Glimpse of Multifaceted Therapeutic Potential of Litchi (*Litchichinensis* Sonn.): From Traditional Medicine to Modern Applications

Abstract

Litchi, known for its delicious taste, it is not just a culinary treat but provides a wide range of medicinal benefits. mostly cultivated in warm climates across China, India.Its rich history intertwines with diverse cultural traditions. Beyond its tantalizing flavor, litchi unveils adiverse range of therapeutic properties. From ancient remedies for diabetes to modern insights into its antioxidant, anti-inflammatory, and anti-viral prowess, litchi emerges as a versatile healer. This review explores the bioactive compounds in different parts of litchi. Key findings of this review reveal the neuroprotective role of the litchi saponins and its anti-cancerous potential by inhibition of tumor growth, ad it hepatoprotective effects against liver toxins. Moreover, its extracts demonstrate significant anti-diabetic, anti-obesity and lipid lowering effects. Suggesting their application in managing metabolic disorders. This paper provides a consolidated version of traditional knowledge with contemporary scientific research emphasizing litchi's potential as a functional food and its increasing relevance in modern health care

Key words:Litchi, sweetness, culinary delight, medicinal benefits

*

Introduction

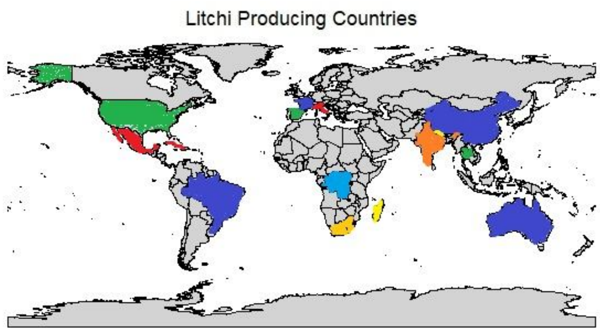
Litchichinensis Sonn, is a delectable sub-tropical fruit cherished for its juicy, succulent flesh. Belonging to the Sapindaceae family and Nepholea subfamily, it thrives under warm subtropical climates. Litchi trees typically feature a sturdy, short trunk with bark ranging from brown to grey in color. There are two main species of litchi: *Litchiphilippinensis* and *Litchichinensis*. *Litchiphilippinensis*, found in the wild in the Philippines, adds to the diversity of this fruit. Litchi cultivation is widespread, with significant production in countries such as China, India, Vietnam, Thailand, Bangladesh, Indonesia, The Philippines, Nepal, South Africa, Australia, and the USA. The fruit itself is characterized by its diminutive size and varying shapes, ranging from conical to heart-shaped or spherical, and is distinguished by its vibrant red hue. Upon peeling away the skin, one uncovers the edible portion—a creamy, translucent pulp enveloping a glossy, brown seed at its center. This combination of sweetness and texture makes litchi a highly sought-after delicacy world-wide.

TABLE 1: Chronology of Litchi Fruit Evolution and Cultural Significance

Han Dynasty, 140 to 86 B.C.	Litchi is mentioned in the literature for the first time during the Han Dynasty.
First published work on litchi culture (1056 A.D.)	A Chinese scholar publishes the first work exclusively focused on litchi culture and varieties.
Monograph on litchi (1059 A.D.)	Ts'ai Hsiang writes the world's first publication entirely devoted to litchi.

Eight monographs on litchi published (1826)	Scholarly interest in litchi increases with the publication of eight monographs.
Litchi as a Tribute	Historical records suggest litchis were sent as tribute around 200 B.C.
Tang Dynasty	Litchi becomes the favorite fruit of Emperor Li Longji and his favored concubine, Yang Yuhuan.
Song Dynasty (960-1279):	Litchi sees high demand, according to Cai Xiang's Treatise on Litchi.
First Century:	Litchis become highly prized, leading to the establishment of special courier services for quick delivery.
Fifth Century:	A Chinese emperor sends runners over a long distance 800 miles to obtain litchis for his beloved from South China region.

(Groff, 1921; Mc Gowan 1884; Goto, 1960; Knight, 1980; Liang, 1981)

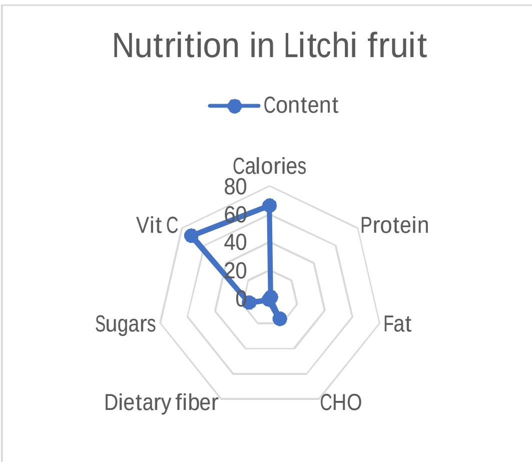


Botanical classification of Litchi	
Kingdom	Plantae
Clade	Tracheophytes
Clade	Angiosperms
Clade	Eudicots
Clade	Rosids
Order	Sapindales
Family	Sapindaceae
Genus	*Litchi*
Species	*chinensis*

Figure:1 Major litchi producing countries of world

The Journey and Impact of Litchi Cultivation in India:Litchi, originatedin China, gradually made its way to Eastern India through Burma during late 17th century, and by the end of the 18th century, it was introduced to Bengal. From there, its cultivation spread to various parts of India. Presently, litchi is cultivated in different parts of world as shown in figure 1. Litchi is commercially grown in several regions, including North Bihar (notably Muzaffarpur and Darbhanga), sub-mountainous districts of Uttarakhand (including Saharanpur, Dehradun, and partially Muzaffarnagar), and in West Bengal (near Hoogly). Successful cultivation is also reported in various districts of Uttar Pradesh (such as Gorakhpur, Deoria, Gonda, Basti, Faizabad, Rampur, Bareilly, Bahraich, Kheri, and Pilibhit), the Nilgiri Hills in South India, Gurdaspur district in Punjab, Araku Valley of Andhra Pradesh, and Kangra Valley of Himachal Pradesh.

