



## Phytochemistry and Pharmacological Properties of Lychee (*Litchi chinensis* Sonn)

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### ABSTRACT

Fruits plants are a reservoir of nutrients and natural drugs. At present, researchers recommend the consumption of fresh fruits to enhance immunity, mental health and physical health. Lychee (*Litchi chinensis* Sonn.) is one of the admired genus of the soapberry family (Sapindaceae) which includes 150 genera and 2,000 species. It is one of the important commercial fruit crop with several pharmaceutical properties. The pericarp, pulp, seeds, fruits, flowers and leaves are a source of bioactive constituents such as procyanidin A2, procyanidin B2, leucocyanidin, isolariciresinol, stigmasterol, epicatechin, saponins, rutin etc. The aim of the present review is to summarize the pharmacological activities represented by the aforementioned bioactive ingredients. Meticulous pharmacological and phytochemical studies on lychee could yield reliable compounds of pharmacological significance for better healthcare.

**Keywords:** Lychee; Anti-oxidant; Pharmacological activities; Fruit crop

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### INTRODUCTION

Polyphenolic compounds are a rich source of food supplements for better health care [1]. Various medicinal systems of the world including 'Ayurveda' has clearly mentioned the scope of medicinal plants as a cure of various diseases and to boost the immunity. There are several plant-derived elite drugs which are to be evaluated scientifically for their mode of action, efficacy and side-effects. If the medicinal plant is a fruit plant, then its demand rises several folds. Lychee is one among the important fruit plants which possess several bioactive compounds exhibiting pharmacological activities.

#### Taxonomical position

Kingdom: Plantae  
Order: Sapindales  
Family: Sapindaceae  
Subfamily: Sapindoideae  
Genus: *Litchi*  
Species: *chinensis*

It is an evergreen plant with a short stout trunk and attains a height upto 30 m. In some varieties, the branches are twisting and spreading forming a crown like appearance, while some have straight and upright branches forming a compact and rounded crown. Leaves are alternate and compound with 2-5 leaflets. The flowers are small, yellowish-white, functionally male or female and apetalous. Fruits are highly variable and depend upon the variety. They can be ovoid, round and heart shaped. Lychee is native to Guangdong and Fujian regions of China and are an important commercial fruit crop of many parts of the world. At present, lychee is cultivated as commercial fruit crop in Central

and South America, some parts of Africa and throughout Asia. China, India, South Africa, Australia, Mauritius, Madagascar, Thailand are now the major lychee producing countries of the world. India is the second largest producer of Lychee in the world, after China. The Table 1 enlists the lychee cultivars grown in different countries of the world. The pharmacological properties of lychee include anti-cancer, anti-platelet, anti-microbial, anti-pyretic, anti-oxidant, hepato-protective, anti-inflammatory, anti-viral, anti-hyperlipidemic, anti-mutagenic etc. [2-13]. This review provides explicit information to researchers about the structures of active ingredients of lychee as well as the pharmacological properties exhibited by them.

**Table 1: Major lychee cultivars grown in different countries**

Country	Cultivars
Australia	Kwai May Pink, Tai So, Souey Tung, Fay Zee Siu, Salathiel, Wai Chee
Bangladesh	Bombai, Muzaffarpur, Bedana, China 3
Brazil	Bengal
China	Early: Sanyuehong, Baitangying
	Mid: Dazao, Heiye, Baila, Feizixiao and Shuidong, Tianyan, Chenzi
	Late: Xiangli, Guiwei, Noumici, Huaizhi, Xuehuaizi, Lanzhu, Bobaitangbo, Yuanhong, Xiafanzi, Nanmuye
Florida, USA	Mauritius and Brewster
India	Bihar/Jharkhand: Deshi, Purbi, China, Kasba, Bedana, Early Bedana, Late Bedana, Dehra Rose, Shahi, Manragi, Maclean, Longia, Kaselia and SwarnaRupa, Ajhauri, Green, Mandraji, Rose Scented
	Uttar Pradesh/Uttarakhand/Himachal Pradesh: Early Large Red, Early Bedana, Late Large Red, Rose Scented, Late Bedana, Calcuttia, Extra Early, Gulabi, Pickling, Khatti, Dehra Dun, Piyazi
	West Bengal/Assam: Bombai, Ellaichi Early, China, Deshi, Purbi and Kasba, Kalyani Selection
	Haryana/Punjab: Early Seedless, Late Seedless, Seedless-1 and Seedless-2, Calcuttia, Muzaffarpur
	Chhattisgarh: Sarguja-1, Sarguja-2
Indonesia	Local Selections
Israel	Mauritius, Floridian
Madagascar	Mauritius
Nepal	Mujafpuri, Raja Saheb, Dehradun, Calcuttia, China
Philippines	Sinco, Tai So, Ulpb Red
South Africa	Mauritius, Mclean Red
Thailand	Tai So, Chacapat, Wai Chee, Haak Yip, Khom
Vietnam	Thieuthauhha
Country	Cultivars

