

Review Article

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

Abstract

Litchi, known for its delicious taste, goes beyond being just a culinary treat and provides a wide range of medicinal benefits. mostly cultivated in warm climates across China, India, and beyond, its rich history intertwines with diverse cultural traditions. Beyond its tantalizing flavor, litchi unveils a tapestry of therapeutic wonders. 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 it's 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 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

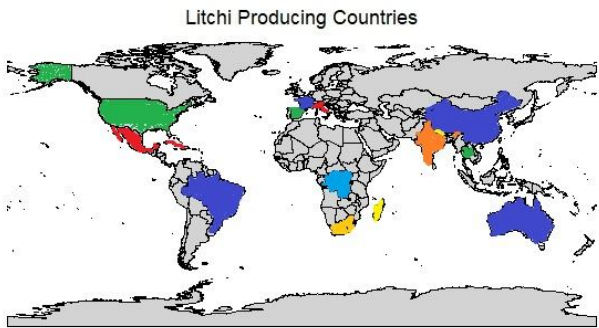
Litchi, scientifically known as *Litchichinensis* Sonn, is a delectable sub-tropical fruit cherished for its juicy, succulent flesh. Belonging to the Sapindaceae family and Nephrolea subfamily, it thrives in regions with warm climates. Litchi trees typically feature a sturdy, short trunk with bark ranging in color from brown to grey. 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.

List 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	<i>Litchi</i>
Species	<i>chinensis</i>

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 Bengal, its cultivation spread to various parts of India. Presently, litchi is cultivated in different parts of world as shown in figure 1. In India, 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-hyperlipidemic, 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 into lower molecular weight proanthocyanidins to improve their bioavailability (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 dietary 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, hepatoprotective, 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 into 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 aims to provide knowledge to researchers for rapid identification of chemical constituents and pharmacological activities.

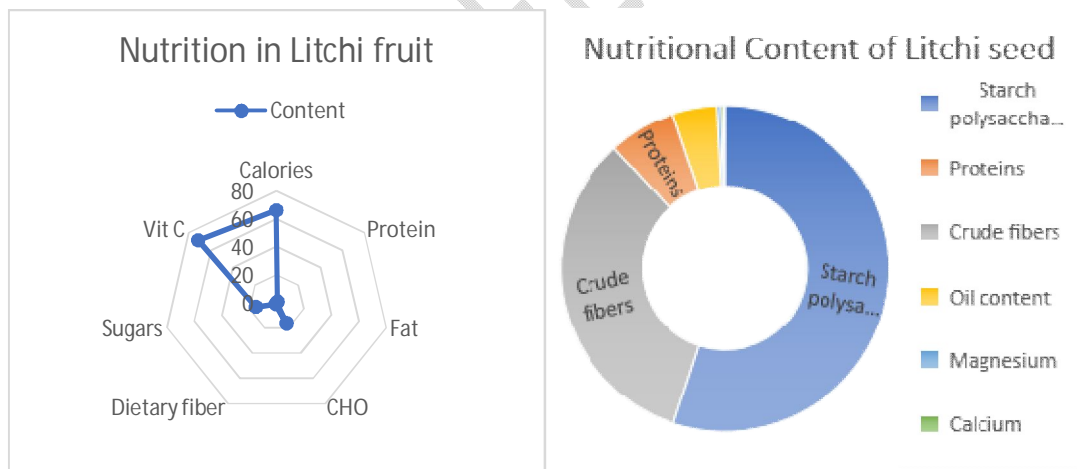


Figure 2&3: nutritional content of litchi fruit and seed

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 (Hossanet *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).

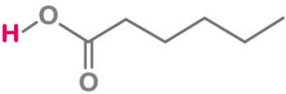

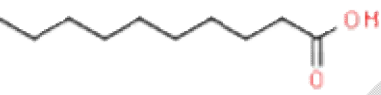
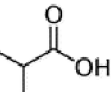
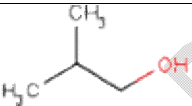

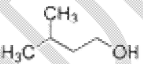
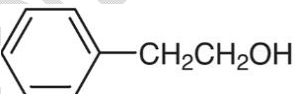


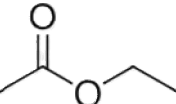
In traditional medicine across Asia and the Pacific, fruits, including litchi, have been utilized to address various health issues such as cough, diarrhea, stomach ulcers, diabetes, dyspepsia, and obesity, as well as to eliminate intestinal worms (Ramjane *et al.*, 2021). Litchi leaves and the fruit's 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 (Upadhyaya&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, a 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).