Recent reports have provided information about efficiency of litchi fruits to impede the growth of cancer cells (Bhat and Al-Daihan., 2014). Litchi seeds are rich source of flavonoids which are highly effective against breast cancer (Xu et al., 2011b).other compounds which are found in seeds have bioactivity such as hypoglycemic, anticancer, antibacterial, anti-hyperlipidemica, anti-platelet and antiviral (Xu et al., 2011b, Li 2008, Chen et al., 2007). Oligonol is a flavanol-rich litchi extract processed to convert the higher molecular weight proanthocyanidins in to lower molecular weight proanthocyanidins to improve their bioavailabailty (Ogasawara et al., 2009). It has 15.57% polyphenol monomer ((+)-catechin and (-)-epicatechin) and 13.3% polyphenol dimer (procyanidin B2) (Ogasawara et al., 2009). US FDA has notified it as new safe dietry ingredient as it has shown to exhibit numerous health benefits including protection against oxidative stress, prevention and treatment of hyperuricemia, reduced fatigue and visceral fat (Yamanishi et al., 2014; Kang et al., 2012; Ogasawara et al., 2009, Sakurai et al., 2008). It also has been shown to inhibit inflammatory marker following exercise (Nishizawa et al., 2011; Lee et al., 2010). Investigations of *L. chinensis* have focused on its biological activities, including its anti-cancerous hepto-protective, antioxidants, anti-platelet anti-viral, anti-mutagenic, anti-microbial anti-hyperlipidemic, antipyretic and anti-inflammatory Nutritional value of litchi fruit and seed has been shown in figure 2& 3. In this review we intend to provide a comprehensive insight in to botanical characterization, distribution, traditional uses, chemical composition and pharmacological activities of litchi, as well as the mechanism of action of bioactive compound and extract. This review aiming to provide knowledge to researchers for rapid identification of chemical constituents and pharmacological activities.



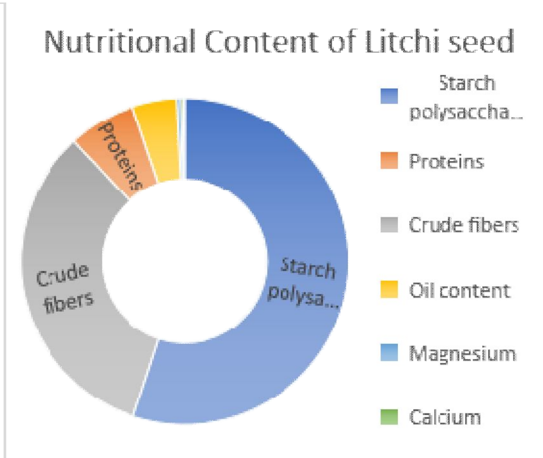


Figure 2&3: Nutritional content of litchi fruit and seed

Traditional uses of litchi in field of medicine

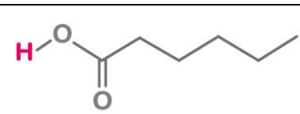
In traditional Chinese medicine (TCM), preparations made from litchi roots, bark, and flowers are utilized as a gargle to mitigate throat discomfort (Hassan et al.2021). Litchi seeds are recognized for their analgesic properties and are utilized to alleviate a spectrum of conditions, including neuralgic disorders, orchitis, hernia, lumbago, ulcers, and intestinal troubles (Chowdhury et al.2022). Moderate consumption of litchi fruit or its decoction is believed to alleviate coughing and provide relief for gastralgia, tumors, and gland enlargements (Vishwakarma et al. 2018). The fruit peel's tea is employed to alleviate smallpox eruptions and diarrhea (Chukwuma et al.2021), while litchi leaves are utilized for poultices to address skin ailments (Hossan et al. 2014). Moreover, litchi seeds macerated in alcohol are employed to treat intestinal complaints in Indo-China (Reza, 2017), while the Malays utilize root decoctions to treat fever, leaves for poulticing, and bark as an astringent for tongue diseases (DeFilipps & Krupnick, 2018). The fatty acids found in litchi seeds hold potential for various industries such as inks, cosmetics, detergents, and lubricants (Anwar et al. 2014), and the bark provides tannin or dyestuff (Srivastava et al.2018). Litchi, with its array of nutritious compounds including dietary fibers, vitamins, amino acids, trace elements, linoleic acid, and other unsaturated fatty acids, is considered a functional food (Roy et al.2023). Processed litchi products such as pickles, preserves, ice cream, yogurt, juice, and wine are popular in China, Taiwan, and Thailand (Shah et al.2011).

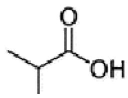
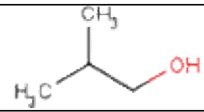
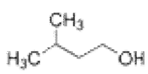
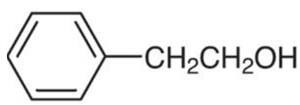
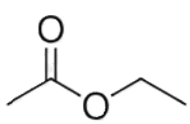
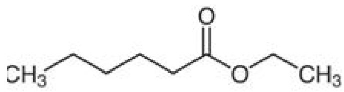
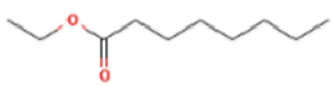
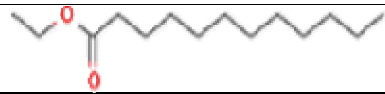
In traditional medicine across Asia and the Pacific, fruits, including litchi, have been utilized to address various health issues such as cough, diarrhea, stomach ulcers, diabetes, dyspepsia, and obesity, as well as to eliminate intestinal worms (Ramjane et al.2021). Litchi leaves and the fruit's astringent coat are employed to treat poisonous animal bites (Anjum et al.2017). Additionally, litchi fruit is reputed to possess diuretic, digestive, carminative, antifebrile, and tonic properties, and is used to alleviate neural pain, dysentery, and swelling (Upadhayaya &Upadhyaya2017). In TCM, litchi pericarp is described as having anti-tussive, analgesic, antipyretic, hemostatic, and diuretic properties (Reza, 2017). Litchi seeds are utilized in TCM to dispel cold and relieve pain, particularly for conditions such as premenstrual and postpartum abdominal pains (Zhang, 2021). Various traditional remedies include mixtures of litchi seeds, cumin, and peel to alleviate hernia or testicular swelling (Upadhyaya & Upadhyaya 2017). In clinical settings, litchi nuts have been formulated into medicinal tablets for treating diabetes, including gestational diabetes (Rahman, 2022). The flower infusion is consumed as a beverage for pleasure or refreshment in Taiwan, while in Vietnam, litchi is used to treat stomachache and pain in the small intestine. The fruit is also esteemed in Taiwan and Vietnam as a thirst-quenching tonic for the brain, heart, and liver (Chen, 2009). Litchi is utilized to promote wound healing (Zhao et al.2020). In India, tea made from powdered seeds is administered to alleviate intestinal troubles and relieve neuralgic pain and nerve inflammation due to its astringent properties (Mir et al.2022).