### Nutritional composition

Lychee fruit is described as a large seeded drupe, with semi-transparent aril (flesh) which is edible and thin corky pericarp (skin). The fruits are consumed fresh. Moreover, many products like squash, canned lychee, syrup, cordial, jam, jelly, juice etc. are also available in market. It can be used as dried or dehydrated (lychee nuts) or used in sorbets and ice-creams [14, 15]. On the basis of variety and climate the fruit contains 60% juice, 8% rag, 19% seed and 13% skin. Apart from proteins, fats, carbohydrates, minerals, fibrous matter, calcium, phosphorus, iron and carotene the fruit is also rich in vitamin B1, riboflavin and vitamin C. Lychees have low content of sodium and saturated fat.

### Phytochemistry

Nowadays, HPLC (High performance liquid chromatography) and HPTLC (High performance thin layer chromatography) has become regular analytical techniques due to their efficiency in quantitation of analytes at

micro or even nanogram levels and cost effectiveness. Leaf, root, seed, fruit and pericarp extracts of various lychee have been subjected to HPLC and HPTLC followed by pharmacological analyses. The review of literature reveals a total of fifty bioactive compounds reported from different parts of the lychee plants (Table 2). These compounds have been categorized as flavonoids, glycosides, amino acid, phenolic compounds, fatty acids, phenolic aldehyde, monoterpenes and anthocyanins.

### Pharmacological properties

Various biologically active constituents are present in different parts of lychee (leaves, flower, fruit, pericarp, seed). These compounds are reported to exhibit several pharmacological activities (Figure1).

#### Leaves

**Anti-oxidant activity:** The antioxidant potential of organic and aqueous extracts of leaves of the plant was investigated by using ABTS (2,2'-azino-bis (3-ethylbenzothiazoline-6-sulphonic acid), FRAP (ferric reducing antioxidant power), DPPH (2,2'-diphenyl-1-picrylhydrazil), TPC (total phenolic content) and the total antioxidant activity assays. 1-butanol, Methanol, aqueous, and ethyl acetate extract of leaves exhibit strong peroxy radical scavenging activity, thus showing its strong anti-oxidant potential [30].

**Analgesic and anti-inflammatory activity:** Analgesic and anti-inflammatory activity of hydro-alcohol extract of leaves was evaluated by using acetic acid-induced writhing test, hot plate method in mice and carrageenan-induced paw edema model in rats respectively. Oral administration of the extract exhibited a strong anti-inflammatory activity and after 4 hours of administration maximum effect was observed [31].

**Hepatoprotective activity:** The protective effect of lychee leaf extract on paracetamol-induced liver damage was demonstrated by observing the effect of extract on various serum biochemical parameters including SGPT (serum glutamate-pyruvate transaminase), SALP (serum alkaline phosphatase), SGOT (serum glutamate-oxaloacetate transaminase) and liver biochemical parameters [32].

#### Flower

**Anti-oxidant activity:** Acetone extract of lychee flowers exhibited strong DPPH radical scavenging activity and also inhibit the oxidation of LDL (low density lipoprotein) thus representing their significant anti-oxidant potential. This was the first attempt to evaluate the anti-oxidant potential of lychee flower [33].

**Cardiovascular activity:** Aqueous extract of lychee flower is a source of flavonoids, phenols and tannins. Flower extract elevate the TEAC (trolox equivalent antioxidant capacity) of the serum and thus decreases the peroxidation of serum lipid in high cholesterol male hamsters. In this way lychee flower extract represents significant cardiovascular activity [34].

**Cyto-toxicity:** Cytotoxic effect of acetone extract of lychee flower was evaluated by using lead and cadmium induced hepatotoxicity and TGF- $\beta$ 1 (transforming growth factor  $\beta$ 1) mediated activation of hepatic cells. Acetone extract decreases the peroxidation and lipids and fragmentation of DNA and thus exhibited a significant cytotoxic activity [35].