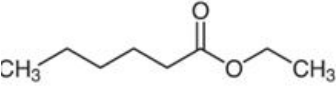



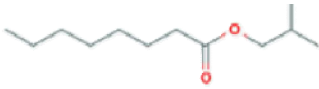
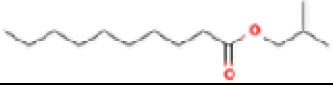

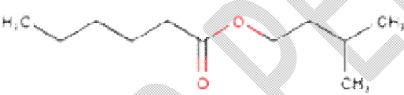

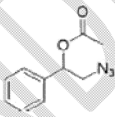
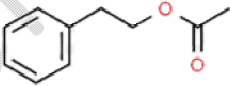
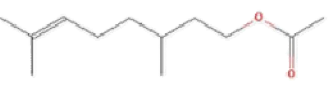
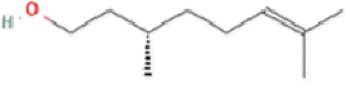

List 2 : Review of literature

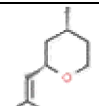
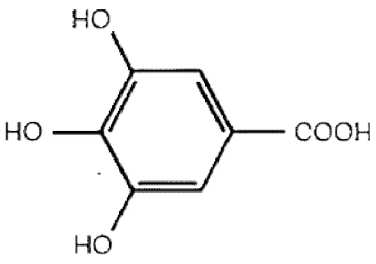
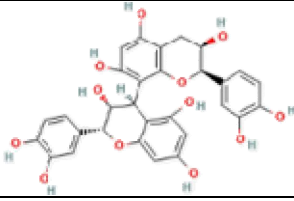
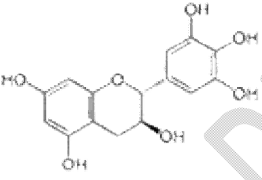
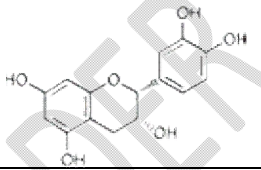
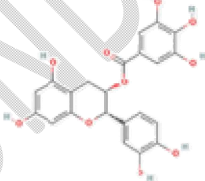
Study	Findings
Wu <i>et al.</i> (2009)	Detected 96 volatile components in 9 litchi cultivars, identifying 43. Common components include geraniol, cis-rose oxide, linalool, β -citronellol, etc. Components with highest OAVs: 1-octen-3-ol, cis-rose oxide, etc.
Mahattanatawee <i>et al.</i> (2007)	Found 51 Odor-active compounds in litchi fruit. 8 volatile sulphur components identified in all samples.
Chyau <i>et al.</i> (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.
Gaydouet <i>al.</i> (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.

List 3 :Major compounds of litchi

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

		coatings.	
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 flavorings and as a solvent.	Pericarp, Seed
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 needed for confirmation. Used in traditional medicine for its astringent and antimicrobial properties	Seed
Procyanidin B ₂		Exhibits antioxidant properties, associated with cardiovascular benefits, have anti-inflammatory effects	Seeds, Pulp
Galocatechin		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

List 4 :Pharmacological Potentials of Litchi		
Specific activity	Cause	References
Neuro-protection activity	Saponins inhibits the apoptosis in hippocampus of alzheimer's diseases	Wang <i>et al.</i> , 2017

Anti-cancer activity	Litchi seed extract is anti-proliferative	Chung <i>et al.</i> ,2017; hsuet <i>et al.</i> ,2012; Guo <i>et al.</i> ,2017
Anti-microbial activity	Lectins in seed extracts are having bacterial antibiofilm having microbial agent	Bose <i>et al.</i> , 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 <i>et al.</i> ,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 as pivotal contributors to the 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 Cu²⁺ 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 has got a good 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 in traditional Chinese medicine, holds significance for regulating Qi, relieving pain, and providing relief

from polydipsia. Moreover, the high antioxidant activity in litchi peel and seeds, 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. Oligonol, 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 HepG₂ 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 Medicinal Uses of Litchi

Litchi's traditional medicinal uses, 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 against different bacterial strains, including *Staphylococcus aureus*, *Streptococcus pyogenes*, *Bacillus subtilis*, *Escherichia coli*, and *Pseudomonas aeruginosa*. Among these, the highly effective inhibition was observed against *S. pyogenes*.

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 Bahijriet *et al.* (2017). Furthermore, litchi fruit pulp extract demonstrates hepatoprotective activity against toxins like carbon tetrachloride (CCl₄), 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 CHCl₃ and MeOH extracts exhibited protective effects, with the MeOH extract being more effective than the CHCl₃ 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. Insights from Pan *et al.* (2017) and Mhatre *et al.* (2019), SlimTym, 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, showcasing 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 implications for 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 is a reservoir of bioactive compounds with multifaceted therapeutic potential. Its integration into 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.

