Litchi chinensis Sonn. – The Queen of Fruits: A Comprehensive Review of its Origin, Distribution, Nutritional Value, Phytochemistry, Pharmacological Properties and Economic Importance

ABSTRACT:

Litchi chinensis Sonn., commonly called litchi or lychee, is cherished as the "Queen of Fruits" for its delectable taste, unique flavor, and attractive appearance. This subtropical evergreen tree belongs to the *Sapindaceae* family and produces small, juicy fruits that are rich in vitamins, minerals, and bioactive compounds. The pulp of the fruit is packed with polysaccharides, polyphenols, and anti-oxidants, which are crucial for fighting oxidative stress and associated health issues. While primarily grown in China, litchi has established a strong presence in India, particularly in the eastern regions, with Bihar being the leading producer. Litchi has specific climate and soil needs, which restrict its cultivation to a limited number of states. Despite its perishable nature, litchi's growing demand has led to the development of value-added products, enhancing its economic significance. In addition to its economic value, litchi has significant pharmacological benefits, with potential advantages in the prevention and management of various health concerns like inflammation, diabetes, and cancer. This review presents a comprehensive overview of litchi's origin, distribution, taxonomic classification, cultivation practices, nutritional value, functional properties, value-added products, various cultivars, traditional uses, phytochemistry, pharmacological properties, and economic importance. Despite the fruitful prospects, challenges remain regarding cultivation practices, including susceptibility to climatic conditions and soil requirements. Furthermore, it highlights the economic significance of litchi farming in India, particularly in Bihar, and stresses the necessity for additional research on its phytochemistry and pharmacological benefits to maximize its use in the food and pharmaceutical industries. Therefore, future initiatives should prioritize leveraging its medicinal properties while promoting sustainable agricultural practices that can adjust to changing climate conditions.

Keywords: *Litchi chinensis* Sonn., Cultivars, Anti-oxidants, Nutritional value, Functional properties, Traditional uses, Phytochemistry, Pharmacological properties, Economic importance.

1. INTRODUCTION:

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The evergreen, subtropical fruit tree known as the Litchi is frequently referred to as the "Queen of Fruits" and is a member of the *Sapindaceae* family. Litchi fruit is renowned for its high quality, delightful taste, and vibrant red hue. The edible section of litchi, known as the pulp, is a good source of nutrients such as polysaccharides, polyphenols, vitamins, and minerals claim Cabral, Cardoso and Pinheiro Sant'Ana (2014). Despite being usually discarded during processing as byproducts, studies have shown that the pericarp and seeds of litchi contain a large amount of bioactive substances, particularly polyphenols (Kessy, Hu, Zhao, and Zhou, 2016). It is a significant fruit with a range of pharmacological or medicinal properties. Several actions including analgesic, anti-oxidant, and effective against inflammation, diabetes, cancer, neurological pain, cardiovascular activity, etc. have been associated with litchi (Srivastava *et al.,* 2018).

Litchi is native of South China, but, according to Blume, Cochin-China and the Philippine islands are the lands of its origin (Popenoe, 1920). It is also reported to have originated in China's Kwangtung and Fukien provinces and have been cultivated in China for about 40 centuries (Ochse *et al.,* 1961). Litchi reached India through Burma and was first introduced in Bengal during the end of the 17^{th} century and then spread to other parts of the country. Litchi, which was introduced in the country in the 18^{th} century has adapted well to the climate in Eastern India, i.e. Bihar, Jharkhand, West Bengal, Tripura, Uttar Pradesh, Uttarakhand, Chhattisgarh, Punjab and Himachal Pradesh (Singh *et al.,* 2012). Presently, litchi is grown in Central and South America, parts of Africa and throughout Asia. China, India, South Africa, Australia, Mauritius, Madagascar and Thailand are now the major litchi-producing countries in the world (Koul and Singh, 2017).

Taxonomical Classification of Litchi:

Kingdom: Plantae

Order: Sapindales

Family: Sapindaceae

Subfamily: Sapindoideae

Genus: *Litchi*

Species: *chinensis*

Litchi is an evergreen plant that can grow up to 30 meters tall and has a thin, sturdy trunk. The complex, alternating leaves have two to five leaflets per leaf (Taak and Koul, 2016). The

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flowers develop on a terminal inflorescence featuring numerous panicles that emerge during the growth of the specific season. The panicles grow in clusters of 10 or more, reaching 10-40 cm or longer, holding hundreds of small white, yellow, or green flowers that are distinctively fragrant (Menzel, 2005). The fruits reach maturity in 80 to 112 days, influenced by the climate, region, and variety. The fruit comes in a wide variation depending on the variety. They might be heart-shaped, ovoid or spherical (Kilari and Putta, 2016). Large-seeded drupes with an edible, semi-transparent aril and thin, corky pericarp are the hallmarks of litchi fruits. Fruits that have aborted seeds are termed as "chicken tongue" and are preferred (Lake, 1988), since these fruits have a high flesh to seed ratio (Anonymous, 1991). These fruits typically have a higher price as they have more edible flesh (Figure 1).

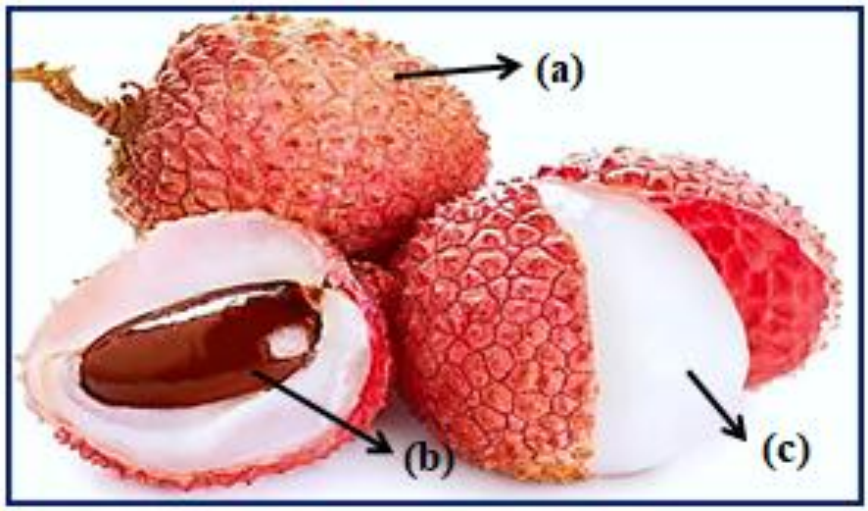

Figure 1. *Litchi chinensis* Sonn. (a) pericarp/peel (b) seed and (c) edible pulp of the fruit

Litchi cannot grow as widely as other fruit crops due to its particular climate and soil needs. Since, flower bud differentiation, flowering, fruit set, fruit quality and flavor development in Litchi is influenced significantly by temperature and humidity. It needs a warm subtropical climate, with brief dry winters that are frost-free and extended hot summers characterized by high rainfall and humidity (Mitra and Pathak, 2008). In litchi growing areas in India the temperature varies from 21º C to 37.8º C during flowering and fruiting. It has been noted that the initiation of flowers in litchi occurs at relatively lower temperatures. Fluctuations in temperature throughout the seasons are beneficial for optimal fruiting. A dry climate, free from rains for about two months before flowering induces flower bud differentiation, blossom and consequently give high production. In India, litchi is grown successfully on a wide range of soil types, which include sandy loams, laterite, alluvial sand, and calcareous

soil, but the best litchi orchards are seen in alluvial sandy loam soils with good drainage and access to the water table (Singh and Babita, 2002). The pH of soils in North Bihar ranges from 7.5 to 8, while in Jharkhand litchi grows well at a pH of 6 to 6.5. It grows well even in calcareous soil with 30 % free lime content. However, in acidic soil of Jharkhand mycorrhizal activity is minimal which affects fruit yield and quality (Pandey and Misra, 1975). The taxonomy, morphology and mycotrophic habit of mycorrhiza association with litchi was described by Pandey and Misra (1975) and their work also confirmed that litchi requires mycorrhiza to grow and produce better quality of fruits. As a result, it's frequently recommended that new orchards be established using soil from existing orchards.

India produces 91 percent of the world's litchis, ranking second only to China in terms of production (Anonymous, 2011). In India, the annual production of litchis reaches 568,200 metric tons across an area of 93,300 hectares (Anonymous, 2018). Litchi ranks 10th in terms of area, 11th in terms of production and 6th in terms of value among fruit crops in India. Bihar, West Bengal, Uttar Pradesh, Jharkhand and Uttarakhand are the principal litchi producing states in India. For the people of Bihar, litchi farming is a significant source of income because the state generates 73.38 percent of the nation's total litchi and about 40 percent of the land is cultivated. Millions of people rely on it for their survival since it creates jobs both on and off farms. Litchi is mostly farmed in North Bihar districts such as Muzaffarpur (also known as the Litchi Capital of India), Vaishali, Samastipur, Sitamarhi, Darbhanga, West Champaran and East Champaran (Kumar *et al.*, 2022). In India, prominent cultivars include Shahi, China, Rose Scented, Early Bedana, Late Bedana, Ajhauli, Bombai, Dehradun, Gulabi, Ellaichi, Kasba and others. Shahi and China are two prominent types of Indian litchi cultivated in Bihar. Due to its exquisite flavor and taste, "Shahi Litchi" is the best kind of Indian Litchi. It is generally known as "Muzaffarpur Litchi" since it thrives within a 50-kilometer radius (Mehta, 2017). Due to its strong demand in urban areas and international markets, "Shahi litchi" is the fourth agricultural product to acquire GI (Geographical Indications) certification from Bihar in 2018.

The main aim of this review is to provide up-to-date information on the origin, taxonomical classification, distribution in India and globally, nutritional values, functional properties, value-added products, production in India, traditional uses, economic importance and chemical constituents, as well as the pharmacological activities of *Litchi chinensis* Sonn.

2. NUTRITIONAL VALUE OF LITCHI:

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Litchi is a non-climacteric fruit; its quality does not increase after harvesting and must mature on the tree. It is a fruit with sweet, transparent and juicy flesh. The nutritional value of litchi fruit is primarily derived from its sugar levels, which vary according to the different varieties. Depending on the variety and the climatic conditions, litchi consists of 60% juice, 19% seed, 13% skin, and 8% rag (Nath *et al.,* 2016). Litchi is a very good source of minerals, several vitamins and healthy anti-oxidant which helps in protection from harmful free radicals. In addition to proteins, fats, carbohydrates, minerals, dietary fibre, calcium, phosphorus, iron, and carotene, the fruit also contains significant amounts of vitamin B1, riboflavin, and vitamin C. Litchi have low content of sodium and saturated fat (Taak and Koul, 2016). The nutritive values of litchi fruit per 100 g are shown in Table 1.

Table 1. Nutritive value of aril of litchi fruit per 100 g

Constituents	Fresh aril (per 100 g)	Dried aril
Calories	63-64	277
Moisture	81-85 %	17.99-22.3 %
Protein	0.68-1.0 g	2.9-3.8 g
Fat	0.30-0.58 g	0.2-1.2 g
Carbohydrate	13.31-16.40 g	70.7-77.5 g
Fibre	0.23-0.40 g	1.4 g
Ash	0.37-0.50 g	1.5-2 g
Calcium	8-10 mg	33 mg
Phosphorus	30-42 mg	-
Iron	0.40 mg	1.7 mg
Sodium	3 mg	3 mg
Potassium	170 mg	1100 mg
Thiamine	28 mg	-
Nicotinic acid	0.40 mg	-
Riboflavin	0.05 mg	0.05
TSS (ºBrix)	18-22	NA
Ascorbic acid	24-60 mg	42 mg

Source: Sahni *et al.*, 2020

3. FUNCTIONAL PROPERTIES OF LITCHI:

As per the Food and Agriculture Organization of the United Nations (FAO), functional food is described as a source that supplies the human body with adequate levels of essential nutrients, including proteins, carbohydrates, fats, vitamins, and minerals, to sustain health. According to the European Food Safety Authority (EFSA), a food item can

be considered benefcial if it provides benefits beyond basic nutritional content, such as improving health and well-being, and reducing the risk of disease. A functional food can be defined as one that not only has a specific nutritional profile but also includes bioactive compounds that enhance the body's functions, offering health advantages and aiding in the management or prevention of diseases (Sheikha, 2022). Therefore, in recent years, great attention has been paid to functional foods, which have additional functions related to health promotion or disease prevention (Castillo-Olvera *et al.*, 2025).