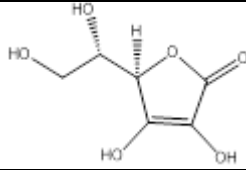
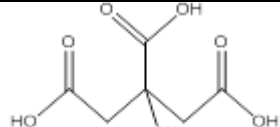
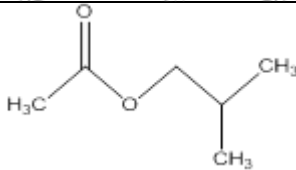
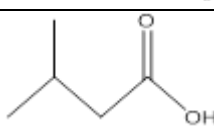
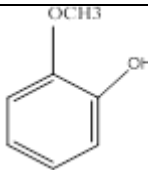
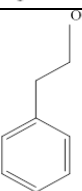
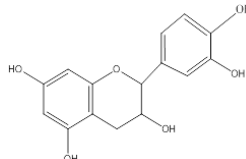
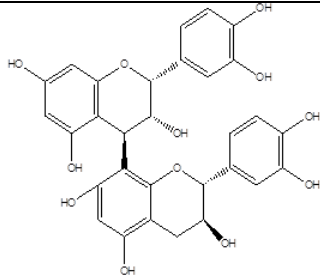
**Anti-lipase activity:** Number of phytochemicals which includes flavonoids, tannins, anthocyanins and proanthocyanins were reported in aqueous extract of lychee flower. Hypercaloric diet-induced rats were used to investigate the anti-lipase activity and it was reported that aqueous extract successfully reduced the size of liver, epididymal and adipose tissues of rat model hence show good anti-lipase activity [36].

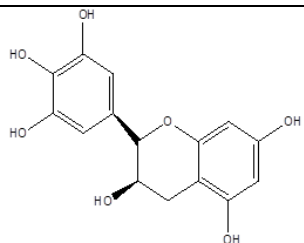
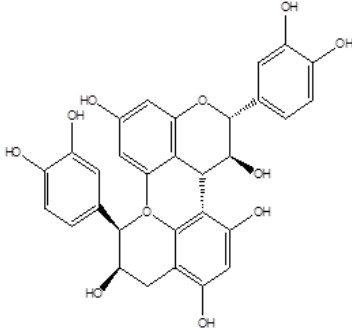
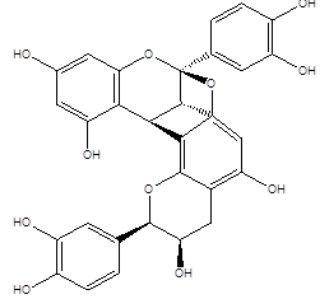
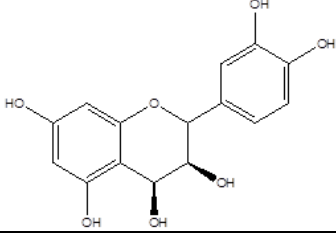
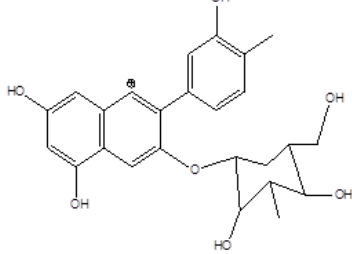
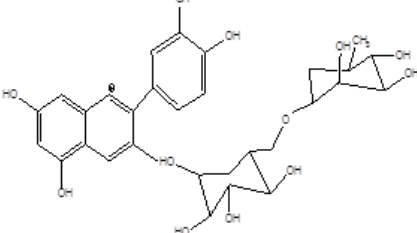
#### Pericarp