References

- Aggarwal V, Tuli H S, Varol A, Thakral, F, Yerer, M. B, Sak, K & Sethi, G. Role of reactive oxygen species in cancer progression: molecular mechanisms and recent advancements. *Biomolecules*, 2019; 9(11), 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, 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, Halder N, Bhattacharya S, Biswas S, 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, 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, R.S., 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
- Bhoopat L, Srichairatanakool S, Kanjanapothi D, Taesotikul T, Thananchai H, 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, Gupta P, (2016). A glucose/mannose binding lectin from litchi (*Litchi chinensis*) seeds: Biochemical and biophysical characterizations. *Biochemistry and Biophysics Reports*. 6, 242–252.
- Chang Y, Yang D, Chiu C, Lin Y, Chen J, 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, Y.B., Wu, K.S., Gu, Y., Chen, J.Z., 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, YounJH, OhJB 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, BariMS,AtaulMFKMM, Haque HMA.(2022). Hepatoprotective potential of selected medicinally important herbs: evidence from ethnomedicinal, toxicological and pharmacological evaluations.
- Chukwuma CI, Izu GO, ChukwumaMS, SamsonMS,MakhafolaTJ, Erukainure OL. (2021). A review on the medicinal potential, toxicology, and phytochemistry of litchi fruit peel and seed. *Journal of Food Biochemistry*.45: e13997.
- Chung YC, Chen CH, Tsai YT, LinCC, 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 (*Litchi chinensis*) seed oil. A reinvestigation. *Journal of Agricultural and Food Chemistry* 41, 886-890.
- Goto YB (1993). Lychee and its processing, pacific Region Food conference1: 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* 2021; 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, S.W., Hahn, S., Kim, J.K., Yang, S.M., Park, B.J., 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.
- KongF, ZhangM, Kuang R, YuS, Chi J, 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, J.G., 2008. The Litchi [in Chinese]. 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 litchi chinensis. *Food Technology and Biotechnology*, 2019; 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, 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, 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, Kumar M. (2021) Litchi (*Litchi chinensis*) seed: Nutritional profile, bioactivities, and its industrial applications. *Trends in Food Science & Technology*. 108, 58-70.
- Qi S, Huang H, Huang J, Wang Q, Wei Q. (2015). Lychee (*Litchi chinensis* 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, Fraguas RM (2015). Bioactive phytochemicals and antioxidant activity in fresh and dried lychee fractions. *Revista Ciencia Agronomica*. 46:163-9.
- Rahman MM, Dhar PS, Anika F, Ahmed L, Islam MR, Sultana NA, 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, 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, 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., 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, De B.(2010). Free radicals, antioxidants, diseases and phytomedicines: current status and future prospect. *Int J Pharm Sci Rev Res*, 3, 91-100.
- ShahBN, Seth AK, 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, YangG, Yu-Ting M, Qi-PinG. (2013). Flavonoids from Litchi (*Litchichinensis* Sonn.) seeds and their inhibitory activities on α -glucosidase. *Chemical Research in Chinese Universities*. 29, 682-685
- Singh LB, Singh UP. (1954). The Litchi, Superintendent Printing and Stationary, Uttar Pradesh, Allahabad.
- Srivastava A, Priyanka M, Parmar MS. (2018). Eco-friendly dyeing of natural fabrics using discarded litchi fruit peel. *Fibre2Fashion*.51, 58-65.
- SuD, ZhangR, HouF, ChiJ, HuangF, YanS, ZhangM. (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, Cheng Q. (2021). Lychee (*Litchi chinensis* Sonn.), the king of fruits, with both traditional and modern pharmacological health benefits. *Pharmacognosy Communications*, 2021; 11(1), 22-25.
- Upadhyaya DC, Upadhyaya CP. (2017). Bioactive compounds and medicinal importance of *Litchi chinensis*. *The Lychee Biotechnology* 2017; 333-361.
- VarjaniSJ, Patel P. (2017). Isolation, Identification, and Pharmacological Activity of Phytochemicals Present in Litchi chinensis. *The Lychee Biotechnology*. 395-403.
- Vishwakarma PK,Nimbolkar PK, KumarS,KanadeNM,Chader S. (2018). Litchi: Queen of Fruit.
- Wang X, Wu J, Yu C, Tang Y, Liu J, 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, 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, Duan C. (2009) Comparison of volatile profiles of nine Litchi (*Litchi chinensis* Sonn.) cultivars from Southern China. *Journal of Agricultural and Food Chemistry*. 57, 9676-9681
- Xiao J, Zhang R, Huang F, Liu L, Deng Y, Wei Z. (2017). Zhang, M. The biphasic dose effect of lychee (*Litchi chinensis* Sonn.) pulp phenolic extract on alcoholic liver disease in mice. *Food & Function*. 8, 189–200.
- Xu X, Xie H, Xu L, 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., 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, Yang B (2020). Detection of toxic methylenecyclopropylglycine and hypoglycin A in litchi aril of three Chinese cultivars. Food Chemistry, 2020; 327.
- Zeng Q, Xu Z, Dai M, Cao X, Xiong X, He S (2020). Effects of simulated digestion on the phenolic composition and antioxidant activity of different cultivars of lychee pericarp. BMC Chemistry. 13(1):27
- Zhang H, 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, Hu, Z. (2020). Nutrient components, health benefits, and safety of litchi (*Litchichinensis* Sonn.): A review. *Comprehensive Reviews in Food Science and Food Safety*. 19(4), 2139-2163.