In this context, litchi fruit is currently a potential functional food because of its nutraceutical properties, chemical composition, and biological activities, such as antioxidant, anti-infammatory, antimicrobial, and anti-carcinogenic activities. Not only the edible part of the fruit, the pulp, which contains bioactive compounds that exert biological activities but also the pericarp and seed are enriched with potentially benefcial properties (Emanuele *et al.*, 2017). It has been documented that the pericarps of litchi have been utilized in traditional medicine for their hemostatic and pain-relieving properties since ancient times. Consequently, a high concentration of bioactive compounds can help in preventing certain illnesses.

Conversely, litchi seeds, often regarded as waste materials, are abundant in starch. As a result, there has been growing interest in litchi seeds due to their distinct functional and structural characteristics, which stem from their low amylose and high amylopectin levels. The starch present in the seeds exhibits a greater pasting viscosity compared to other starches like those from mango seeds or logans, making them suitable for controlled drug release (Morales-Trejo *et al.*, 2022).

4. VALUE-ADDED PRODUCTS OF LITCHI:

Litchi is a fruit that spoils quickly, and various value-added products are created from it. Litchi squash is a concentrated beverage made from litchi pulp that is rich in flavor. Litchi nut, which is dried litchi fruit, is a very popular product in China. Additionally, other items such as dehydrated litchi pulp, canned litchi, wine, juice, pickles, jelly, ice-cream, and preserves are made from the litchi fruit. (Sahni *et al.*, 2020) (Figure 2).

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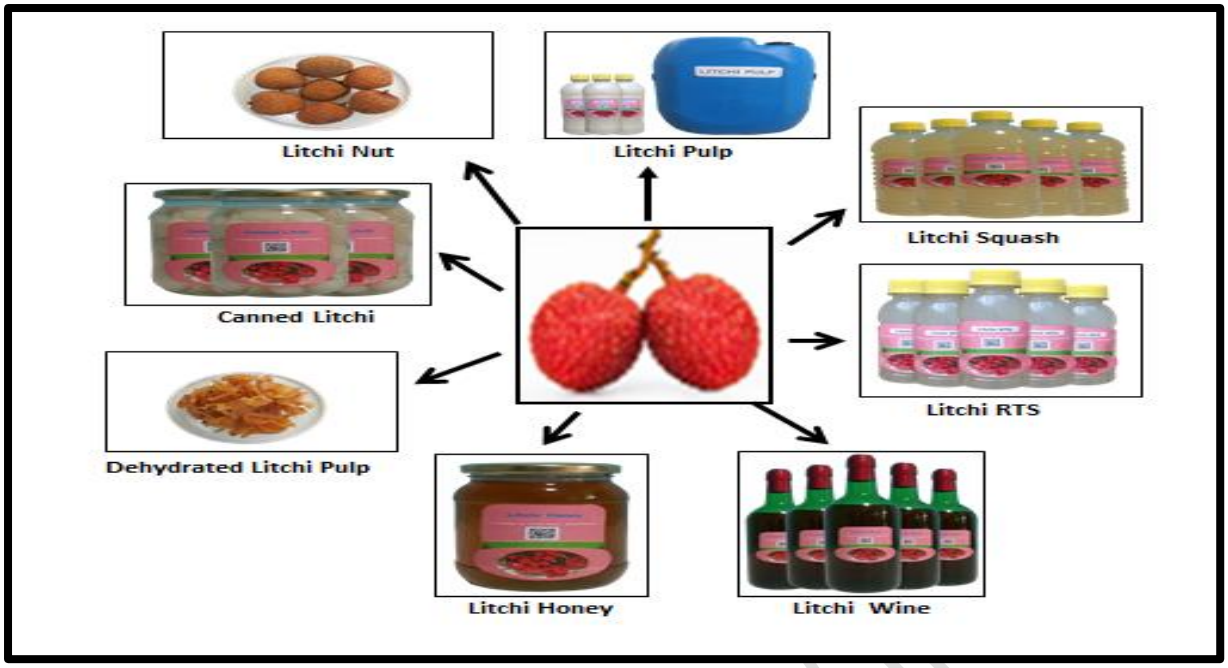

Figure 2. Value added products of litchi

5. TRENDS OF AREA AND PRODUCTION OF LITCHI:

In India, the area and production of litchi have seen considerable growth over the past thirty years. The trend reveals that the area under litchi cultivation is expanding every year from 49,300 hectares in 1991-92 to 97,900 hectares in 2020-21 (Table 2). Total production of litchi also boosted from 243,800 to 720,100 metric tons in the same time period. However, the productivity of litchi is stagnant about 7.4 t ha-1.

Table 2. All India Area, Production and Productivity of Litchi

Year	Area (in '000 Ha)	Production (in '000 MT)	Productivity (in MT/Ha)
1991-92	49.3	243.8	4.9
2001-02	58.1	355.9	6.1
2002-03	54.1	476.4	8.8
2003-04	53.7	478.5	8.9
2004-05	60	368.6	6.1
2005-06	63.2	392.1	6.2
2006-07	65	403	6.2
2007-08	69	418	6.1
2008-09	72	423	5.9
2009-10	74.4	483	6.5
2010-11	78	497	6.4
2011-12	80.4	538.1	6.7
2012-13	82.7	580.1	7
2013-14	84.2	585.3	7
2014-15	85	528.3	6.2

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2015-16	90.1	558.8	6.2
2016-17	93.3	568.2	6.1
2017-18	92.3	686.4	7.4
2018-19	95.5	721.4	7.6
2019-20	96.6	726.2	7.5
2020-21	97.9	720.1	7.4

Source: Horticultural Statistics at a Glance 2021

6. STATE-WISE PRODUCTION OF LITCHI:

In FY 2022-23, Bihar was the leading producer of litchis with 308.77 thousand tonnes followed by West Bengal and Jharkhand at 81.59 thousand tonnes and 65.90 thousand tonnes respectively (Table 3).

Table 3. State-wise production of litchi

India's Litchi Production State-wise in FY 2022-2023		
State	**Production in tonnes (000 tonnes)**	**Share (%)**
Bihar	308.77	41.39
West Bengal	81.59	10.94
Jharkhand	65.90	8.83
Punjab	62.44	8.37
Assam	60.93	8.17
Chhattisgarh	59.55	7.98
Uttar Pradesh	41.65	5.58
Odisha	24.23	3.25
Uttarakhand	19.07	2.56
Himachal Pradesh	6.18	0.83
Haryana	3.52	0.47
Nagaland	3.39	0.45
Tripura	3.14	0.42

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Jammu and Kashmir	2.33	0.31
Mizoram	1.85	0.25
Sikkim	0.95	0.13
Manipur	0.32	0.04
Karnataka	0.12	0.02
Arunachal Pradesh	0.09	0.01
Kerala	0.00	0.00
Grand Total	**746.02**	

Source: APEDA (AgriExchange)

7. LITCHI DISTRIBUTION IN THE WORLD:

Many litchi cultivars are known in various parts of the world, including 26 major and 40 minor cultivars identified in Guangdong, China, 33 cultivars in India and numerous local selections in Australia, Florida, Taiwan, Thailand and Hawaii (Table 4). Because, litchi is one of the most environmentally sensitive fruit trees, improper selection of cultivars can result in erratic or no fruit production (Singh *et al.*, 2012).

Table 4. Major litchi cultivars grown in different countries

Country	Major Cultivars
China	Sum Yee Hong, Baitangying, Fay Zee Siu, No Mai Chee, Bah Lup, Souey Tung, Kwai May Red
Vietnam	Vaithieu
Thailand	Tai So (Hong Huay), Chacapat (Chakrapad), Wai Chee (Kim Cheng), Haak Yip (O-Hia), Kom
India	Shahi, China, Bombai, Rose Scented, Bedana, Calcuttia, Longia
Nepal	Mujafpuri, Raja Saheb, Dehradun, Calcuttia, China
Bangladesh	Bombai, Muzaffarpur, Bedana, China 3
Indonesia	Local Selections

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Philippines	Sinco, Tai So, UPLB Red
South Africa	Mauritius, McLean's Red
Israel	Mauritius, Floridian
Madagascar, Mauritius and Reunion	Mauritius
Florida, USA	Mauritius, Brewster
Brazil	Bengal

Source: Singh *et al.*, 2012

8. LITCHI DISTRIBUTION IN INDIA:

Litchi is cultivated on a commercial scale in the eastern regions of India, including Bihar, West Bengal, Jharkhand, Uttarakhand, and Uttar Pradesh. The crop is also gaining popularity in Punjab, Himachal Pradesh, Jammu and Kashmir, Arunachal Pradesh, Tripura, Karnataka and Tamil Nadu because of its high profitability and better export potential (Pandey and Sharma, 1989; Cebeco, 2001). The major litchi growing states of the country and the variety cultivated are shown in Figure 3.

Litchi varieties cultivated in the country are highly variable due to different climatic and soil conditions (Singh and Babita, 2002). Cv. Shahi is regarded as the most popular and finest variety of Indian litchi due to its exquisite aroma and flavor. Cv. China ranks as the second most favoured variety of litchi. Other significant varieties include Rose scented, Bombai, Elaichi, Dehradun, Bedana, Late Large Red, Late Seedless, Calcuttia, and Purbi (Sahni *et al.*, 2020). In West Bengal, research by Ghosh *et al.*, (2000) indicated that cv. Bombai is the predominant commercial variety, while cv. Bedana is recognized for its superior quality, characterized by high pulp recovery and shrivelled seeds. Cv. Early Large Red is the earliest maturing variety, becoming ripe in the first week of May. In Tripura, Das (2013) investigated the climatic conditions of the state concerning the number of fruits per plant, time of maturity, bearing habits, and quality characteristics of litchi crops. Cv. Shahi, cv. Swarna Roopa, cv. Muzaffarpur, cv. Late Bedana and cv. Bombai was found excellent in performance. Nonetheless, cv. Shahi excelled in all aspects, including flavor, taste, aroma, and other quality factors, and enjoys significant market demand.