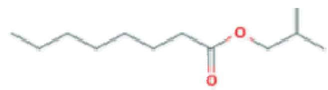
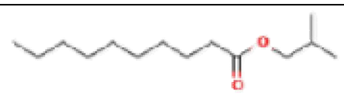
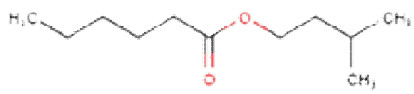
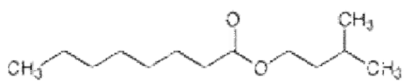
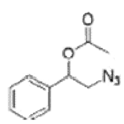
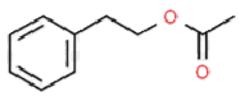
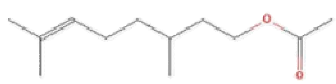
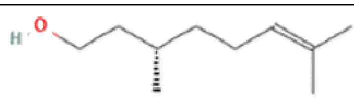
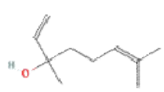
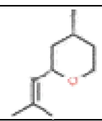
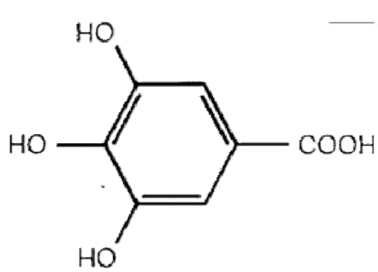
TABLE 2: Comparative overview of Different Literature

Study	Findings
Wu et al. (2009)	Detected 96 volatile components in 9 litchi cultivars, identifying 43. Common components include geraniol, cis-rose oxide, linalool, β-citronellol, etc. Components with highest OAVs: 1-octen-3-ol, cis-rose oxide, etc.
Mahattanatawee et al. (2007)	Found 51 Odor-active compounds in litchi fruit. 8 volatile sulphur components identified in all samples.
Chyau et al. (2003)	Identified 25 compounds in free and bound volatile fractions of litchi juice. Major compounds: acetoin, geraniol, etc. Aroma: free fraction - fresh-fruity; bound fraction - odourless.
GC-MS Analysis of Aroma (Various Studies)	Revealed over 100 components in litchi fruit pulp and leaves, including monoterpenes, sesquiterpenes, alcohols, etc.
Gaydou et al. (1993)	Reported fatty acid composition of litchi seed lipids, including palmitic acid, oleic acid, linoleic acid, and CPFAs. CPFA fraction: dihydrosterculic acid, cis-7-8-methylenehexadecanoic acid, etc.

TABLE 3: Major compounds of litchi

Compound	Structure	Properties	Part
Hexanoic acid		Fatty acid with a strong, unpleasant odor. Used in flavorings, fragrances, and as	Seed

		a precursor in synthesis.	
Octanoic acid		Medium-chain fatty acid with a rancid odor. Found in coconut oil and used in the production of esters.	Pericarp, Seed
Decanoic acid		Fatty acid with a fruity odor. Used in the production of esters for artificial flavoring.	Pericarp, Seed
Isobutyric acid		Carboxylic acid with a strong odor resembling that of cheese or vomit	Pericarp, Seed
Isobutyl alcohol		Colorless liquid with a fruity odor. Used as a solvent and in the production of esters	Pericarp, Seed
Active amyl alcohol		Clear liquid with a strong odor. Used in the production of perfumes and as a solvent.	Pericarp, Seed
Isoamyl alcohol		Colorless liquid with a strong, fruity odor. Used in flavorings and fragrances.	Pericarp, Seed
2-Phenylethyl alcohol		Colorless liquid with a floral aroma. Used in perfumery and as a flavoring agent.	Pericarp, Seed
1-Butanol		Clear liquid with a strong odor. Used as a solvent and in the production of chemicals	Pericarp, Seed
1-Octanol		Colorless liquid with a mild odor. Used in the production of esters and as a solvent.	Pericarp, Seed
Ethyl acetate		Colorless liquid with a fruity odor. Used as a solvent and in the production of paints and coatings.	Pericarp, Seed
Ethyl hexanoate		Colorless liquid with a fruity odor. Used in the production of artificial fruit flavors.	Pericarp, Seed
Ethyl octanoate		Colorless liquid with a fruity odor. Used in the production of artificial fruit flavors.	Pericarp, Seed
Ethyl decanoate		Liquid with a fruity odor. Used in the production of flavorings and as a solvent.	Pericarp, Seed
Ethyl dodecanoate		Liquid with a fruity odor. Used in the production of	Pericarp, Seed

		flavorings and as a solvent.	
Isobutyl octanoate		Liquid with a fruity odor. Used in the production of flavorings and as a solvent	Pericarp, Seed
Isobutyl decanoate			Pericarp, Seed
Isoamyl acetate		Liquid with a banana-like odor. Used as a flavoring agent and in the production of perfumes.	Pericarp, Seed
Isoamyl hexanoate		Liquid with a fruity odor. Used in the production of flavorings and as a solvent.	Pericarp, Seed
Isoamyl octanoate		Liquid with a fruity odor. Used in the production of flavorings and as a solvent.	Pericarp, Seed
Isoamyl decanoate		Liquid with a fruity odor. Used in the production of flavorings and as a solvent.	Pericarp, Seed
2-Phenylethyl acetate		Liquid with a floral aroma. Used in perfumery and as a flavoring agent.	Pericarp, Seed
Citronellyl acetate		Liquid with a floral, rose-like odor. Used in perfumery and as a flavoring agent	Pericarp, Seed
Citronellol		Liquid with a floral, rose-like odor. Used in perfumery and as a flavoring agent.	Pericarp, Seed
Linalool		Liquid with a floral aroma. Used in perfumery and as a flavoring agent.	Pericarp, Seed
Geraniol cis-Rose oxide		Liquid with a rose-like aroma. Used in perfumery and as a flavoring agent	Pericarp, Seed
Gallic acid		Exhibits strong antioxidant properties, scavenging free radicals and protecting cells from damage. May have anti-inflammatory effects, potentially reducing inflammation in the body, studied for potential anticancer properties, although further research is	Seed

