rambutan seeds are poisonous when fresh, but dried and roasted seeds are consumed. Besides, rambutan seeds fat are used in food and cosmetic preparations [8,45]. Raw seeds are narcotic, exhibit analgesic effects, and can lead to coma and death [46]. However, in the food processing

industry, seeds are considered as a major waste and attempts have been made for their effective utilization [47-49].

### 4.3.1 Nutrients and composition

High amounts of fats (fatty acids like arachidic acid, oleic acid, stearic acid and palmitic acid)and protein (presence of both essential and non-essential amino acids) contents have been recorded in dried seeds [8, 17, 47, 50, 51]. Crude fat content of fresh seed is reportedto range between 36–38%. Some of the major fatty acids like arachidic acid ranged between 26.03–33.27% and oleic acid between 33.35-46.64% [41]. Manaf et al. [52] reportedseeds to have a higholeic (42.0%) and arachidic acids (34.3%).Post-fermentation and turning intervals up to eight days, the seeds were found to contain 32% of crude fat with major fatty acids beingoleic acid (41-42%) and linoleic acid (28-33%) [53].

Though seed fat is bitter in taste, this has been recommended to be an alternative for cocoa butter [54,55]. Reports on potential uses of seed fat in bioenergy production and in food industries are available [8,56].Seed bitterness is attributed to alkaloids and seed 'testa' is reported to have ample amounts of saponin and tannins [57].Methanol extract of rambutan seed is reported to have high level of polyphenols, flavonoids, and alkaloids [7, 26].Oh et al. [58] have reported 13.3 mg/g of condensed phenoliccontent in rambutan seedsand, appreciable amounts of essential minerals in seed oil were reported [59,60].Harahap et al. [59] reported rambutan seeds nutritional composition that 2.26% ash, 38.9% crude fat,12.4% protein and48.1% carbohydrate. Wahini et al. [61] have described on the potential uses of $Ca(OH)_2$ treated rambutan seed to be an good alternative source to produce value added products. Raw, boiled and roasted seeds extracted with methanol have been evaluated for anti-nociceptive, antibacterial, antioxidant and antifungal activities [21,26,46, 62,63].

### 4.3.2 Biological activities

**Antimicrobial activity**

A trypsin inhibitor of 22.5 kDa has been extracted from the seeds of red-skinned rambutan[64], which was later evaluated for HIV-1-reverse transcriptase inhibition activity. Results of this study indicated and $IC_{50}$value of 0.73 μMinhibition of reverse transcriptase. Antibacterial activity ofdifferent solvent extracts (ether, methanol, water) of rambutan seed is reported against pathogenic bacteria [65].

**Antioxidant, antidiabetic and anticancer activity**

Seed extracts and fractions exhibited higher superoxide dismutase activity (SOD activity of 3.37 and 3.03 μg/ml in ethyl acetate and aqueous fractions, respectively). In addition, the extracts were envisaged to possess high potential to be used as hypoglycemicagent [66].

Cytotoxicity effects of methanolic extract of the seed and pericarp against human mouth carcinoma cells (CLS-354: $IC_{50}$ values being 305 and 292 μg/mL, respectively) was demonstrated by Hamzah et al. [67].Overall, it is vital that the existing gap in scientific knowledge relevant to molecular mechanisms of the biological activities are evaluated and confirmed for rambutan fruits [68].

**Conclusions**:

Rambutan is a nutraceutically valued seasonal fruit of the tropics composed of vital nutrients, phytonutrients, polyphenolic compounds and other antioxidant rich compounds concentrated in the pulp, skin and seed portions. Comparatively, the pulp and peel portion is related with higher bioactivities exhibiting antioxidant, antimicrobial, anti-cholesterol, anti-cancer activities. Research studies are warranted to provide information on the nutraceutical value of individual cultivar, effect of agronomical practices, geographical origin, and fruit maturity

stages on quality and status of bioactive compounds in the fruits. Developing appropriate post-harvest storage facilities to enhance shelf life as well as for retention of bioactive compounds and vital nutrients of fruits is another arena to explore. Characterization of individual bioactive compounds, fruit volatiles and sugar components in various rambutan cultivars and varieties needs to be documented. Seeds are recommended for food and cosmetics usage, however, their safety evaluation needs to be determined with the evidence. Studies reported till date have concentrated more on *in vitro* and *in vivo* models (animals), however no reports are available on the human trials, a gap that needs to be filled. Fruits products like jams, syrups, and others are in market. However, new healthy product innovations are required to process fruits pulps to value added products, which can retain the original flavour of the fruit. Scientific literate on impact of processing technologies on bioactive compounds is scarce and this needs to be explored. Finally, effective and sustainable utilization of wastes and by-products of rambutan to reduce stress on the environment is the need of the hour.

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