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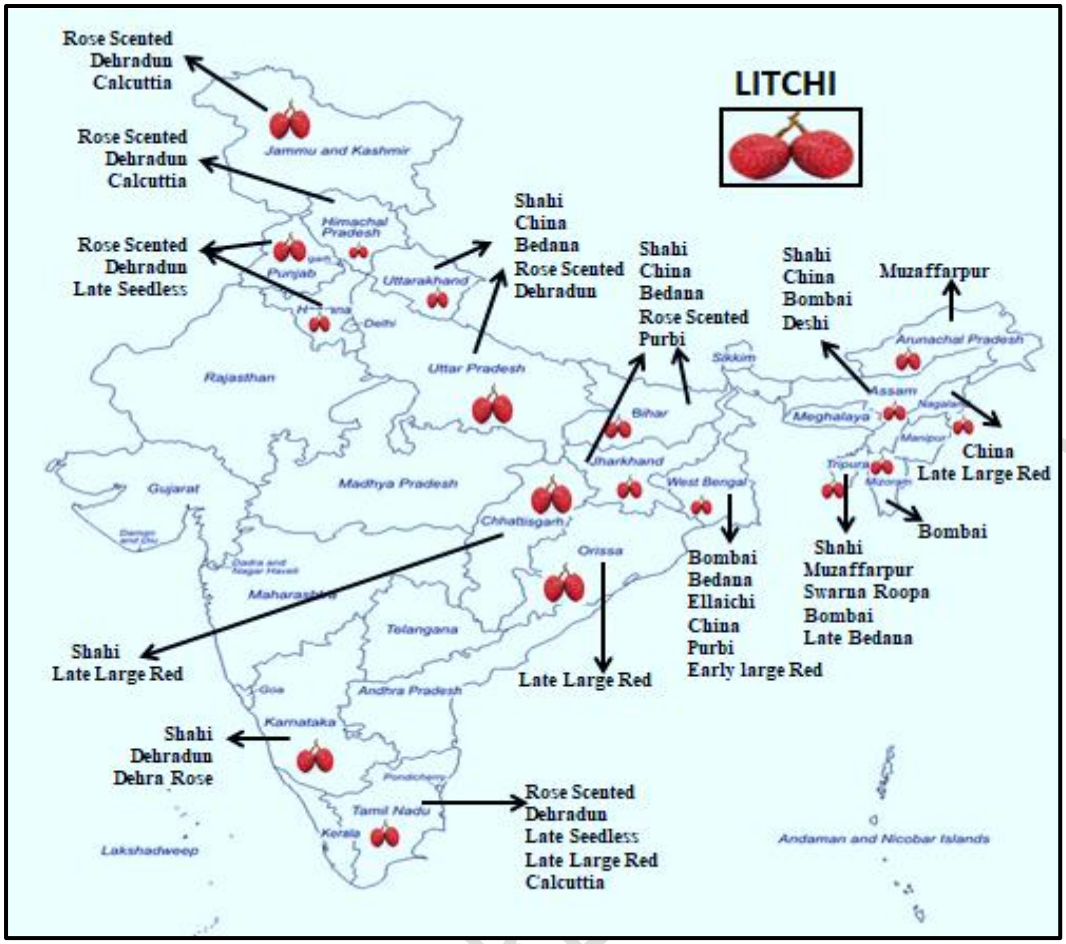

Figure 3. Map showing major litchi producing states of India and the variety cultivated

9. LITCHI VARIETIES:

India cultivate various types of litchi adapted to diverse climatic and soil conditions. Additionally, genetic factors play a role in determining the shape, size, and flavor of the fruit. Indian cultivars greatly vary in three different characteristics namely flushing pattern, flush colour and flowering ability. According to Singh, (1998) cultivars were classified in five categories based on these characteristics. Group A, which has 7 cultivars is the early group, Group B and C are mid-season, Group D being the late group and Group E, which is very late, whose cultivation is confined to Muzaffarpur (Sarkar *et al.*, 2018). A key to important litchi cultivars classification is given in Table 5.

Table 5. Key to important cultivars of litchi grown in India

1. Flush pink, leaf boat-shaped, dark green, panicle long, fruits oblong with round apex	
Colour of fruit deep pink	Shahi and Tirkolia

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Rose flavour	Rose Scented
Colour of fruit light and greenish	Green
High cracking and big seed	Ajhauli
Late in Maturity	Dehradun
2. Deep pink flush, leaf with twist along the length, curved upward from the midrib and down along their length, panicle long, fruit oblong with pointed apex	
Color of fruit pink	China
Fruits deep pink	Purbi and Mandraji
Fruits in bunches	Bombaia and Calcuttia
Early maturity	CHES-2
3. Dark pink flush, oval shaped leaves, compact and small panicles, Fruit round, smooth, more chicken tongue seed (aborted seed)	
Early maturing	Early Bedana or Early Seedless
Late maturing	Late Seedless or Late Bedana
Deep pink colour	Swarna Roopa
Mid season maturity	Swarna Roopa
4. Deep pink flush, boat-shaped and dark green long leaves, panicle long, largest size fruit	
Deep in colour	Kasba
5. Small elongated leaves, light green in colour, panicle compact, fruit medium in size, very late maturity	
Pulp sweet and excellent flavour	Longia
Pulp sour	Kaselia and Khatti

Source: H.P. Singh and S. Babita (2002) Lychee Production in the Asia-Pacific Region

9.1. LITCHI VARIETIES GROWN IN INDIA:

1. **Shahi:** Shahi is one of the most popular cultivars grown in North Bihar, Jharkhand, Uttaranchal and Uttar Pradesh region in India. This cultivar is the earliest to arrive in different parts of India, arriving between the second week of May and the first week of June. Trees of this cultivar produce fruits ranging from 100 to 150 kg per tree and the fruits are light in weight (20 to 25 g each). The more the fruit matures the more it is prone to cracking in zones in low humidity and low soil moisture content. The pulp of the fruit is greyish white, soft, juicy and sweet with TSS content ranging from 19 to 22º Brix. The Seed size varies proportionally with the fruit size (Singh & Babita, 2002; Sarkar *et al.*, 2018) (Figure 4).
2. **China:** The name 'China' was selected for this cultivar because of its superiority. This medium late season cultivar is tolerant to heat waves and fluctuations in soil moisture. Fruits ripen from May end to June end in different states of India. Trees of China cultivar are smaller than that of the other cultivars and they are high yielding. Fruits are tyrant rose coloured, medium heavy. The fruit pulp is white, soft, juicy, sweet having TSS of 17-18º Brix, 11% total sugar and 0.43% acidity. The seeds are dark chocolate in colour,

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oblong to concave shaped and medium in size (Singh & Babita, 2002; Sarkar *et al.*, 2018) (Figure 4).

3. **Rose Scented:** It is commercially cultivated for table purpose in Uttarkhand and Muzaffarpur area of Bihar. In addition to having excellent fruit quality, it is well-known for its unique rose scent which is why it is called Rose Scented. Ripening begins in the first week of June for this mid-season variety. Average yield is around 80-90 kg per tree. Medium-sized to large fruits are deep rose pink in color and typically oval or heart-shaped. Pulp is grayish-white, soft, moderately juicy (54.8%) and sweet with 21.7º brix TSS, 14.57 per cent total sugars and 0.30 per cent total acidity. Fruits have excellent aroma (Rai, *et al.*, 2001). Fruits are moderately susceptible to sunburn and cracking (Chauhan, 2001) (Figure 4).
4. **Mandraji:** The trees of this cultivar are vigorous and attain a height of 6.0 m and spread of 6.0 m. The large fruits (22 to 26 g) are formed in clusters. The thick skin is very rough and has attractive bright red colour. Fruit shape is oblong with medium shoulders. Pulp is soft, juicy with pleasant flavour. The fruits contain 19.5º brix TSS and 0.43 per cent acidity. The seeds are smooth with shining light chocolate colour. It matures in the last week of May to first week of June (Chauhan, 2001) (Figure 4).
5. **Purbi:** The eastern part of Bihar is where it is primarily grown for table purposes. The oblong-conical medium-sized fruits ripen in the last week of May or the first week of June. Red tubercles on a pinkish brown background emerge when they reach maturity. The average yield is 90 to 100 kg per tree; pulp recovery 57 to 60 per cent. Pulp is soft, juicy with pleasant flavour, having TSS 19.0º brix and acidity 0.44 per cent. The seeds are smooth and shining light chocolate in colour. Fruits are less susceptible to cracking (Chauhan, 2001) (Figure 4).
6. **Bombai:** This cultivar is important in West Bengal which matures generally in the second week of May and fruit yield is 80-90 kg per tree. Fruits are large, heart shaped and the weight ranges from 15-20 g with TSS of 17º Brix. The mature fruits are carmine red in colour with uranium greenskin background. The aril is greyish white, soft, juicy, containing 11% total sugar and 0.45% acidity. The seed is elongated, smooth and shiny having light chocolate colour (Singh & Babita, 2002) (Figure 4).
7. **Dehra Dun (Dehra Rose, Dehra Dhun):** This is a significant cultivar that is grown under the name Dehra Rose in Punjab and Uttar Pradesh. Fruits have small seeds, but are susceptible to cracking (Anonymous, 2001). It yields high-quality fruit (Morton 1987). It is a late-maturing cultivar and the fruits mature by third week of June. This cultivar

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produces medium-to-large fruits with an oblique heart to conical shape and a weight of approximately 15.2 g. As it ripens the fruits skin turns a gorgeous rose pink color. The pulp has a TSS of 18º Brix is moderately juicy and is greyish white. The total amount of sugar and acidity is 10.4 percent and 0.44 percent respectively. Most seeds are oblong in shape and tiny and shrunken. When this cultivar is rainfed its skin is prone to cracking. The cultivars name implies that it was chosen in Dehra Dun (Singh & Babita, 2002) (Figure 4).

8. **Ajhauli:** This is an early maturing variety selected from Ajhauli village. On a sixteen-year-old tree it produces roughly 80–100 kg of fruit. The fruits have large seeds weigh 15 to 18 g and are red in color. It shares many similarities with Shahi that make it impossible to tell them apart based on vegetative characteristics. This variety is highly prone to cracking but under irrigated conditions cracking is minimized (Singh and Babita, 2001) (Figure 4).
9. **Early Bedana (Early Seedless):** This cultivar ripens early and usually have small seeds. In Punjab this variety is referred to as "Early Seedless" for this reason. It is a medium fruit yielding cultivar and fruits are generally of 15-18 g weight having oval or heart shape, rough surface with uranium green skin (Singh & Babita, 2002). The skin is covered with red tubercles at maturity (Kumar, 2011). The fruits seed is tiny, shrunken, shiny and dirty chocolate in color while the pulp is white, soft and juicy. The TSS of the pulp ranges between 17.2-19.8º Brix (Singh & Babita, 2002) (Figure 4).
10. **Late Bedana (Late Seedless):** Late Bedana, also known as Late Seedless, is a cultivar that ripens later in the season and produces 60–80 kg of fruit per tree. The size of this cultivar is medium, but it has a higher pulp content. At maturity, the conical fruits develop dark blackish brown tubercles and a color range from vermillion to carmine. Pulp has a low acidity and a TSS content of 18–20º Brix. Figure 4 shows the tiny, fusiform-shaped, chocolate-colored seeds (Singh & Babita, 2002).
11. **Gulabi:** The quality of this late maturing variety is impacted by rain. The tree produces fruits that are medium to large in size and have a medium to oblong shape. The rind color transitions with maturity from shrimp red to carmine red, while the fruit pulp remains firm and greyish white in hue. The TSS content of the pulp is 18.2º Brix, with a total sugar percentage of 10.7% and a titratable acidity of 0.49%. The glossy, chocolate-hued seed is large, substantial, and has an oblong-cylindrical form (Singh & Babita, 2002; Sarkar et al., 2018).