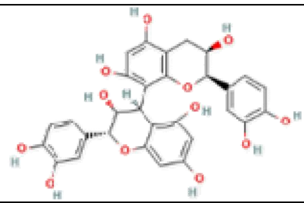
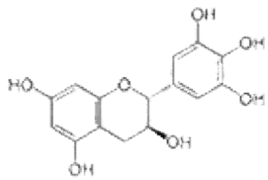
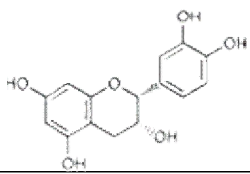
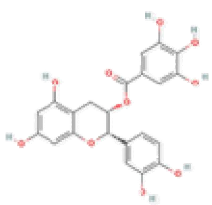
		needed for confirmation, Used in traditional medicine for its astringent and antimicrobial properties	
Procyanidin B_2		Exhibits antioxidant properties, associated with cardiovascular benefits, have anti-inflammatory effects	Seeds,Pulp
Gallocatechin		Possesses antioxidant properties, studied for potential cardiovascular benefits	Pericarp, Seed
Epicatechin		Known for antioxidant properties, studied for potential cardiovascular benefits, may have neuroprotective effects	Leaves, Pericarp, Pulp, Seed
Epicatechin-3-gallate		Exhibits antioxidant properties, Investigated for potential cardiovascular benefits	Seed

TABLE 4: Pharmacological Potentials of Litchi

Specific activity	**Cause**	**References**
Neuro-protection activity	Saponins inhibits the apoptosis in hippocampus of alzheimer's diseases	Wang et al.2017
Anti-cancer activity	Litchi seed extract is anti-proliferative	Chung et al.2017; hsu et al.2012; Guo et al.2017
Anti-microbial activity	Lectins in seed extracts are having bacterial antibiofilm having microbial agent	Bose et al. 2016
Anti-obesity/ anti-hyperlipidemic activity	Unsaturated fatty acids present in seed extract results in inhibition of pancreatic lipase and help in reducing obesity	Pirahanchi and Sharma, 2019
Anti-diabetic activity	Litchi seed extract A,B,C,D&E inhibit breakdown of glucose hence reduction on blood glucose level	Choi et al.2017

Hepato-protective effect	The hepatoprotective effect are the result of anti-lipid peroxidation	

Antioxidant Properties of Litchi Peel and Seeds

Reactive oxygen species (ROS) serve an important role in onset and progression of various severe illnesses, including neurodegenerative disorders, cardiovascular ailments, and cancer (Aggarwal et al.2019). Their detrimental effects on DNA can lead to somatic mutations and the development of organ malignancies. Notably, the copper and iron binding sites within cellular macromolecules serve as primary sites for ROS production. However, the generation of these free radicals can be mitigated by the chelation of metal ions through antioxidants like flavonoids, tannins, and phenolic acids (Sen et al.2010). Augmenting the body's endogenous antioxidant defenses or supplementing with exogenous antioxidants presents a promising approach to combat the detrimental effects of ROS-induced oxidative stress (Pizzino et al.2017). The market acceptance of natural antioxidants is considerable owing to their high safety profiles. Furthermore, Sun et al. (2010) conducted analyses on the reducing power and scavenging activities of DPPH, hydroxyl, and superoxide radicals, revealing that (-)-epicatechin demonstrated superior reducing power and radical-scavenging capabilities compared to procyanidin A2 and even vitamin C (used as a positive control). Meanwhile, Kong et al. (2010) evaluated the antioxidant activities of water-soluble polysaccharide fractions LFP1, LFP2, and LFP3 isolated from litchi pulp, with LFP3 exhibiting the most potent scavenging effect on superoxide and hydroxyl radicals, along with high reducing power. Moreover, litchi has immense antioxidant and radio-protective properties, demonstrating substantial protection to pBR322 plasmid DNA and *Escherichia coli* cells from gamma radiation-induced damage (Varjani & Patel, 2017). Furthermore, Mir & Parveen (2022) documented inhibitory effects on Cu^{2+} induced human LDL oxidation by epicatechin and procyanidin A2 obtained from litchi flower. Litchi peel and seed fractions, along with other fruits of similar family, boast high antioxidant activity, attributed to their rich content of polyphenols, flavonoids, and other phytochemicals (Punia et al. 2021). Dried litchipulp polysaccharide havegood antioxidant ability (Gao et al. 2017).These compounds offer various health benefits, including cardiovascular protection, anti-inflammatory effects, and potential anticancer properties. Litchi seed, a staple ingredient in traditional Chinese medicine, holds significance for relieving pain, and providing relief from polydipsia. Moreover, the high antioxidant activity in litchi peel and seeds is attributed to compounds like ascorbic acid and beta-carotene, underscores its health-promoting properties.

Inhibitory Effects on Adipogenesis, Lipid Oxidation and glycemia

There were significant improvements observed in non-insulin-dependent diabetes with the use of litchi seed anti-diabetic pills, benefiting 80% of the studied cases (Zhang and Teng, 1986). Litchi seed extract reduced blood sugar and liver glycogen levels in a rat model of non-insulin diabetes. (Li et al. 2018), this extract also inhibited α-glucosidase Ren et al. (2011). Shen et al. (2013) identified several compounds in litchi seeds with α-glucosidase inhibitory effects, with quercetin and phlorizin showing the strongest activity. Oligonal, is a compound found in litchi, improved insulin resistance and reduced body weight and abdominal fat in animal models (Chang et al. 2013).Qi et al. (2015) used litchi seed water extract to effectively inhibits adipogenesis and reduced lipid oxidation, useful for quality of meat products.Xu et al.(2011) reported utilization of discarded litchi seeds in Chinese medicine, helping in reducing epigastric and testicular pain.

Zhao et al. (2020) concluded that litchi pulp extracts enhanced glucose consumption in $HepG_2$ cells, particularly (-)-epicatechin. Wu et al. (2015) found that litchi pulp extracts inhibited α-glycosidase activity in a dose-dependent manner. Consuming a polyphenol-rich litchi-flower solution lowered serum and hepatic lipids in high-fat/cholesterol-fed hamsters (Chang et al. 2013; Yang et al. 2010).Queiroz et al. (2015) observed higher antioxidant activity of peel and seeds of litchi due to ascorbic acid and β-carotene.