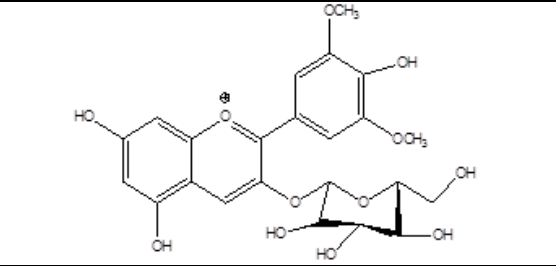
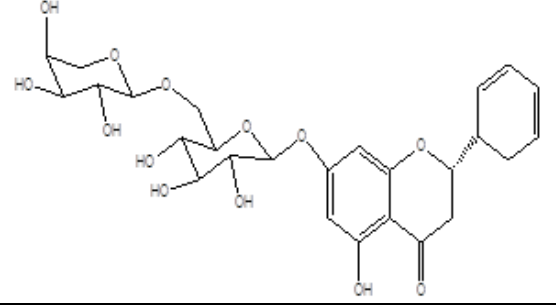
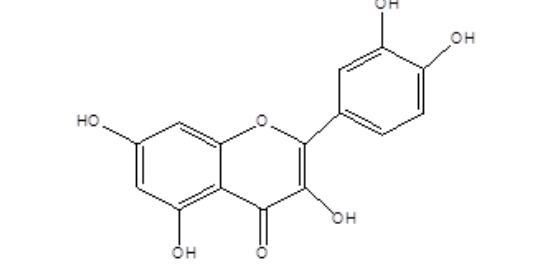
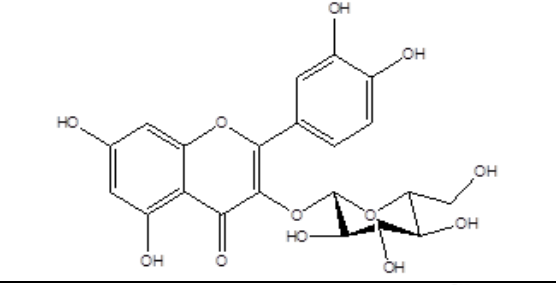
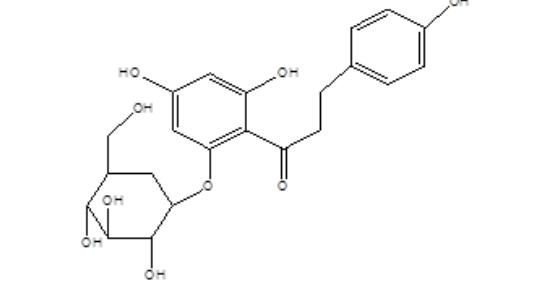
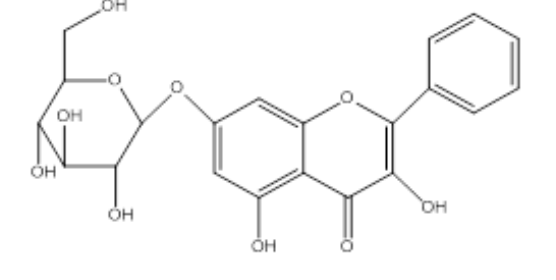
**Anti-oxidant activity:** The antioxidant potential of lychee skin is well defined [12, 13]. Lychee skin contains many active constituents which represents free radical scavenging activity these are glutathione, ascorbic acid, polysaccharides, carotenoids [17, 18] flavonoids (flavonols and anthocyanins) and phenolic acids [37]. It has been reported that procyanidin B2, epicatechin, epigallocatechin and procyanidin B4 are the chief flavonoids in fruit skin [23]. Two flavonoids that are anthocyanins and procyanidins are the major compounds which contribute maximum to antioxidant activity [23]. Different types of flavonoids also differ in their antioxidant potential [38]. It has also been reported that skin of immature fruit has a much stronger antioxidant potential as compare to mature fruit [17].

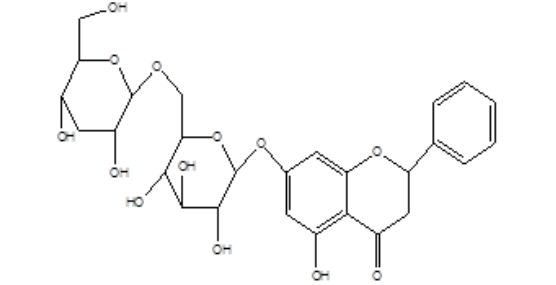
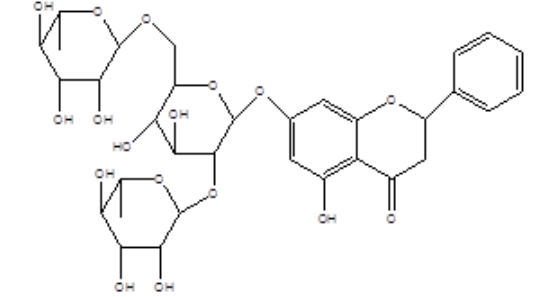
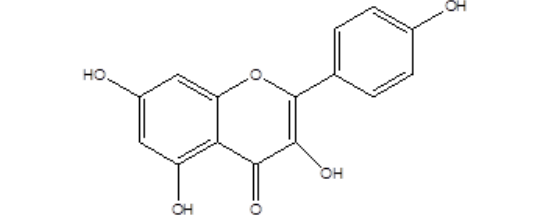
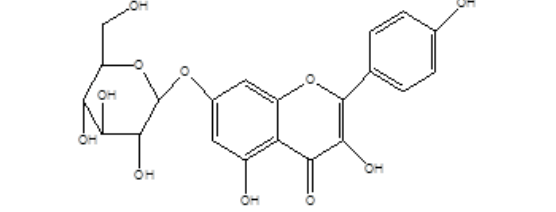
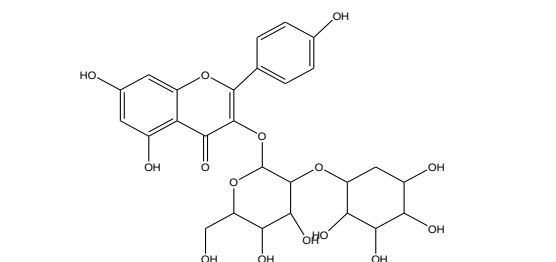
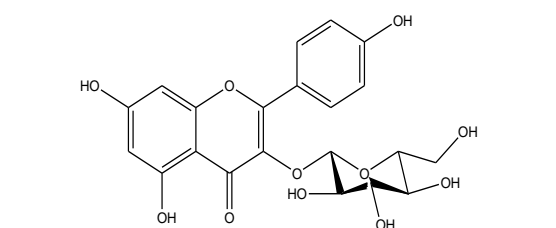
**Anti-cancer activity:** Lychee pericarp is rich source of insoluble fiber (40% dry weight), which inhibit rectum cancer, diabetes and hemorrhoids [2]. Aqueous extract of lychee skin significantly inhibited the growth of cancer cells (human hepatoma cells) in vitro and suppressed the development of cancer cells in mice with liver cancer [3].