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12. **Ellaichi (Elachi, Elaichi):** This significant cultivar in West Bengal exhibits reduced susceptibility to sunburn and cracking. This cultivar is mid-season and produces approximately 50-60 kg of fruit each year. The fruits exhibit a conical shape and are characterized by a marigold-orange red hue, with each weighing approximately 12-15 grams. The pulp exhibits a creamy white color, characterized by a soft and juicy texture, accompanied by a pleasant flavor profile. This variety exhibits a TSS content of 18º Brix, total sugar of 11.5%, and acidity of 0.45%, along with a smaller seed size (Singh & Babita, 2002; Sarkar et al., 2018).
13. **CHES-2:** This cultivar matures late and was developed through clonal selection from Bombaia at the Central Horticultural Experiment Station in Ranchi. Fruits exhibit resilience against sunburn and cracking. The fruits exhibit a deep red hue, are conical in shape, and are found in clusters of approximately 15 to 20. The fruit weighs an average of 21.3 g, comprising 3.8 g of seed and 16.1 g of pulp. The fruits exhibit a total soluble solids measurement of 19.8° Brix and an acidity level of 0.20 percent. The vegetative characteristics of this cultivar resemble those found in China; however, the timing of flowering and fruiting occurs earlier (Singh and Babita, 2001).
14. **Calcuttia or Calcutta:** The tree exhibits reduced growth vigor, reaching a height of 4 meters and a spread of 6 meters. This variety is a heavy bearer, producing 80-100 kg of fruit per tree. It reaches maturity in the final week of June. Fruits are large, oblong, and exhibit a tyrian rose color with dark tubercles upon maturity. The pulp is characterized by a creamy white color, softness, juiciness, and a high sweetness level of 18.2º Brix (TSS). It exhibits reduced susceptibility to sunburn and cracking (Bose, 2001).
15. **Bengal:** The fruits, weighing between 23 and 27 grams, develop in large clusters, comprising up to 50 or more individual fruits. The thick skin exhibits a rough texture and a vibrant red coloration. The fruits exhibit an egg-round to lopsided heart shape, characterized by uneven shoulders. The fruit tip exhibits a pronounced point. Protuberances exhibit a sharp-pointed to wedge-shaped morphology. The flesh exhibits a soft texture, sweetness, and moderate juiciness. Under drought conditions, the aril is frequently underdeveloped and may fail to encompass the seed at the pointed end. This results in a flesh recovery of 50 percent or less. Consequently, this marketing type is deemed ineffective (Anonymous, 2001) (Figure 4).
16. **Deshi:** This cultivar is early-maturing and primarily cultivated in Bihar and West Bengal. Trees exhibit medium vigor, reaching a height of 5.5 meters and a spread of 6.5 meters. Maturity commences in the third week of May. The fruit yield ranges from 90 to 100 kg

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per tree. Fruit bearing is consistent and abundant, with individual fruits typically weighing between 22 and 24 grams. The fruit exhibits an oval to oblong-conical shape, with a mature coloration of bright rose-pink. The fruit pulp exhibits a grayish-white coloration, characterized by its softness and juiciness. The total soluble solids (TSS) in the pulp measure 20.8° Brix, while the acidity is 0.35 percent. Seeds exhibit a smooth texture, are dark chocolate in color, predominantly oblong in shape, and weigh approximately 3.7 grams. It exhibits reduced susceptibility to sunburn and cracking. This cultivar is appropriate for canning (Chauhan, 2001).

17. **Early Large Red:** This cultivar produces fruits measuring slightly over 3.4 cm in length, typically exhibiting an obliquely heart-shaped form; they are crimson to carmine red in color, with green interspaces. The skin exhibits a rough, firm, and leathery texture, with a slight adherence to the underlying flesh. The flesh exhibits a grayish-white coloration, is firm in texture, possesses a sweet flavor, and is of high quality. It exhibits moderate yield and early maturation (Morton, 1987).
18. **Kasba:** This cultivar is significant in Bihar. Trees exhibit moderate vigor, reaching a height of 6.0 m and a spread of 7.0 m. Fruits mature between the third week of May and the first week of June. The fruit yield ranges from 85 to 100 kg per tree. Fruits exhibit an oval to oblong-conical morphology, displaying a bright rose pink coloration upon maturity. The plant demonstrates a favorable response to stress and nutrient application. The fruit weighs between 23 and 27 grams, potentially making it the heaviest among known varieties; however, the quantity of fruit is limited. The pulp exhibits a grayish-white coloration, is soft and juicy, with a total soluble solids (TSS) measurement of 16.8° Brix and an acidity level of 1.14%. Fruits exhibit reduced susceptibility to sunburn and cracking. The cultivar demonstrates superior performance in marginal soils due to its enhanced nutrient absorption capacity (Singh and Babita, 2001; Chauhan, 2001) (Figure 4).
19. **Kaselia:** This is a late-maturing cultivar discovered in isolation. The tree is of moderate size. Fruits acquire a pink-red hue. The pulp content is relatively low, and the seeds are large. This cultivar is alternatively referred to as ‘Khatti’ or ‘Pickling’. The cultivar has not achieved commercial success (Singh and Babita, 2001).
20. **Late Large Red (Syn. Muzaffarpur):** This variety of litchi is significant and is primarily cultivated in Bihar and the neighboring states. This variety consistently produces a substantial yield each year, averaging 80-100 kg per tree. The fruits are substantial in size, exhibiting an oval or oblong conical shape, adorned with crimson red tubercles. The

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pulp exhibits a greyish-white color, is soft, and moderately juicy, with a total soluble solids (TSS) measurement of 20.3º Brix. The pulp recovery ranges from 62 to 65 percent (see Figure 4).

21. **Longia:** This cultivar enjoys a widespread presence in North Bihar and is favored for its late maturity characteristics. The tree exhibits a medium stature, characterized by diminutive leaves of a pale hue, and features compact panicles. The fruits exhibit a moderate size, and the aril possesses a remarkable fragrance. The shy bearing habit has led to a diminishing preference for this cultivar, with pulp recovery ranging from 50 to 55 percent (Singh and Babita, 2001) (Figure 4).
22. **Swarna Roopa:** A late-maturing, crack-resistant cultivar selected in Ranchi; features visually appealing red fruits with small seeds and a high aril content of 65 to 70 percent; fruits are medium-sized, weighing 15-17 grams, and possess a high pulp content. The pulp exhibits elevated total soluble solids and reduced acidity. The cultivar is appropriate for prolonged harvesting as it ripens later than in China, and it is esteemed for its appealing fruit coloration. This cultivar is advised for commercial cultivation (Singh and Babita, 2001).
23. **Sabour Bedana:** A superior variety recently introduced by Sabour in Bihar; ripens in early June; trees are robust, reaching an average height of 10-12 m; average yield is 80-90 kg per tree; fruits are large (24-30 g); fruit color is an appealing carmine red with a uranium green skin background; sweet, tender, and juicy; small, chicken tongue seeds comprise 80 to 90 percent; and aril recovery is 75 to 80 percent.
24. **Trikolia:** This is an early strain of litchi identified from landrace orchard stock in East Champaran. This genotype resembles Shahi and exhibits enhanced fruit retention capacity. The mean weight of the fruit ranges from 18 to 20 grams (Singh et al., 2012) (Figure 4).
25. **Green (Extra Early Green):** The fruit measures 3.2 cm in length, predominantly heart-shaped, with occasional rounded or oblong variations. It exhibits a yellowish-red coloration interspersed with green, featuring a slightly rough, leathery skin that adheres slightly. The flesh is creamy-white, firm, and possesses good quality with a slightly acidic flavor. Seeds may be oblong, cylindrical, or flat, exhibiting varying qualities. Early in the season (Singh et al., 2012) (Figure 4).

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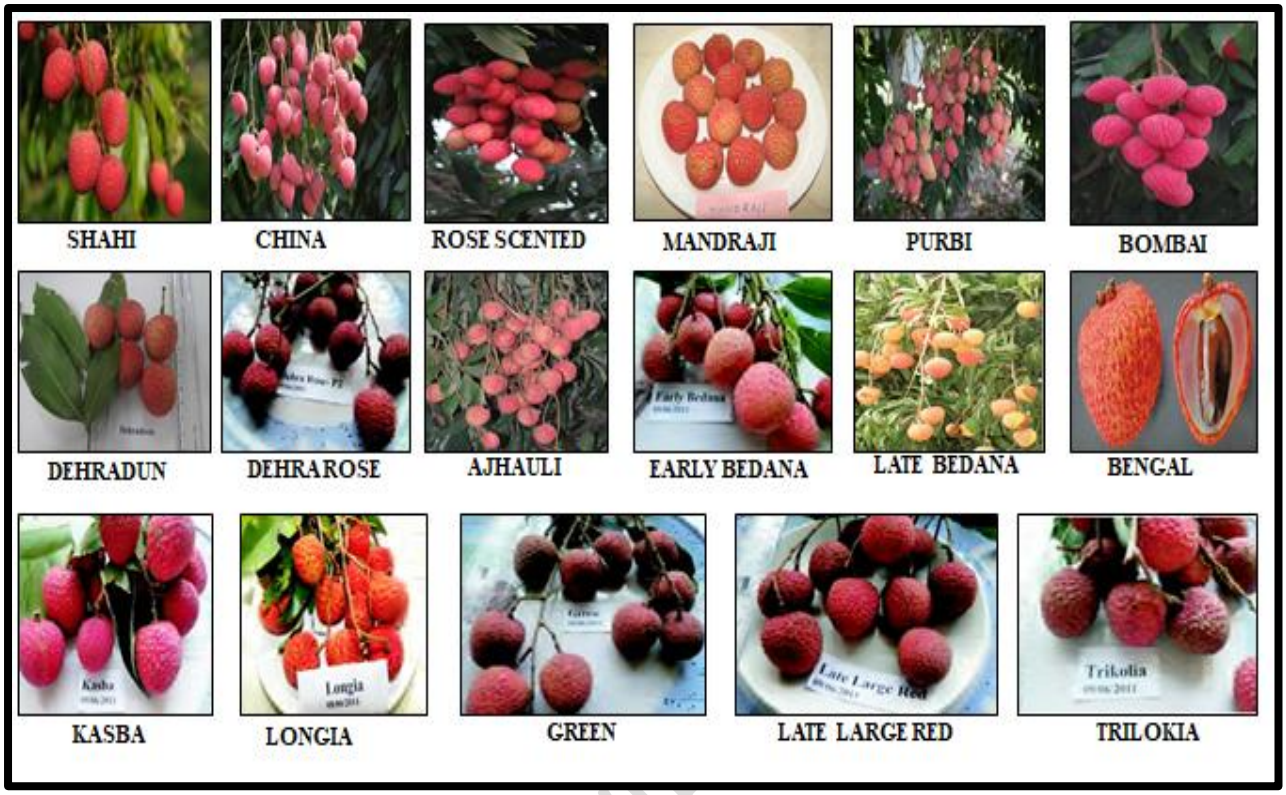

Figure 4. Litchi varieties grown in India (Source: Singh *et al.*, 2012)

9.2. LITCHI VARIETIES FROM CHINA AND OTHER COUNTRIES:

26. Aili: It came from nearby Litchi Chinensis seedlings. This is a dwarf variety, yielding average fruit weight of 24.8 g. This choice is advised for growing in Hainan Province (Miao et al., 1998).

27. Bah Lup: According to Anonymous (2001), Bah Lup is an early Chinese variety that is good for export. It typically has large oval seeds, a tree that is medium in vigor and dome-shaped, and fruits that are medium to large (20-29 g) and nearly heart-shaped. Its skin is thin, soft, brilliant red to slightly purple, and it has obtuse protuberances. The flesh recovery can reach 77 percent.

28. Bai-Teng-Ying: One month earlier than for a standard cultivar Hei-Ye in that region, floral variation occurs between October and February in this litchi varietal. The tree has good tolerance to some negative environmental factors (Ooyang, et al., 1994), is dwarfing in vigour, precocious, early maturing, generates consistently high yields of good quality fruits.

29. Brewster (Chen family purple): This variety was acquired from Fujian, China, by Reverend W.M. Brewster and was propagated in Florida in 1903. Brewster stands out as one of the rare cultivars featuring distinct lenticels, characterized by corky outgrowths on

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its branches. Leaflets are sizable, deep green, and taper to a point at the tips. The recent growth appears in a reddish-brown hue. The fruits, medium to large in size (20-26 g), exhibit a heart shape and feature a vibrant pinkish-red, thick, and rough skin, growing in small, loose clusters. The flesh is subtly aromatic, succulent, and sweet when it reaches full ripeness, yet it possesses an acidic quality when unripe. Seeds vary in size from small to medium, with as much as 80 percent remaining undeveloped following cool weather. Oblong seeds are plump and feature a blunt tip. The recovery of flesh ranges from 65 to 75 percent (Anonymous, 2001). The fruits are sizable, conical or wedge-shaped, red in color, featuring soft flesh that is more acidic compared to that of Kwai Mi, and the seeds are frequently well-developed and large (Morton, 1987). Brewster bears in mid-season and is significant, although the seed is typically well-formed and large (Figure 5).