Traditional uses of Litchi in Medicine

Litchi's traditional medicinal uses are documented in ancient texts like Ben Cao Gang Mu, include promoting body fluid production and improving overall vitality. Litchi skin and seeds have been utilized in traditional Chinese medicine to treat ailments such as dysentery, metrorrhagia, and epigastric pain (Sun et al. 2020)

Anti-inflammatory and Antiviral Properties of Litchi Seeds

Dong et al. (2019) suggest that methyl jasmonates in litchi seeds contribute to their anti-inflammatory activity, potentially serving as functional food ingredients. Moreover, litchi seeds exhibit anti-influenza virus and visceral obesity-reducing properties, expanding their therapeutic potential beyond traditional medicine.The liquid extract of *L. chinensis* seeds, as reported by Bhat and Al-daihan (2014), demonstrated moderate growth inhibition ofdifferent bacterial strains, including *Staphylococcusaureus*, *Streptococcuspyogenes*, *Bacillussubtilis*, *Escherichiacoli*, and *Pseudomonasaeruginosa*. Among these, inhibition against *S. pyogenes*was highest.

Furthermore, analysis of the EtOAc-soluble extract of litchi leaves by Upadhyaya & Upadhyaya(2017) revealed the presence of (-)-epicatechin, procyanidin A2, luteolin, and quercetin-3-O-rutinoside. Notably, luteolin exhibited robust antimicrobial activity against various pathogens, including *S. aureus*, *E. coli*, *S. dysenteriae*, *Salmonella*, and *B. thuringiensis*. However, epicatechin, procyanidin A2, and quercetin-3-O-rutinoside displayed comparatively weaker antimicrobial effects (Wen et al. 2014).

Potential Hypolipidemic and Hepatoprotective Effects

Hyperlipidemia poses a significant risk to human health, characterized by elevated levels of blood lipids.Oligonol, a compound found in litchi, may offer future hypolipidemic and weight-controlling benefits, particularly for overweight and obese individuals, as proposed by Bahijri *et al* (2017). Furthermore, litchi fruit pulp extract demonstrates hepatoprotective activity against toxins like carbon tetrachloride (CCl_4), along with anti-apoptosis and anti-lipid peroxidation effects, suggesting potential for liver health promotion.The hepato-protective effects of *L. chinensis* leaf extracts on paracetamol-induced liver damage in Wistar albino rats were investigated by Basu et al. (2012). Their study revealed that both $CHCl_3$ and MeOH extracts exhibited protective effects, with the MeOH extract being more effective than the $CHCl_3$ extract, comparable to the effects of silymarin. Additionally, Bhoopat et al. (2011) found that aqueous extracts of Gimjeng and Chakapat litchi fruit pulps demonstrated promising hepato-protective activities at doses of 100 and 500 mg/kg. These protective effects were attributed to their antioxidant and anti-apoptotic properties, suggesting their potential as therapeutic agents akin to silymarin.Alcohol consumption long-term and excessive inevitably results in different accumulation levels of fat, which is likely to develop into fatty liver, alcoholic hepatitis, and even liver cancer. Xiao et al. (2017) revealed the potential of Litchi pulp polyphenol extract (LPPE) in mitigating susceptibility to alcohol-induced liver diseases. LPPE displayed dual effects on mice with alcoholic hepatic disease, demonstrating both hepatic disease improvement and effective control when administered in a liquid diet containing 0.4 g/L LPPE and 4% w/v ethanol. The study suggested that the protective mechanisms of litchi polyphenols against hepatic diseases included attenuation of ethanol-induced oxidative stress, inhibition of ethanol-induced lipogenesis, and modulation of gut microbiota composition. In their study, Su et al. (2017) demonstrated that litchi pulp extract effectively mitigated dyslipidemia in mice subjected to a high-fat diet. This was evidenced by reductions in total cholesterol (TC), triglycerides (TG), and low-density lipoprotein-cholesterol (LDL-c), along with elevated levels of high-density lipoprotein-cholesterol (HDL-c). They proposed a potential molecular mechanism involving the downregulation of miR-33 and miR-122, which in turn modulates adenosine triphosphate-binding cassette transporter A1, carnitine palmitoyltransferase 1a, and fatty acid synthase. Additionally, the study highlighted the link between obesity-induced dyslipidemia and the heightened risk of various diseases.Pan et al. (2017) and Mhatre et al. (2019) reported SlimTrym, formulated with citrus polymethoxyflavones, green tea extract, and litchi pulp extract, emerges as a promising solution against dietary obesity and hepatic steatosis. This innovative blend targets pancreatic lipase, a key enzyme in lipid digestion, suggesting its potential effectiveness in combating obesity. Moreover, Mhatre et al. (2019) demonstrated the remarkable pancreatic lipase inhibitory activity of litchi seed protein isolated via 70% ammonium sulfate precipitation. By merging these findings, a synergistic approach leveraging the bioactive components of litchi offers a compelling strategy for addressing obesity-related health concerns.

Functional Food Applications and Safety Considerations

Litchi pericarp, identified by Zeng et al. (2019), presents an affordable and nutritious functional food ingredient. Additionally, the antioxidant properties of litchi, elucidated by Bhoopat et al. (2011), contribute to its hepatoprotective effects, presenting its multifaceted therapeutic potential.Recent research by Zeng et al. (2019) has identified litchi pericarp as an affordable and nutritious functional food ingredient. Furthermore, studies by Bhoopat et al. (2011) have highlighted the antioxidant properties of litchi, which contribute to its hepatoprotective effects, demonstrating its multifaceted therapeutic potential. Litchi seeds contain higher levels of uncommon fatty acids, such as dihydrosterculic acid and 2-hexyl-cyclopropanoic acid, which constitute a significant portion of their total fatty acid composition. These fatty acids are known for their reactivity within the human body, although the cyclopropene ring undergoes disintegration during refining and degradation processes, rendering the oil suitable for consumption. Additionally, litchi seeds exhibit varying concentrations of MCPG and hypoglycin A (HGA), crucial indicators of safety for consumption as a potential nutraceutical source. MCPG, an amino acid isolated from litchi kernels in 1962, is metabolized into Methylenecyclopropyl-formyl-CoA (MCPF-CoA), a toxic compound known for its hypoglycemic activity by disrupting fatty acid β-oxidation. However, the presence of these toxic amino acids in litchi seeds hinders direct consumption due to their ability to retard gluconeogenesis and fatty acid β-oxidation, leading to adverse effects. Studies have linked MCPG and HGA toxins to acute encephalopathy and gastrointestinal complications in regions like India, Vietnam, and Bangladesh. Consumption of an excessive amount of litchi seed or aril can lead to toxicity in humans. Studies have estimated that the maximum tolerant dose (MTD) of hypoglycin A (HGA) for a rat weighing 230 g was 1.5 mg/kg, whereas for a human weighing 60 kg, it could be as low as 0.22 mg/kg. This suggests that ingestion of more than 13.2 mg of HGA may result in acute toxic encephalopathy. Therefore, the utilization of litchi seeds as a health ingredient necessitates careful consideration of their MCPG and HGA content, optimizing their inclusion in food or pharmaceutical formulations to ensure safety and efficacy.