**Table 2: Bioactive compounds reported in lychee**

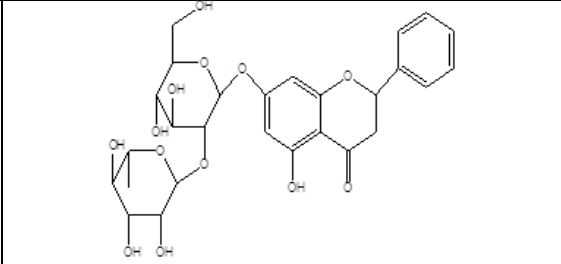
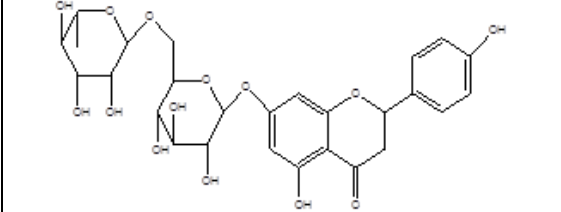
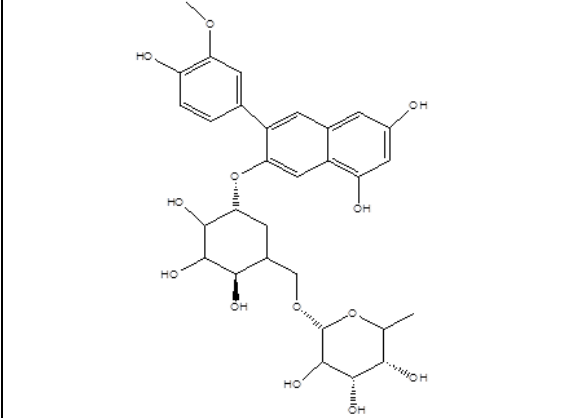
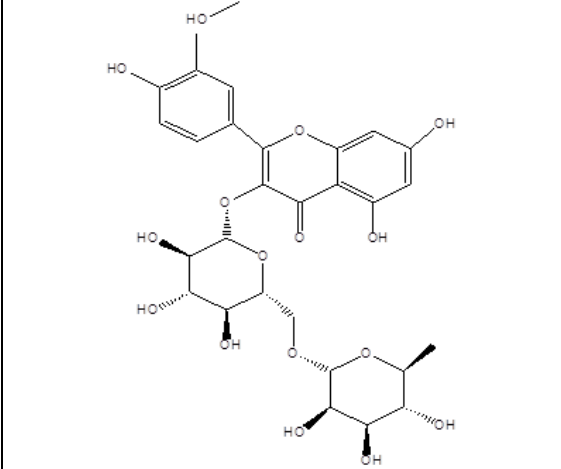
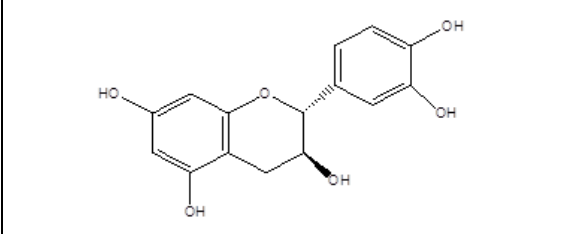
S. No.	Name of compound	Structure	Property	Reference(s)
<b>Flavonoids</b>				
1	Ascorbic acid		Growth and repair of tissues in all parts of the body	[16-19]
2	Citric acid		Anti-bacterial; anti-fungal; anti-oxidant	
3	Isobutyl acetate		Anti-bacterial	
4	Isovaleric acid		Anti-bacterial	
5	Guaiacol		Anti-microbial activity	
6	2-phenyl ethanol		Anti-tyrosinase; anti-microbial	
7	Epicatechin		Anti-oxidant, free radical scavenging activity, reduce blood sugar level, anti-diabetic, anti-cancer	[16,19, 20-26,]
8	Procyanidin B2		Anti-oxidant activity; prevents malignancies	

9	Epigallocatechin		Chemoprevention and anti-cancer activities
10	Procyanidin B4		Possess anti-oxidant activity; inhibition of proliferation and induction of apoptosis in cancer cells through up and down-regulation of multiple genes
11	Procyanidin A2		Prevents hyperglycemia and type 2 diabetes
12	Leucocyanidin		Protects the stomach lining
13	Cyanidin-3-O-glu		Free-radical scavenging activity
14	Cyanidin-3-O-rut		Free-radical scavenging and anti-platelet aggregating activity