30. **Chacapat:** A well-known variety from Thailand; characterized by late maturity; trees may produce small fruit with diminutive seeds. Under these conditions, this marketing type is deemed ineffective. The "Chacapat" trees exhibit moderate vigor, an erect growth form, and possess long branches with dense foliage. The fruit is typically large, ranging from 28 to 32 grams, and is characterized by a round to slightly heart-shaped morphology. The skin is characterized by a thin and soft texture, exhibiting a deep red hue with less prominent yellow markings compared to Salathiel. Skin segments exhibit swelling characterized by obtuse protuberances. The flesh exhibits moderate juiciness and retains acidity upon full ripeness. Most seeds are large, resulting in a flesh recovery rate of 60 to 70 percent.
31. **China-3:** This variety is among the most highly regarded cultivated in Bangladesh. The trees reach an average height of 5 to 6 meters and possess comparatively smaller leaves. This variety is classified as late, with fruit ripening occurring in the final week of June. Fruits exhibit a globose shape, characterized by a combination of red, orange, and green patches. The mean weight of fruit is 25 grams. Pulp exhibits a creamy white color, characterized by its softness and juiciness. TSS of 18º Brix, with a small seed size and a pulp-to-seed ratio of 15:1 (Singh et al., 2012).
32. **Dahong Nuomizi:** This variety matures from late June to early July, yielding large fruits that weigh between 20 and 25 grams. Fruits are vibrant red, featuring a small stone and succulent, juicy flesh that boasts a rich sweetness, with a soluble solids content ranging from 18-21%. The quality of eating is excellent; however, the yields lack consistency and the transportability is inadequate. The cultivar is cultivated in Guangzhou, Dongguan, and Conghua counties within Guangdong province, China (Li, 1996).Dahongpao is cultivated

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in the Eastern Sichuan province of China. Dahongpao is an early red variety that matures in mid to late July, yielding large fruit clusters weighing between 500 and 1000 grams. The fruit shelling rate is 81.6%, and the eating quality is rated very good (Wong, 1999).

33. **Dong Si Ji Li:** This litchi line in China is uncommon and utilized in hybridization programs. Despite its uneven elongated-oval fruits with soft textured sour aril, characteristics such as year-round flowering, high total soluble solids (TSS), and vitamin C content (53.7 mg/100g) render it highly suitable as a parent in breeding programs (Rai et al., 2001).
34. **E Dan Li:** This cultivar is appropriate for canning due to its pristine and luminous white aril. Fruits that are reddish yellow, oval or cordate in shape possess a weight ranging from 18.2 to 21.9 grams, an edible portion percentage of 70.4 to 77.3, a Brix value between 15.3 and 18.0, and a vitamin C content of 22.1 to 27.6 mg per 100 grams. Ripening occurs in late June in China (Rai et al., 2001).
35. **Edanli:** This is a regional variety, cultivated in Hainan Province, China. Its large fruits and high quality have led to its continued popularity in recent years. The fruits produced weigh 52 g, with approximately 72% of that being edible flesh. The soluble solids content of Edanli exceeds that of Ziniangxi slightly. The ascorbic acid content of Ziniangxi is 1.0% higher than that of Edanli, reaching 90%, whereas Edanli has only 50%. The fruit color of Edanli is a dark greenish red (Li, et al., 2003).
36. **Emperor:** This cultivar is appropriate for canning due to its luminous and immaculate white aril. Oval or cordate fruits, reddish yellow in color, possess thin and delicate skin, weighing between 18.2 and 21.9 grams, with an edible portion comprising 70.4 to 77.3 percent, a Brix measurement of 15.3 to 18.0, and containing 22.1 to 27.6 mg of vitamin C per 100 grams. It matures in late June in China (Rai et al., 2001).
37. **Fay Zee Siu:** This is a novel litchi cultivar intended for cultivation in South Africa. The primary attributes of this early cultivar include its fruit size (24-32 g), fruit quality (small seeds, appealing color, pleasant aroma, and juiciness), early maturation (early to mid-November), and excellent storage quality. Crop yields and quality are comparable to the prevalent cultivars HLH Mauritius and McLean's Red (Froneman, 1999). The flesh is robust, saccharine, delectable, and highly aromatic. Seeds exhibit variability, resulting in a flesh recovery of 77 to 82 percent (Anonymous, 2001).
38. **Fei Tsu Hsiao or Fi Tsz Siu (Imperial Concubine's Laugh or Smile):** This varietal produces thin-skinned, amber-colored fruits with very sweet and aromatic meat. The seeds range in size from huge to quite tiny. It turns early in the season (Morton, 1987).

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39. **Feizixiao:** It is an early-fruiting cultivar, characterized by high and consistent yields. The fruits are substantial, weighing up to 60 grams, and possess an appealing appearance. The fruit is succulent, featuring a small pit, and possesses a sweet flavor, indicative of superior eating quality. Fruits are non-cracking and optimal for consumption when the skin exhibits a green hue with a subtle red tinge. Trees exhibit vigorous growth; however, they are susceptible to calcium deficiency in litchi orchards (Wu and Zhang, 1997). It is a mid-season cultivar characterized by high yield and appealing fruits, optimal for cultivation at elevations ranging from 600 m to 1300 m (Zhuang, 1999) (Figure 5).
40. **Fengli:** It was chosen among local Litchi chinensis seedlings. With rather high soluble solids content (18%), four-year-old Fengli trees produced an average of 11.6 kg fruits. Growing in Hainan Province of China, this variety is advised (Miao, et al., 1998).
41. **Groff:** The Haak Yip cultivar seedling is distinguished by its remarkable characteristics. Originally designated as H.A.E.S. Selection 1-18-3 by the Hawaiian Agricultural Experiment Station, it received the name Groff in 1953. The tree exhibits a straight form and possesses moderate strength. It reliably yields late in the season, achieving optimal maturation. The fruit is of medium size, exhibiting a dark rose-red hue with green or yellowish tints at the apex of each tubercle. The flesh exhibits a pale and solid appearance, maintaining its integrity without the loss of moisture. The flavor is excellent, characterized by sweetness with a subtle acidity. A significant proportion of the fruits possess abortive, chicken tongue seeds, leading to an increase of approximately 20 percent in flesh compared to fully developed seeds (Morton, 1987) (Figure 5).
42. **Guiwei:** This cultivar is cultivated in the Eastern Sichuan province of China (Wong, 1999). This litchi variety is characterized as a late-maturing type, well-suited for cultivation in the upper and middle reaches of the Yangtze River within Sichuan Province. This variety is appropriate for cultivation in regions where the mean annual temperature exceeds 18º C (Yuan and Zhu, 2001). It reaches maturity in early to mid-August in the Luzhou district. Fruits typically exhibit a substantial size, averaging 24 grams, and possess a dark red epidermis. The flesh exhibits a pure white color, is tender and juicy, with a soluble solids content of 18.2° Brix, a vitamin C (ascorbic acid) concentration of 58.96 mg/100 ml, and possesses a subtle aroma. The trees exhibit precocity and high productivity, with 6-year-old specimens yielding over 5 kg of fruit, and some reaching up to 26.5 kg (Zhu and Yuan, 1999) (Figure 5).
43. **Haak Yip (Hak Ip, Hei Yeh, Black Leaf) :** Seeds are of medium size; this is a mid-season variety. The trees are medium in height, characterized by dense foliage and long,

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thin, fragile branches. The fruit is heart-shaped, medium-sized (20-22 g), and grows in large, compact clusters (15-30 fruits). The skin of the fruit is smooth, thin, purplish-red, and soft, with no raised protuberances. It is susceptible to insect attack and features a distinctive suture line. The shoulders are wide and even. The flesh separates easily from the seed, exhibiting sweetness, crispness, slight aroma, and excellent quality. The fruit is medium-sized and fully developed, yielding a flesh recovery of 68 to 76 percent. It is exported from China (Singh et al., 2012) (Figure 5).

44. **Hsiang Li or Heung Lai (fragrant lychee):** The tree exhibits a distinctive erect habit, characterized by upward-pointing leaves. The fruit is diminutive, notably rough and prickly, exhibiting a deep red hue, containing the smallest seeds among all varieties, and possesses a superior flavor and fragrance. The season is advanced (Morton, 1987) (Figure 5).
45. **Jixin:** It was chosen in China's Ibin prefecture and is a promising litchi variety from the cultivar Dahongpao. It yields bigger fruits (24.2 g) with a greater total soluble solids content (17.4-18.1º brix) and is prolific (Li et al., 1999).
46. **Kaimana or Poamoto:** This is an open-pollinated seedling selection of the Haak Ip cultivar, developed by R.A. Hamilton at the Poamoto Experiment Station, University of Hawaii, and released in 1982. The fruit is similar to Kwai Mi, yet it is twice the size, deep red in color, of superior quality, and the tree consistently produces fruit (Morton, 1987). It has been distributed to Australia for assessment. The fruit is large (25 g), heart-shaped, and has purple-red skin; the skin segments are swollen, and the protuberances are smooth when mature. The flesh is crisp, sweet, and of excellent quality. The seeds are medium-sized, and the flesh recovery ranges from 60 to 65 percent (Figure 5).
47. **Kwai May Red:** The “Kwai May Red” tree is characterized by its shy bearing habits. Its fruit closely resembles that of “Kwai May Pink,” differing primarily in skin color, which is red instead of pink-orange. The fruit exhibits good quality, with firmer flesh and a higher proportion of chicken tongues (50-60 percent). Additionally, it has a higher flesh recovery rate (70-80 percent) and a slightly superior flavor profile. The fruit is distinctly aromatic and is exported from China (Anonymous, 2001) (Figure 5).
48. **Kwai May Pink:** Originating in China, potentially as a variant or seedling of “Kwai May Red”; mid-season; exhibiting good bearing capacity. The extended harvest period may be attributed to the attainment of acceptable sweetness and flavor prior to fruit maturation. The trees are large and upright, featuring long, slender branches that extend vertically. The fruit are medium-sized (18-22 g) and round, characterized by very rough, thick skin.

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The skin transitions in color from yellow to yellow-pink to orange-pink as it matures, with full coloration indicating over-maturity. The flesh is firm, crisp, sweet, juicy, and aromatic; the fruit is sweet prior to achieving full maturity. Seeds exhibit variability, containing up to 70 percent chicken tongues; flesh recovery ranges from 67 to 77 percent (Anonymous, 2001) (Figure 5).

49. **Khom:** Originating in Thailand with materials sourced from China, this variety exhibits superior performance in tropical climates. The trees are characterized by their vigorous, erect growth, long, robust branches, and dense foliage. The fruit varies in size (8-20 g) and shape, ranging from long-heart to nearly round, influenced by seasonal conditions. After cooler weather, the fruit tends to be smaller and more elongated. At maturity, the skin segments exhibit smoothness and variability in size, shape, and arrangement, with sharp-pointed protuberances. Fruits are produced in small, loose clusters. The size of the seeds is proportionate to the fruit, with smaller fruits containing chicken tongues. Flesh recovery ranges from 60 to 80 percent (Anonymous, 2001) (Figure 5).
50. **Mauritius:** Although it came from China, the island off the southeast coast of Africa is where it got its name, and it has been widely grown commercially there for many years. About one in ten of the tasty, pink to crimson fruits will develop chicken tongue seeds. This is a South African introduction. Its fruits have brilliant red skins and range in shape from spherical to broadly oval. Compared to Sinco (Sotto, 2001), the fruits are bigger (Figure 5).
51. **No Mai Chee (Noumici):** A highly valued and extensively cultivated cultivar, characterized by its large stature and dense canopy with drooping branches. It matures late and typically commands a price that is two to three times higher than that of other cultivars. The fruit is large (21-28 g) and predominantly features chicken tongues, resulting in a flesh recovery rate of 75 to 85 percent. The flesh exhibits a smooth, firm, and clean texture, characterized by a distinct sweet fragrance; it is appropriate for consumption as fresh fruit and for drying (Figure 5).
52. **O-Hia (Baidum):** Trees exhibit medium stature, characterized by dense foliage on elongated, slender branches, though not as lengthy as those of Haak Yip. This cultivar is significant in Thailand and bears resemblance to Haak Yip, yet does not conform to all its characteristics. The fruit of “O-Hia” are smaller and less uniform in size, exhibiting blotchy markings on the skin, which is yellow-red at maturity rather than purple-red. They are less sweet than “Haak Yip” and contain more chicken tongues. Fruits are available during the mid-season; they are medium-sized (20-22 g) and heart-shaped. The

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skin transitions from a blotchy yellow to a deep red as it matures. The skin segments exhibit irregularity in size, shape, and arrangement, characterized by swelling and smooth to obtuse protuberances. The flesh is characterized by its juiciness and sweetness, with seeds predominantly plump (10-15% chicken tongue), resulting in a flesh recovery rate of 65 to 75 percent (Figure 5).