Conclusion

Litchi stands not only as a fruit but as a botanical important plant with profound effectson human health and well-being. Through researches carried out we have uncovered medicinal properties embedded within its flesh, seeds, and peels. Studies have revealed litchi's antioxidant prowess, with compounds like gallic acid and procyanidin B2 showcasing remarkable abilities to combat oxidative stress and inflammation. Moreover, litchi's anti-diabetic potential, evidenced by its ability to regulate blood sugar levels and inhibit adipogenesis, holds promise for addressing metabolic disorders. Its anti-inflammatory and antiviral properties, particularly in litchi seeds, offer exciting avenues for combating infectious diseases and inflammatory conditions. Furthermore, litchi's hepatoprotective effects, as observed in various studies, suggest its potential as a therapeutic agent for liver ailments. Oligonol, a compound found in litchi, holds promise for controlling lipid levels and promoting weight management, offering hope for addressing obesity-related health concerns. On concluding these findings, it becomes evident that litchi represents more than just a fruit; it isa reservoir of bioactive compounds with therapeutic potential. Its integration as functional foods and pharmaceutical formulations could revolutionize preventive and therapeutic healthcare strategies. Moreover, litchi's rich antioxidant profile underscores its role in promoting longevity and mitigating age-related diseases. Looking ahead, further research into litchi's bioactive constituents, mechanisms of action, and clinical efficacy is warranted. Harnessing the full therapeutic potential of litchi requires interdisciplinary collaboration, innovative research methodologies, and a nuanced understanding of its biological properties. By unlocking the secrets of this botanical gem, we pave the way for novel therapeutic interventions and holistic approaches to health and wellness. In litchi, we find not only a delicious fruit but a source of inspiration and innovation with profound implications for human health.

Declaration

During the preparation of this work the author(s) used Grammarly in order to avoid grammatical errors. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

Conflict of Interest

The authors whose names are listed immediately below certify that they have NO affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

Disclaimer (Artificial intelligence)

Author(s) hereby declare that generative AI technologies such as Large Language Models, etc. have been used during the proof reading and grammatical editing of manuscript using Chat gpt.3.0

Details of the AI usage are given below:
1. chat gpt 3.0 for proof reading and grammatical mistakes.

Disclaimer (Artificial intelligence)

Option 1:

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

Option 2:

Author(s) hereby declare that generative AI technologies such as Large Language Models, etc. have been used during the writing or editing of manuscripts. This explanation will include the name, version, model, and source of the generative AI technology and as well as all input prompts provided to the generative AI technology

Details of the AI usage are given below:

1.

2.

3.

References

Aggarwal V, Tuli H S, Varol A, Thakral, F, Yerer, M. B, Sak, K & Sethi, G. (2019). Role of reactive oxygen species in cancer progression: molecular mechanisms and recent advancements. *Biomolecules*; **9**: 735.

Anjum J, Lone R and Wani K A. 2017. Lychee (*Litchichinensis*): Biochemistry, panacea, and nutritional value. *Lychee disease management*, 237-256.

Anwar F, Mahmood T, Mehmood T and Aladedunye F. 2014. Composition of fatty acids and tocopherols in cherry and lychee seed oils. *Journal: Journal Of Advances in Biology*; **5**.

Bahijri SM, Ajabnoor G, Hegazy GA, Alsheikh L, Moumena MA and Bashanfar BM. 2017. Supplementation with oligonol, prevents weight gain and improves lipid profile in overweight and obese Saudi females. Current Nutrition and Food Science. **13**:1-7.

Basu S, Haldar N, Bhattacharya S, Biswas S and Biswas M. 2012. Hepatoprotective activity of *Litchi chinensis* leaves against paracetamol-induced liver damage in rats. American;Eurasian Journal of Scientific Research. 7: 77-81.

Bhat RS and Al-daihan S. 2014. Antimicrobial activity of *Litchi chinensis* and *Nephelium lappaceum* aqueous seed extracts against some pathogenic bacterial strains. Journal of King Saud University-Science **26**: 79-82.

Bhat RS and Al-daihan S. 2014. Antimicrobial activity of *Litchichinensis* and *Nepheliumlappaceum* aqueous seed extracts against some pathogenic bacterial strains. Journal of King Saud University-Science **26**: 79-82

Bhoopat L, Srichairatanakool S, Kanjanapothi D, Taesotikul T, Thananchai H and Bhoopat T. 2017. Hepatoprotective effects of lychee (*Litchi chinensis* Sonn.): A combination of antioxidant and anti-apoptotic activities. *Journal of Ethnopharmacology*. **136:** 55-66.

Bose PP, Bhattacharjee S, Singha S, Mandal S, Mondal G and Gupta P. 2016. A glucose/mannose binding lectin from litchi (*Litchi chine*nsis) seeds: Biochemical and biophysical characterizations. *Biochemistry and Biophysics Reports*. **6**: 242–252.

Chang Y, Yang D, Chiu C, Lin Y, Chen J and Chen Y. 2013. Antioxidative and anti-inflammatory effects of polyphenol-rich litchi (*Litchi chinensis* Sonn.)-flower-water extract on livers of high-fat-diet fed hamsters. Journal of Functional Foods. **5:** 44-52

Chen TM. 2009. *A tradition of soup: flavors from China's Pearl River Delta*. North Atlantic Books.

Chen YB, Wu KS, Gu Y, Chen JZ. 2007. Research progress in the chemical constituents and pharmacological effects of lychee seeds. Chinese Journal of Infection Traditional Chinese medicine **14**: 97-98.

Choi SA, Lee JE, Kyung MJ, Youn JH, Oh JB and Whang WK. 2017. Anti-diabetic functional food with wasted litchi seed and standard of quality control. *Applied Biological Chemistry***60**: 197–204.