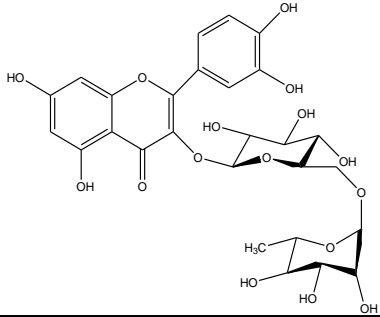
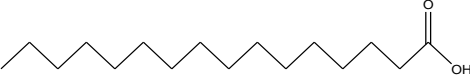


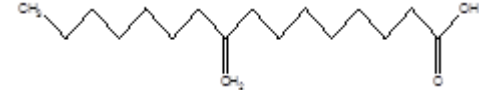
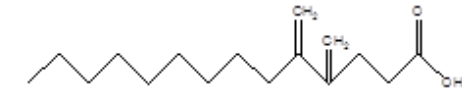
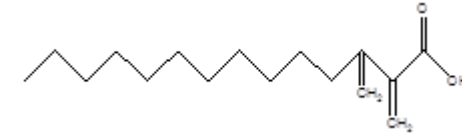
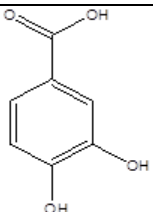
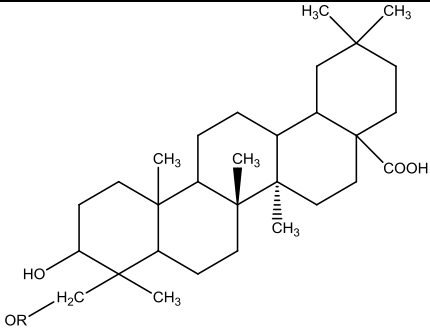
15	Malvidin-3-acetyl-O-glucosin		Anti-oxidant properties
16	(2S)-pinocembrin-7-O-(6''-O- $\alpha$ -L-arabinosyl- $\beta$ -D-glucopyranoside)		Anti-diabetic property
17	Quercetin		Supports normal respiratory health; supports cardiovascular health; promotes balanced blood pressure; offers protection against stress; offers nutritional support for overall health
18	Quercetin 3-O-glucoside		
19	Phlorhizin		Anti-oxidant; anti-diabetic
20	Pinocembrin-7-O-glucoside		Anti-oxidant activity; used to treat cerebral ischemia, neurodegenerative diseases, cardiovascular diseases and atherosclerosis

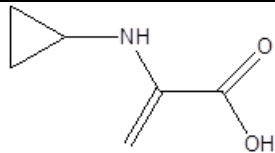
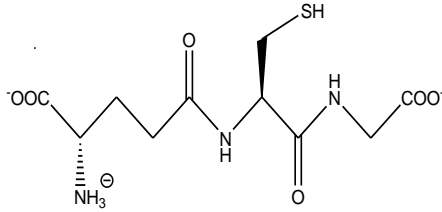
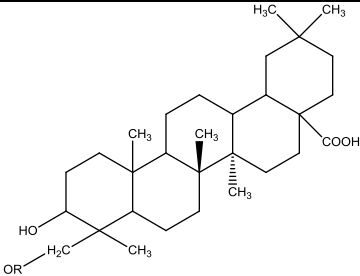
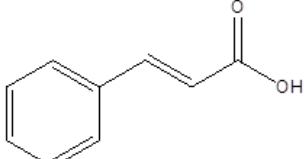
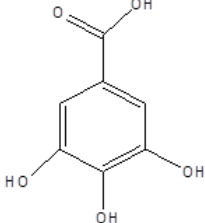
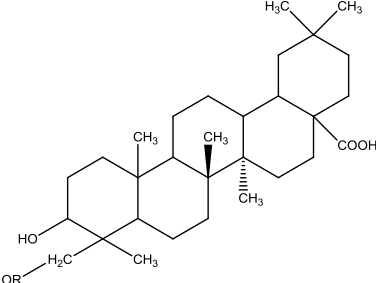
21	Pinocembrin-7-O-[(6''-O-β-D-glucopyranoside)-β-D-glucopyranoside]			
22	Pinocembrin-7-O-[(2'',6''-di-O-α-L-rhamnopyranosyl)-β-D-glucopyranoside]			
23	Kaempferol			
24	Kaempferol-7-O-β-D-glucopyranoside			
25	Kaempferol 3-O-rutinoside			
26	Kaempferol 3-O-glucoside			