53. **Salathiel:** Salathiel is believed to have originated in Australia, potentially as a chance seedling of No Mi Ci (Batten, 1984). Trees are small and compact, occasionally producing elongated branches with underdeveloped leaves. The fruit is small (15-18 g), egg-shaped to ball-shaped in cooler regions, and grows in small loose clusters. The skin of the fruit is thick, moderately rough, and features prominent markings. The fruit tip is obtuse, transitioning to round in cooler areas. The flesh is thick, crisp, juicy, and very sweet, with most fruit being sweet prior to full coloration. Most fruit contain chicken tongue seeds, resulting in a flesh recovery of 76 to 80 percent.
54. **Sum Yee Hong:** Chinese cultivar with big seeds, early maturation, medium-sized tree exhibiting an open, spreading growth habit; fruit size is enormous (26-42 g) with brilliant red, thick skin; flesh recovery is 60%.
55. **Sinco:** This cultivar is significant and is grown in the mountains of the Philippines. It is a regional seedling variety from China. The fruits in this cultivar are spherical to oval and have a matte red appearance (Sotto, 2001).
56. **Sweetheart:** It is a reliable producer and represents the highest quality litchi. It yields large, heart-shaped fruit, each containing chicken tongue seeds. Production levels are comparable to those of Mauritius, prompting small-scale commercial plantings by cultivators aiming for premium food markets and gourmet restaurants. This cultivar is rapidly becoming as the preferred option among dooryard cultivators because to its dependability and exceptional quality (Singh et al., 2012) (Figure 5).
57. **Tai So:** A medium-seeded cultivar from China, characterized by uneven fruiting; the trees frequently exhibit poor flowering; they are strong and spreading with an open crown, possessing branches with weak crotch angles. Substantial fruit (22-26 g) with an ovate form, characterized by flat shoulders and a rounded apex; the skin is thin and vividly red; at maturity, the protrusions are hair-like and sharp-pointed; the flesh is slightly chewy, attaining a moderately crisp texture when completely ripe; flesh recovery ranges from 60 to 70%. Up to 50 percent of fruit contain chicken tongue seeds, which are prone to splitting or sunburn in hot, arid conditions; they are also cultivated in Thailand and Australia (Figure 5).

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58. Wai Chee: This litchi cultivar is widely cultivated in China and is also favored in Thailand and Australia. Wai Chee constitutes approximately 80 percent of plants in Guanxi and produces reliably, as it blossoms late and evades chilly spring temperatures. It is predominantly consistent in China, but inconsistent in Australia. Ripe fruits may remain on the tree for several days. The diminutive (16-18 g) spherical fruits develop in compact loose clusters. The epidermis exhibits a deep crimson hue. The shoulders are flat, typically exhibiting ridges on one side at the suture line. The skin possesses a medium texture, with less roughness than Haak Yip. The meat is tender, very succulent, and sweet. The proportions of skin, seed, and aril are 23.6%, 8.1%, and 68.2%, respectively. The mean seed weight is 2.0 g (Chauhan, 2001). The majority of seeds are completely grown, resulting in a meat recovery of 63 to 73 percent. Despite their rich flavor, the bigger seeds and mushy flesh of fruits diminish their eating quality and market value (Anonymous, 2001).

59. Ziniangxi: It was chosen from indigenous litchi seedlings. It is a regional cultivar, cultivated in Hainan Province. Owing to its substantial fruits and superior quality, it continues to be widely cultivated in recent years. It yields fruits weighing 52 grams, with around 72% of edible flesh. The soluble solids concentration is somewhat inferior to that of Edanli. The ascorbic acid level of Ziniangxi is 1.0% more than that of Edanli, reaching 90%, whereas Edanli contains just 50%. The fruit color of Ziniangxi is purplish-red. Owing to the substantial output of Ziniangxi, its cultivation is advised in Hainan province (Li, et al., 2003; Miao, et al., 1998).

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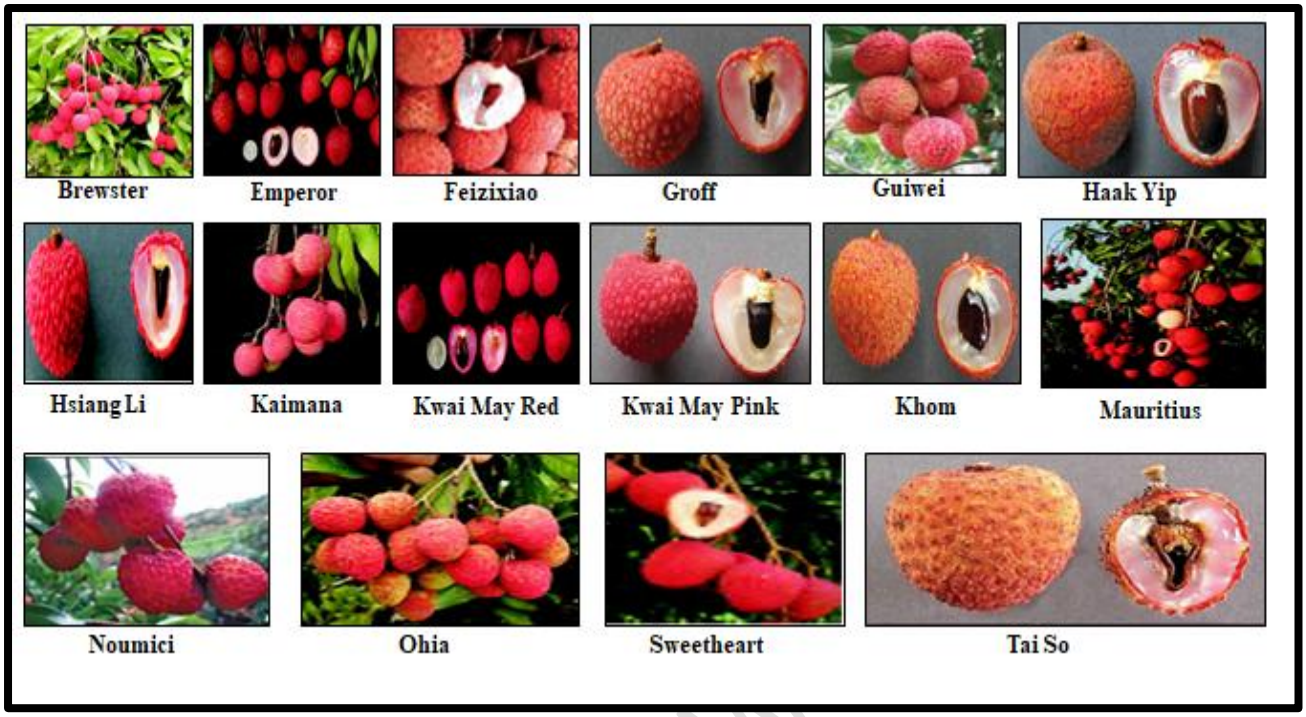

Figure 5. Litchi varieties from china and other countries (Source: Singh *et al.,* 2012)

10. TRADITIONAL USES OF LITCHI:

The medicinal attributes of various components of Litchi chinensis Sonn. in addressing a range of ailments have a historical foundation rooted in traditional medicinal practices. The Litchi tree is utilized for its fruits, leaves, and flowers within the frameworks of Ayurvedic and Unani medicine (Srivastava et al., 2018). The foliage exhibits a verdant hue, characterized by 2-4 paired leaflets, and demonstrates utility in mitigating inflammation and exhibiting antioxidant properties (Yamanishi et al., 2014). In the realm of traditional Chinese medicine, the litchi fruit has been employed to address a multitude of ailments, encompassing wounds, neuralgic discomfort, testicular inflammation, nerve inflammation, gastralgia, orchitis, hernia, intestinal issues, digestive ulcers, as well as excretory and reproductive complications (Anjum et al., 2017; Ibrahim & Mohamed, 2015). Recent investigations have revealed that both crude and purified extracts of Litchi chinensis Sonn. exhibit a diverse array of biological activities, including antioxidant, anti-inflammatory, antimicrobial, anti-obesity, hepatoprotective, anticancer, antidiabetic, and antiviral properties (Castillo-Olvera et al., 2025) (Figure 6).

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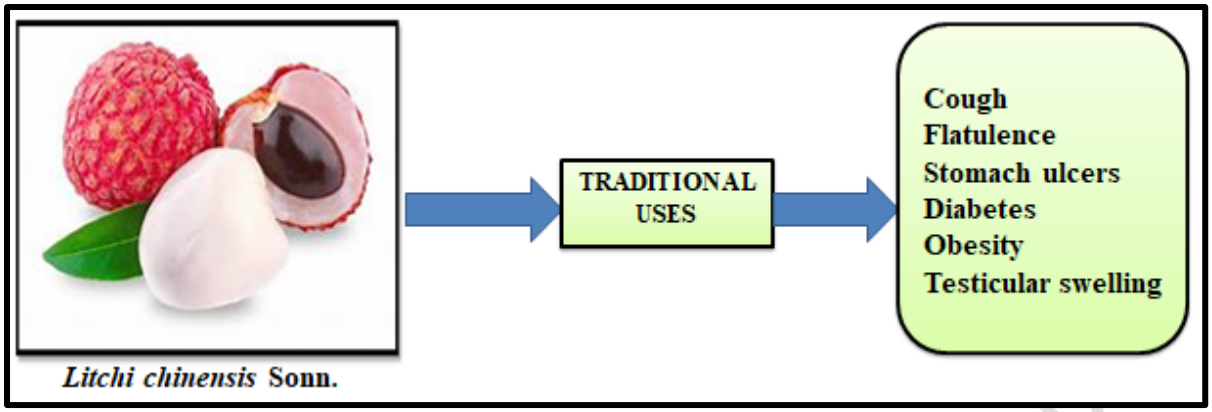
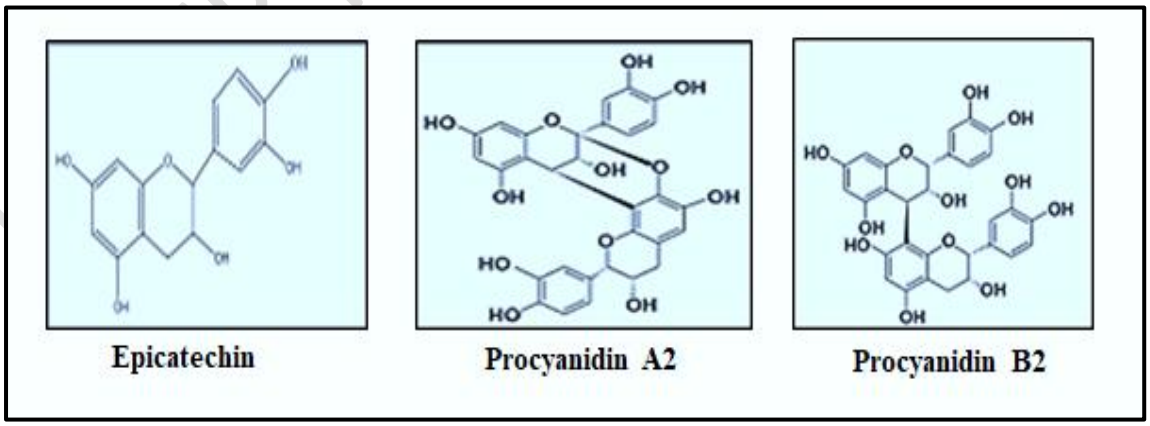


Figure 6. Traditional uses of Litchi (*Litchi chinensis* Sonn.)