Chowdhury MA, K A A, Bari MS, Ataul MFKMM, Haque HMA.2022. Hepatoprotective potential of selected medicinally important herbs: evidence from ethnomedicinal, toxicological and pharmacological evaluations.

Chukwuma CI, Izu GO, Chukwuma MS, Samson MS, Makhafola TJ, Erukainure OL. 2021. A review on the medicinal potential, toxicology, and phytochemistry of litchi fruit peel and seed. *Journal of Food Biochemistry*. **45**: 13997.

Chung YC, Chen CH, Tsai YT, Lin CC, Chou JC, Kao TY Hsu CP. (2017) Litchi seed extract inhibits epidermal growth factor receptor signalling and growth of two non-small cell lung carcinoma cells. *BMC Complementary and Alternative Medicine*. **17**:16.

Chyau CC, Ko PT, Chang CH, Mau JL. (2003) Free and glycosidically bound aroma compounds in lychee (*Litchi chinensis* Sonn.). *Food Chemistry***80**:387-392.

DeFilipps RA, Krupnick GA. (2018) The medicinal plants of Myanmar. *PhytoKeys***102**: 1.

Dong X, Huang Y, Wang Y, He X. (2019) Anti-inflammatory and antioxidant jasmonates and flavonoids from lychee seeds. *Journal of Functional Foods*. **54**:74-80.

Gaydou EM, Ralaimanarivo A, Bianchini JP. 1993. Cyclopropanoic fatty acids of litchi (L*itchi chi*nensis) seed oil. A reinvestigation. Journal of Agricultural and Food Chemistry **41**: 886-890.

Goto YB. 1993. Lychee and its processing, pacific Region Food conference **1**: 15-23

Guo C, Yang J, Wei J, Li Y, Xu J, Jiang Y. 2003. Antioxidant activities of peel, pulp and seed fractions of common fruits as determined by FRAP assay. *Nutrition Research*.**23**:1719-26

Guo H, Luo H, Yuan H, Xia Y, Shu P, Huang X, Zhang J. 2017. Litchi seed extracts diminish prostate cancer progression via induction of apoptosis and attenuation of EMT through Akt/GSK-3beta signalling. *Scientific Reports*. 7

Guo H, Luo H, Yuan H, Xia Y, Shu P, Huang X. 2017. Litchi seed extracts diminish prostate cancer progression via induction of apoptosis and attenuation of EMT through Akt/GSK-3beta signalling. *Scientific Reports*,**7**: 41656.

Hassan, L, Muhammad AS, Mohammad E. 2021. "Herbal Remedies Effective against COVID-19." *Coronavirus Disease-19 (COVID-19): A Perspective of New Scenario,* 219.

Hayes WB. 1954. Fruit Growing in India, Kitabistan, Allahabad; pp. 180-6

Indu M. 2017. “Litchi – The Queen of Fruits.” IOSR Journal of Humanities and Social Science (IOSR-JHSS), **8**: 21–25

Kang SW, Hahn S, Kim JK, Yang SM, Park BJ and Chul Lee S. 2012. Oligomerized lychee fruit extract (OLFE) and a mixture of vitamin C and vitamin E for endurance capacity in a double blind randomized controlled trial. Journal of Clinical Biochemistry and Nutrition 50:106-113.

Kong F, Zhang M, Kuang R, Yu S, Chi J and Wei Z. 2010. Antioxidant activities of different fractions of polysaccharide purified from pulp tissue of litchi (*Litchichinensis* Sonn.). *Carbohydrate Polymers*. **81**:612-616.

Li X, Wu Q, Sui Y, Li S, Xie B, Sun, Z.2018. Dietary supplementation of A-type procyanidins from litchi pericarp improves glucose homeostasis by modulating mTOR signalling and oxidative stress in diabetic ICR mice. *Journal of functional foods*; **44**:155-165.

Li, JG, 2008. The Litchi. Beijing: China: China Agricultural Press.

Mahattanatawee K, Perez-Cacho PR, Davenport T, Rouseff R. 2007. Comparison of three lychee cultivar odor profiles using gas chromatography-olfactometry and gas chromatography-sulfur detection. *Journal of Agricultural and Food Chemistry* 55: 1939-1944

Mhatre SV, Bhagit AA, Yadav RP.2019. Proteinaceous pancreatic lipase inhibitor from the seed of *litchichinensis*. *Food Technology and Biotechnology* 57: 113–118.

Mir H, Perveen N. 2022 Phyto-chemistry and therapeutic potential of litchi (*Litchi chinensis* Sonn.): An age-old ingredient in traditional medicine. *Indian Journal of Traditional Knowledge (IJTK) 21*: 29-39

Naik KC. 1949. South Indian Fruits and Their culture. P. Varadachary and company, Madras.

Ogasawara J, Kitadate K, Nishioka H, Fujii H, Sakurai T, Kizaki T, Izawa T, Ishida H, Ohno H. 2009. Oligonol, a new lychee fruit-derived lowmolecular form of polyphenol, enhances lipolysis in primary rat adipocytes through activation of the ERK1/2 pathway. Phytotherapy Research **23**: 1626-1633.

Pan MH, Yang G, Li S, Li MY, Tsai ML, Wu JC and Lai CS. 2017. Combination of citrus polymethoxyflavones, green tea polyphenols, and Lychee extracts suppresses obesity and hepatic steatosis in high-fat diet induced obese mice. *Molecular Nutrition & Food Research*. 6

Pirahanchi Y and Sharma S. 2019. Biochemistry, lipase. https://www.ncbi.nlm.nih.gov/books

Pizzino G, Irrera N, Cucinotta M, Pallio G, Mannino F, Arcoraci V, Bitto A. 2017. Oxidative stress: harms and benefits for human health. *Oxidative medicine and cellular longevity*.

Punia S and Kumar M. 2021 Litchi (*Litchi ch*inenis) seed: Nutritional profile, bioactivities, and its industrial applications. *Trends in Food Science & Technology*. **108**: 58-70.

Qi S, Huang H, Huang J, Wang Q and Wei Q. 2015. Lychee (*Litchichinensis* Sonn.) seed water extract as potential antioxidant and anti-obese natural additive in meat products. Food Control. **50**:195-201.

Queiroz EDR, Abreu CMPD, Oliveira KDS, Ramos VDO and Fraguas RM 2015. Bioactive phytochemicals and antioxidant activity in fresh and dried lychee fractions. *RevistaCiencia* Agronomica. **46**:163-9.