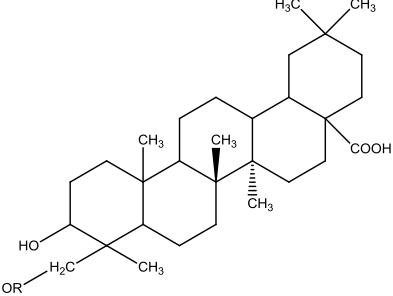
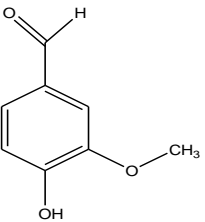
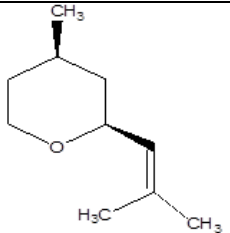
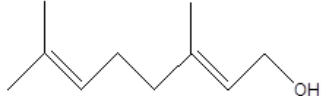
Anti-oxidant;  
anti-cancer

27	Onychin		Anti-oxidant; anti-cancer
28	Nairutin		Anti-oxidant
29	Peonidin 3-O-rutinoside		Anti-oxidant
30	Narcissin (Isorhamnetin-3-O-rutinoside)		Anti-oxidant
31	Catechin		Anti-oxidant



32	Rutin		Anti-oxidant; helps the body to utilize vitamin c and produce collagen; heals conditions such as haemorrhoids and high blood pressure and reduces cholesterol levels	
<b>Fatty acids</b>				
33	Palmitic acid		Blood lipid reducing activity	[21, 27]
34	Linoleic acid		Anti-oxidant; anti-carcinogenic	
35	Dihydrostercolic acid		Anti-cancer; anti-tumor	
36	8-methylenehexadecanoic acid		Anti-bacterial	
37	Cis-5,6-methylenetetradecanoic acid		Anti-bacterial	
38	Cis-3,4-methylenedodecanoic acid		Anti-bacterial	
39	Protocatechuic acid		A major metabolite of anti-oxidant polyphenols, possess anti-cancer property	
<b>Glycoside</b>				
40	Saponin		Cholesterol reduction, anti-oxidant, reduce cancer risk, immunity booster, reduce bone loss, anti-oxidant	[10, 12, 28]

Amino acid				
41	$\alpha$ -methylencyclopropylglycine		Possesses hypoglycaemic activity	
42	Glutathione		It is capable of preventing damage to important cellular components caused by reactive oxygen species such as free radicals, peroxides, lipid peroxides and heavy metals.	[29]
Anthocyanin				
43	Cyanidin glycoside		Anti-oxidant; anti-ageing	[22]
Phenolic acid				
44	Trans-cinnamic acid			
45	Gallic acid		Anti-tumor; anti-oxidant; anti-inflammatory	
46	Chlorogenic acid		Anti-oxidant; blood pressure lowering effect; laxative effect	

47	Caffeic acid (3,4-dihydroxycinnamic acid)		Anti-oxidant; anti-hypertension; anti-thrombosis; anti-fibrosis, anti-virus and anti-tumor
<b>Phenolic aldehyde</b>			
48	Vanillin		Anti-oxidant; Anti-bacterial
<b>Monoterpene</b>			
49	Cis-rose oxide		Anti-inflammatory
50	Geraniol		Anti-oxidant; anti-cancer properties

In both cases, the anticancer potential of the extract was depended on dose and time. Lychee skin extract effectively suppress the growth of breast cancer cells [39]. A report indicated that two flavonoids epicatechin and procyanidin B2 are highly effective in inhibiting the growth of human breast cancer cells and human lung fibroblast, although their toxicity to cancer cells was lower than that of paclitaxel (standard anti-cancer drug) [40].

### Seed

Dried lychee seed is characterized by traditional Chinese medicine as slightly bitter, warming, cold-driving, pain-killing, Qi flow promoting and liver- and kidney-tonifying [41]. There is ample information on the health promoting and medical functions of lychee seed, including antioxidant, anti-cancer, anti-virus, controlling diabetes, and reducing blood lipids.

**Anti-oxidant activity:** As mentioned above, lychee seed contains flavonoids, which contribute to the antioxidant activity of the seed. Ethanol and Water extracts of the seed has been reported to reduce the damage caused by free radicals and promote SOD (superoxide dismutase) activity in ALX (alloxanmo mohydrate) treated mice [42].

**Anti-cancer activity:** Water extract of the seed significantly suppress the growth of hepatoma tumor cells in mice [43]. Seed extract of lychee prevents the formation of telomere in hepatoma cells which ultimately stops the division of cancer cells, which leads to the inhibition of cancer cell growth [44].