11. PHYTOCHEMISTRY:

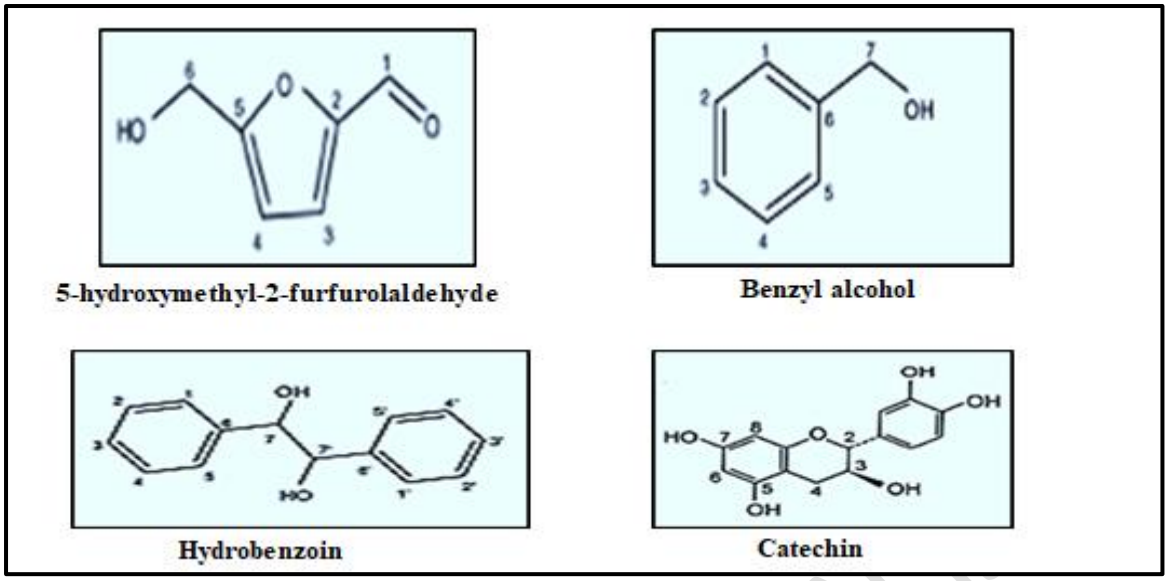
Extracts from the leaf, root, seed, fruit, and pericarp of litchi fruits have been analyzed using HPLC (High-Performance Liquid Chromatography) and HPTLC (High-Performance Thin-Layer Chromatography), followed by pharmacological study. The literature research identifies 50 bioactive chemicals derived from various portions of the lychee plant (Table 6). These substances have been categorized as flavonoids, glycosides, amino acids, phenolic compounds, fatty acids, phenolic aldehydes, monoterpenes, and anthocyanins (Srivastava et al., 2018).

Leaves: Leaves possess Epicatechin, procyanidin A2, and procyanidin B2 (Castellain et al., 2014), which are likely accountable for their anti-diabetic, anti-cancer, antioxidant, and free radical scavenging properties, as well as their ability to lower blood sugar levels (Srivastava et al., 2018).



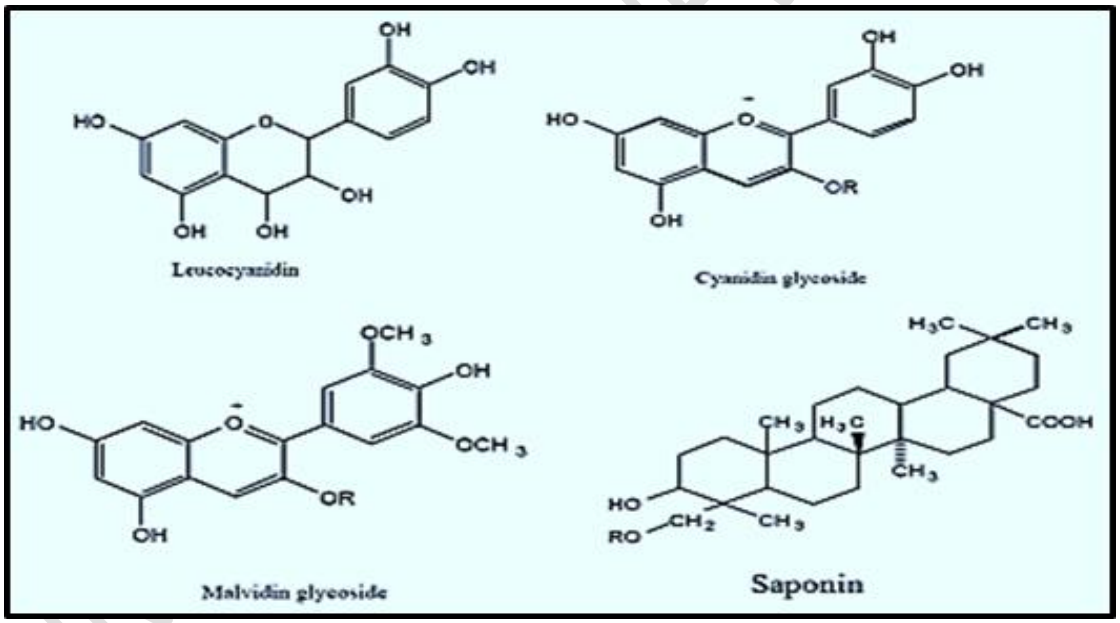
Source: Kilari and Putta, 2016

Fruit: Fruit comprises catechin benzyl alcohol, and 5-hydroxymethyl-2-furfurolaldehyde, hydrobenzoin (Zhou et al., 2012).



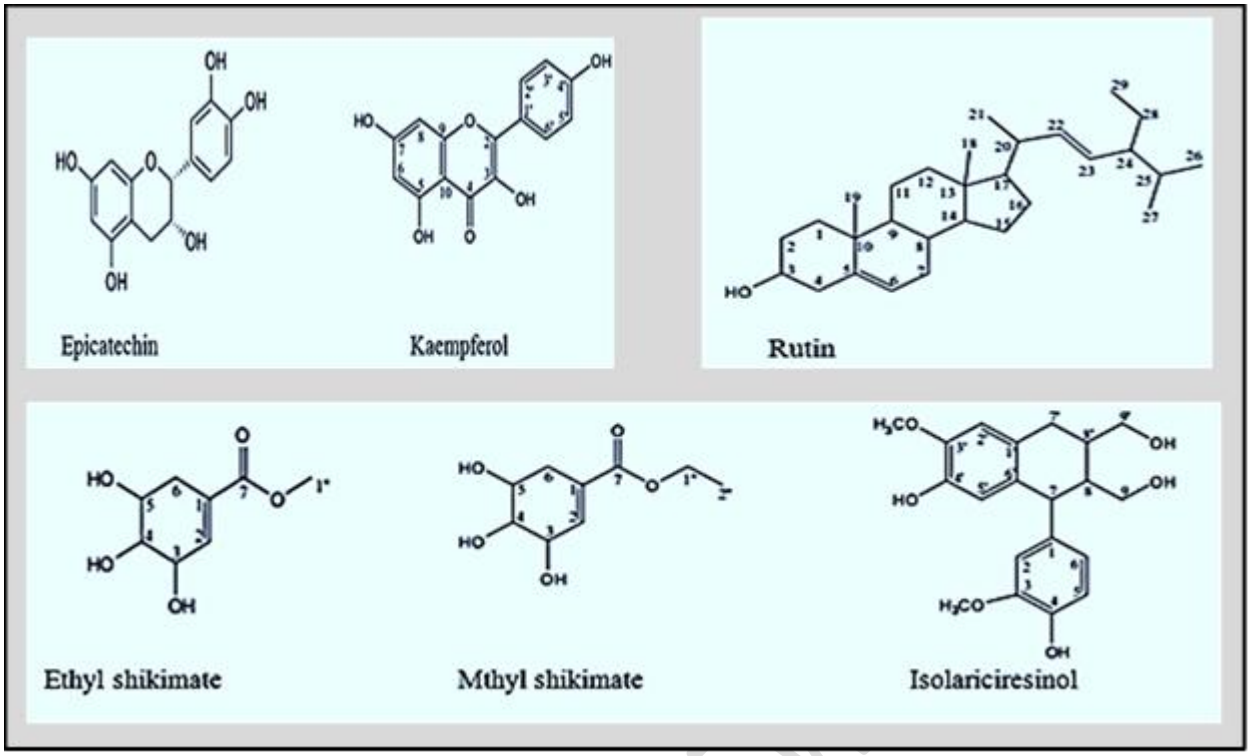
Source: Kilari and Putta, 2016

Seed: Seed contains cyanidin glycoside, malvidin glycoside, saponins and Leucocyanidin (Kilari and Putta, 2016).



Source: Kilari and Putta, 2016

Pericarp: Pericarp contains rutin, Epicatechin, ethyl shikimate, kaempferol, isolariciresinol methyl and shikimate (Ma *et al.*, 2014).



Source: Kilari and Putta, 2016

Table 6. Bioactive compounds reported in *Litchi chinensis* Sonn.

S.no.	Name of compound	Class	Property	Reference(s)
1.	Ascorbic acid	Organic Compound	Growth and repair of tissues in all parts of the body	Ong and Acree (1999), Huang and Wu (2006), Yang et al. (2006) and Wu et al. (2009)
2.	Citric acid		Anti-bacterial; anti-fungal; anti-oxidant	
3.	Isobutyl acetate		Antibacterial	
4.	Isovaleric acid		Antibacterial	
5.	Guaiacol		Antimicrobial activity	
6.	2-phenyl ethanol		Anti-tyrosinase; antimicrobial	
7.	Epicatechin	Flavonoids	Anti-oxidant; free-radical scavenging activity; reduce blood sugar level; anti-diabetic; anti-cancer	Rooyen and Redelinghuys (1983), Ding (1999), Ong and Acree (1999), SariniManchado *et al.* (2000), Luximon-Ramma *et al.* (2003), Luo *et al.* (2006),
8.	Procyanidin B2		Anti-oxidant activity; prevents malignancies	

9.	Epigallocatechin		Chemoprevention and anti-cancer activities	Liang *et al.* (2006), Gong *et al.* (2008), Shen *et al.* (2013), Wu *et al.* (2009), and Reichel *et al.* (2014)
10.	Procyanidin B4		Possess anti-oxidant activity; inhibition of proliferation and induction of apoptosis in cancer cells through up- and downregulation of multiple genes	
11.	Procyanidin A2		Prevents hyperglycemia and type 2 diabetes	
12.	Leucocyanidin		Protects the stomach lining	
13.	Cyanidin-3-O-glu		Free-radical scavenging activity	
14.	Cyanidin-3-O-rut		Free-radical scavenging and anti-platelet aggregating activity	
15.	Malvidin-3-acetyl-O-gluoenin		Anti-oxidant properties	
16.	(2S)-pinocembrin-7-O-(6″-O-αL-arabinosyl-β-Dglucopyranoside)		Anti-diabetic property	
17.	Quercetin		Supports normal respiratory health; supports cardiovascular health; promotes balanced blood pressure; offers protection against stress; offers nutritional support for overall health	
18.	Quercetin 3-O-glucoside			
19.	Phlorizin		Anti-oxidant; anti-diabetic	
20.	Pinocembrin-7-O-glucoside		Anti-oxidant activity; used to treat cerebral ischaemia, neurodegenerative diseases, cardiovascular diseases and atherosclerosis	
21.	Pinocembrin-7-O-[(6″-O-β-D glucopyranoside)-β-Dglucopyranoside]			
22.	Pinocembrin-7-O-[(2″,6″-di-O-α-L-rhamnopyranosyl)]-β-Dglucopyranoside			