Rahman MM, Dhar PS, Anika F, Ahmed L, Islam MR, Sultana NA and Rauf A. 2022. Exploring the plant-derived bioactive substances as antidiabetic agent: an extensive review. *Biomedicine & Pharmacotherapy*. **152**: 113217.

Ramjane H, Bahorun T, Ramasawmy B, Ramful-Baboolall D, Boodia N, Aruoma OI and Neergheen, VS. 2021. Exploration of the potential of terrestrial and marine biodiversity for the development of local nutraceutical products: a case for mauritius. *American Journal of Biopharmacy and Pharmaceutical Sciences*, ***1***.

Reza HM. 2017. *Department of Pharmaceutical Sciences* (Doctoral dissertation, North South University).

Roy S, Sarkar T, Upadhye VJ and Chakraborty R. 2023. Comprehensive Review on Fruit Seeds: Nutritional, Phytochemical, Nanotechnology, Toxicity, Food Biochemistry, and Biotechnology Perspective. *Applied Biochemistry and Biotechnology*.**1**: 172.

Sakurai T, Nishioka H, Fujii H, Nakano N, Kizaki T, Radak Z, Izawa T, Haga S and Ohno H. 2008. Antioxidative effects of a new Lychee fruit-derived polyphenol mixture, Oligonol, converted into a low-molecular form in adipocytes. *Bioscience, Biotechnology, and Biochemistry*.**72:** 463-476.

Sen S, Chakraborty R, Sridhar C, Reddy YSR and De B.2010. Free radicals, antioxidants, diseases and phytomedicines: current status and future prospect. *International Journal of Pharmacological Science Reviews and Research* **3**: 91-100.

Shah BN, Seth AK and Modi DC. 2011. Fruit and fruit products as functional foods. *International Journal of Food Safety, Nutrition, Public Health and Technology*. **3**: 14.

Shen R, Duo-Duo X, Yang G, Yu-Ting M and Qi-Pin G. 2013. Flavonoids from Litchi (*Litchichinensis* Sonn.) seeds and their inhibitory activities on α-glucosidase. Chemical Research in Chinese Universities. **29**: 682-685

Singh LB and Singh UP. 1954. The Litchi, Superintendent Printing and Stationary, Uttar Pradesh, Allahabad.

Srivastava A, Priyanka M and Parmar MS. 2018. Eco-friendly dyeing of natural fabrics using discarded litchi fruit peel. *Fibre2Fashion*. 51; 58-65.

Su D, Zhang R, Hou F, Chi J, Huang F, Yan S, Zhang M. (2017). Lychee pulp phenolics ameliorate hepatic lipid accumulation by reducing miR-33 and miR-122 expression in mice fed a high-fat diet. *Food & Function*, **8**: 808–815.

Sun W, Shahrajabian MH, Shen H and Cheng Q. 2021. Lychee (*Litchi chinensis* Sonn.), the king of fruits, with both traditional and modern pharmacological health benefits. *Pharmacognosy Communications*; **11**, 22-25.

Upadhyaya DC and Upadhyaya CP. 2017. Bioactive compounds and medicinal importance of *Litchi ch*inensis. *The Lychee Biotechnology*,**333-361**.

Varjani SJ and Patel P. 2017. Isolation, Identification, and Pharmacological Activity of Phytochemicals Present in Litchi chinensis. *The Lychee Biotechnology*. 395-403.

Vishwakarma PK, Nimbolkar PK, Kumar S, Kanade NM and Chader S. 2018. Litchi: Queen of Fruit.

Wang X, Wu J, Yu C, Tang Y, Liu J, and Chen H. 2017. Lychee seed saponins improve cognitive function and prevent neuronal injury *via* inhibiting neuronal apoptosis in a rat model of Alzheimer's disease. *Nutrients*. **9**: 105.

Wen L, Wu D, Jiang Y, Prasad KN, Lin S, Jiang G, He J, Zhao M, Luo W and Yang B. 2014. Identification of flavonoids in litchi (*Litchichinensis* Sonn.) leaf and evaluation of anticancer activities. *Journal of Functional Foods*. **6**: 555-563

Wu Y, Pan Q, Qu W and Duan C. (2009) Comparison of volatile profiles of nine Litchi (L*itchi chinen*sis Sonn.) cultivars from Southern China. *Journal of Agricultural and Food Chemistry*. **57**: 9676-9681

Xiao J, Zhang R, Huang F, Liu L, Deng Y, Zhang M and Wei Z. 2017. The biphasic dose effect of lychee (Lit*chi chinensis* Sonn.) pulp phenolic extract on alcoholic liver disease in mice. *Food & Function*. **8**: 189–200.

Xu X, Xie H, Xu L and Wei X. 2011. A novel cyclopropyl-containing fatty acid glucoside from the seeds of *Litchichinensis*. *Fitoterapia***82**: 485-488

Xu X, Xie H, Hao J, Jiang Y, Wei X. 2011b. Flavonoid glycosides from the seeds of Litchi chinensis. Journal of Agricultural and Food Chemistry **59**: 1205-1209.

Yamanishi R,Yoshigai E, Okuyama T, Mori M, Murase H, Machida T, Okumura T and Nishizawa M. 2014. The Anti-inflammatory effects of flavanol-rich lychee fruit extract in rat hepatocytes. *PLoS ONE* 9: e93818.

Yang J, Zhu X, Zhang P, Wang Y, Xiao Y and Yang B 2020. Detection of toxic methylenecyclopropylglycine and hypoglycin A in litchi aril of three Chinese cultivars. *Food Chemistry*, **327**.

Zeng Q, Xu Z, Dai M, Cao X, Xiong X and He S. 2020. Effects of simulated digestion on the phenolic composition and antioxidant activity of different cultivars of lychee pericarp. *BMC Chemistry*.13:27

Zhang H and Teng Y. 1986 Effect of liren (semen litchi) antidiabetes pills in 45 cases of diabetes mellitus. *Journal of Traditional Chinese Medicine*. **6**: 277-278.

Zhang Y. 2021 Diet according to traditional chinese medicine for health and longevity. *Nutrition, Food and Diet in Ageing and Longevity*. 331-356.

Zhao L, Wang K, Wang K, Zhu J and Hu Z. 2020. Nutrient components, health benefits, and safety of litchi (*Litchichinensis* Sonn.): A review. *Comprehensive Reviews in Food Science and Food Safety*. **19**: 2139-2163.