**Reduces blood sugar and lipid:** There are several reports available about the effects of Lychee seed in reducing blood sugars and lipids and in promoting the function of liver [12, 42, 45, 46]. The water extracts of lychee seeds successfully reduced blood sugar level in ALX induced diabetic rats and that effect was similar to that of "biguanides" that is anti-diabetic drug, and it was found that the effect of lychee seed extract was long lasted than

(more than 1 week) biguanides [46]. Seed extract reduced the sugar level in blood because it suppresses the uptake of glucose by blood capillary but promote glucose uptake in ambient tissues [42]. Guo et al. 2003 also found that lychee seed extract alleviated sugar metabolism disorder and improved sensitivity to insulin in rat suffering from insulin resistant Type 2 diabetes (T2DM) induced by streptomycin, and therefore reduced blood sugar [12]. Some authors suggested that  $\alpha$ -methylenecyclopropylglycine in lychee seed was the most effective to reduce the level of blood sugar and glucogen in liver in ALX treated mice [29] while others suggested that anti-diabetes activity was related to saponins [12, 28].

Anti-gastralgia	Promotes blood circulation
Anti-tumor	Improves digestion
Anti-inflammatory	Relief from heart burn
Anti-pyretic	Boosts immune system
Anti-diabetes	Prevents cataract
Astringent	Anti-arthritis, gout
Anti-helminthic	Acts against influenza
Anti-stress	Reduce eye disorders
Anti-osteoporosis	Aids weight loss
Anti-oxidant	Promotes nervous system
Anti-cancer	Maintains fluid balance
Anti-viral	Imparts glow to skin
Anti-asthma	Improves liver functioning
Free-radical scavenging	Carbohydrate metabolism
Removes skin-blemishes	Production of RBC'S
Cures sore throat	Improves appetite
Reduces sunburns	Prevents signs of aging
Helps reduce weight	Skin UV- protectant
Promotes hair growth	

Figure 1: Pharmacological properties of *Litchi chinensis*

**Anti-virus activity:** There are many reports about the anti-virus effects of lychee seed extracts, which were effective against hepatitis B virus [5-10] respiratory syncytial virus (RSV) [25], influenza virus [24] and SARS coronavirus [26]. Zheng and Zheng 1992 found that seed extract was the second most effective to control hepatitis B among 1000 tested herbal medicines [5]. It has also been reported that lychee seed extract directly inhibit the expression of HbsAg (antigen) and HBV-DNA (Hepatitis B virus) [7]. Xu et al. 2004, examined 6 extraction fractions of the seed, all of them strongly inhibit the expression of HBsAg and HbeAg in Hep G 2.2.15 cell line [8]. Most authors suggested that anti-virus effect of the seed extracts is due to the presence of flavonoids while some suggested that saponins in lychee seed is the most effective constituent [10, 25, 26, 43].

### Fruit

**Anti-inflammatory activity:** Ethanol extract of lychee is a mixture of flavanol monomers, dimers and trimers. The effect of lychee-fruit extract was observed on interleukin treated rat hepatocytes and it was reported that ethanol extract significantly inhibits the production of interleukin induced Nitric oxide. The flavanols present in ethanol extract may have been responsible for anti-inflammatory effect and can be used to cure inflammatory diseases [47].

**Aldose reductase inhibition activity:** Aldose reductase is an enzyme responsible for sugar induced cataract. Methanol and ethanol extract of lychee fruit was found to inhibit the functioning of aldose reductase enzyme in rat. In this way fruit-extract can be prove significant so as to cure the diabetic related complications [48].

**Anti-viral activity:** An experiment was conducted to find the inhibitory effect of phenolic extract of Lychee on Betanoda virus (causative agent of viral nervous necrosis in marine fishes). It was reported that oligonol present in phenol extract inhibited the replication of virus and thus can be used as an anti-viral agent [49].

**Hepato-protective activity:** Aqueous and alcoholic extract of fruit has significantly shown hepatoprotective activity at an orally administrated dose of 250 mg/kg body weight and 500 mg/kg body weight. Their hepatoprotective activity is comparable to LIV-52 (reference drug). Fruit extract decreases the weight of CCl<sub>4</sub> induced liver and thus can be used as a potent hepato-protective agent [50].

#### Other Functions

Lychee seed extracts are also reported to cure haemorrhoids [51].

### CONCLUSIONS

Several investigations have been done to estimate the pharmacological properties of lychee. It can be concluded that almost all parts of the plant contain bioactive compounds which are responsible for its pharmacological properties. These results indicate and encourage us for sustainable production of lychee for both pharmaceuticals and dietary purpose. However, sufficient clinical trials are also required for the evaluation and safety of the aforementioned natural compounds. There is also a need to develop a robust micro-propagation technique so as to enhance the rate of multiplication of the quality plants. More researches are required so as to produce seed-less varieties, to increase the fruit shelf-life, to produce disease-free crop and to reduce the post-harvest loss of the crop.

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