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23.	Kaempferol		Anti-oxidant; anti-cancer	
24.	Kaempferol-7-O-β-Dglucopyranoside			
25.	Kaempferol 3-O-rutinoside			
26.	Kaempferol 3-O-glucoside			
27.	Onychin		Anti-oxidant; anti-cancer	
28.	Nairutin		Anti-oxidant	
29.	Peonidin 3-O-rutinoside		Anti-oxidant	
30.	Narcissin (Isorhamnetin-3-O-rutinoside)		Anti-oxidant	
31.	Catechin		Anti-oxidant	
32.	Rutin		Anti-oxidant; helps the body to utilize vitamin C and produce collagen; heals conditions such as haemorrhoids and high blood pressure and reduces cholesterol levels	
33.	Palmitic acid	Fatty acids	Blood lipid-reducing activity	Ding (1999) and Ning *et al.* (1996)
34.	Linoleic acid		Anti-oxidant; anticarcinogenic	
35.	Dihydrosterculic acid		Anti-cancer; anti-tumour	
36.	8-methylenehexadecanoic acid		Antibacterial	
37.	Cis-5,6 methylenetetradecanoic Acid		Antibacterial	
38.	Cis-3,4-methylenedodecanoic Acid		Antibacterial	
39.	Protocatechuic acid		A major metabolite of antioxidant polyphenols;possess anti-cancer property	
40.	Saponin	Glycoside	Cholesterol reduction; antioxidant; reduce cancer risk; immunity booster; reduce bone loss; anti-oxidant	Yang *et al.* (2004), Guo *et al.* (2003a, b), Yang and Liang (2004), and Jiang *et al.* (2008)
41.	α-Methylenecyclopropylglycine	Amino acid	Possesses	Huang (1994)

			hypoglycaemic activity	
42.	Glutathione		It is capable of preventing damage to important cellular components caused by reactive oxygen species such as free radicals, peroxides, lipid peroxides and heavy metals	
43.	Cyanidin glycoside	Anthocyanin	Anti-oxidant; anti-ageing	Sarni-Manchado *et al.* (2000)
44.	Trans-cinnamic acid	Phenolic acid	Anti-oxidant; antimicrobial	
45.	Gallic acid	Phenolic acid	Anti-tumour; anti-oxidant; anti-inflammatory	
46.	Chlorogenic acid	Phenolic Compounds	Anti-oxidant; blood pressurelowering effect; laxative effect	
47.	Caffeic acid (3,4-dihydroxycinnamic acid)	Phenolic Compounds	Anti-oxidant; antihypertension; antithrombosis; anti-fibrosis; anti-virus and anti-tumour	
48.	Vanillin	Phenolic Aldehyde	Anti-oxidant; antibacterial	
49.	Cis-rose oxide	Monoterpene	Anti-inflammatory	
50.	Geraniol		Anti-oxidant; anti-cancer properties	

Source: B. Koul and J. Singh, 2017

12. PHARMACOLOGICAL PROPERTIES OF LITCHI:

Different parts of the lychee plant, including the leaves, flowers, fruit, pericarp, and seeds, contain various biologically active constituents. These compounds demonstrate various pharmacological activities (Figure 7).

A. Leaves

Anti-oxidant activity: The investigation into the antioxidant potential of both organic and aqueous extracts derived from the leaves of the plant was conducted utilizing a range of assays, including ABTS (2,2'-azinobis 3-ethylbenzothiazoline-6-sulfonic acid), FRAP (ferric

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reducing antioxidant power), DPPH (2.2'-diphenyl-1-picrylhydrazyl), TPC (total phenolic content), and total antioxidant activity assessments.The extracts of 1-butanol, methanol, aqueous solutions, and ethyl acetate derived from leaves demonstrate significant peroxyl radical scavenging activity, indicating a robust anti-oxidant potential (Castellain et al., 2014).

Analgesic and anti-inflammatory activity: The analgesic and anti-inflammatory properties of the hydro-alcohol extract of leaves were assessed through the acetic acid-induced writhing test, the hot plate method in mice, and the carrageenan-induced paw edema model in rats, respectively. The oral administration of the extract demonstrated significant anti-inflammatory activity, with the peak effect observed four hours post-administration (Chauhan et al., 2014).

Hepatoprotective activity: By examining the extract's impact on several serum biochemical parameters, such as SGPT (serum glutamate-pyruvate transaminase), SALP (serum alkaline phosphatase), SGOT (serum glutamate-oxaloacetate transaminase), and liver biochemical parameters, it was possible to demonstrate the protective effect of litchi leaf extract against paracetamol-induced liver damage (Basu et al., 2012).

B. Flower

Anti-oxidant activity: By examining the extract's impact on several serum biochemical parameters, such as SGPT (serum glutamate-pyruvate transaminase), SALP (serum alkaline phosphatase), SGOT (serum glutamate-oxaloacetate transaminase), and liver biochemical parameters, it was possible to demonstrate the protective effect of litchi leaf extract against paracetamol-induced liver damage (Basu et al., 2012).

Cardiovascular activity: The aqueous extract of litchi flower contains flavonoids, phenols, and tannins. Flower extract increases the TEAC (trolox equivalent antioxidant capacity) of serum, thereby reducing serum lipid peroxidation in male hamsters with high cholesterol. Litchi flower extract demonstrates notable cardiovascular activity (Yang et al., 2010).

Cyto-toxicity: The cytotoxic effect of acetone extract from litchi flowers was assessed through lead and cadmium-induced hepatotoxicity and TGF-β1 (transforming growth factor beta 1) mediated activation of hepatic cells. The acetone extract reduces lipid peroxidation and DNA fragmentation, demonstrating significant cytotoxic activity (Hwang et al., 2013).

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Anti-lipase activity: The aqueous extract of lychee flower has been reported to contain a variety of phytochemicals, including flavonoids, tannins, anthocyanins, and proanthocyanins. Rats subjected to a hypercaloric diet were utilized to examine the anti-lipase activity, revealing that the aqueous extract effectively diminished the size of the liver, epididymal, and adipose tissues in the rat model, thereby demonstrating significant anti-lipase activity (Wu et al., 2013).

C. Pericarp

Anti-oxidant activity: Litchi skin comprises several active elements that exhibit free radical scavenging action, including glutathione, ascorbic acid, polysaccharides, carotenoids, flavonoids (flavonols and anthocyanins), and phenolic acids. Luximon-Ramma et al., 2003 identified procyanidin B2, epicatechin, epigallocatechin, and procyanidin B4 as the predominant flavonoids in fruit skin. The primary chemicals contributing significantly to antioxidant activity are the flavonoids anthocyanins and procyanidins. Various flavonoid types have distinct antioxidant capacities. Reports indicate that the skin of young fruit possesses much more antioxidant capacity compared to that of mature fruit (Huang and Wu, 2006).

Anti-cancer activity: Rich in insoluble fiber (40% dry weight), litchi pericarp helps to prevent rectum cancer, diabetes, and hemorrhoids (Li et al., 2006). In vitro and in animals with liver cancer, aqueous extract of litchi skin notably slowed the growth of cancer cells (human hepatoma cells). Litchi skin extract reduces the spread of breast cancer cells quite successfully. Although their toxicity to cancer cells was less than that of paclitaxel, the standard anti-cancer medication, a research revealed that two flavonoids epicatechin and procynidin B2 are rather efficient in stopping the proliferation of human breast cancer cells and human lung fibroblast (Zhao et al., 2007).

D. Seed

Traditional Chinese medicine describes dried lychee seed as somewhat bitter, warming, cold-driving, painkillers, Qi flow stimulating, liver- and kidney-toniating agent (Tian, 2005). Lychee seed's medicinal and health-promoting properties abound: antioxidant, anti-cancer, anti-virus, diabetes management, and blood lipids reduction (Taak and Koul, 2016).

Anti-oxidant activity: The litchi seed contains flavonoids that enhance its antioxidant action. Extracts of ethanol and water from the seed have been shown to mitigate free radical damage

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and enhance superoxide dismutase (SOD) activity in alloxan monohydrate-treated mice (Pan et al., 1999).

Anti-cancer activity: The water extract of the seed markedly inhibits the proliferation of hepatoma tumor cells in mice (Wang et al., 2007). Litchi seed extract inhibits telomere synthesis in hepatoma cells, hence halting cancer cell division and suppressing cancer cell proliferation (Xiao et al., 2007).

Reduces blood sugar and lipid: Numerous studies indicate that litchi seed may reduce blood sugar and cholesterol levels while enhancing liver function (Wu et al., 1991).The aqueous extracts of litchi seeds effectively lowered blood sugar levels in ALX-induced diabetic rats, exhibiting an impact comparable to that of biguanides, an anti-diabetic medication, with the litchi seed extract demonstrating a more prolonged effect than biguanides (Zheng et al., 1998). Seed extract lowered blood sugar levels by inhibiting glucose absorption in blood capillaries while enhancing glucose uptake in surrounding tissues (Pan et al., 1999). Guo et al. (2003) discovered that lychee seed extract mitigated sugar metabolic disorders and enhanced insulin sensitivity in rats with insulin-resistant Type 2 diabetes (T2DM) caused by streptomycin, therefore lowering blood glucose levels.

Anti-virus activity: Numerous studies indicate that litchi seed extracts have antiviral properties against hepatitis B virus (Xiao et al., 2005), respiratory syncytial virus (RSV) (Liang et al., 2006), influenza virus (Luo et al., 2006), and SARS coronavirus (Gong et al., 2008). Zheng and Zheng (1992) discovered that seed extract ranked as the second most efficacious treatment for hepatitis B among 1,000 evaluated herbal remedies. Lychee seed extract has been found to directly decrease the production of HbsAg (antigen) and HBV-DNA (Hepatitis B virus) (Pan et al., 2000). Many publications proposed that the antiviral properties of seed extracts are attributed to flavonoids, while others indicated that saponins in litchi seeds are the most potent component (Jiang et al., 2008).

E. Fruit

Anti-inflammatory activity: Ethanol extract of litchi is a mixture of flavanol monomers, dimers and trimers. The effect of litchi-fruit extract was observed on interleukin treated rat hepatocytes and it was reported that ethanol extract significantly inhibits the production of interleukin induced Nitric oxide. The flavanols present in ethanol extract may have been

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792 responsible for anti-inflammatory effect and can be used to cure inflammatory diseases
793 (Yamanishi et al., 2014).

794 **Aldose reductase inhibition activity:** Aldose reductase is an enzyme implicated in sugar-
795 induced cataract formation. The methanol and ethanol extracts of litchi fruit were observed to
796 decrease the activity of the aldose reductase enzyme in rats. Thus, fruit extract may be helpful
797 in treating diabetes-related problems (Lee et al., 2009).

798 **Anti-viral activity:** An experiment was performed to investigate the inhibitory impact of
799 phenolic extract from litchi on Betanoda virus, the causal agent of viral neurological necrosis
800 in marine fish. Oligonol found in phenol extract has been observed to suppress viral
801 replication, indicating its potential as an antiviral drug (Ichinose et al., 2013).

802 **Hepato-protective activity:** The aqueous and alcoholic extracts of the fruit have
803 demonstrated considerable hepatoprotective action at orally administered doses of 250 mg/kg
804 and 500 mg/kg body weight. Their hepatoprotective efficacy is comparable to that of LIV-52
805 (reference medication). Fruit extract reduces the weight of CCl4-induced liver, indicating its
806 potential as a strong hepatoprotective agent (Souza et al., 2006).

807 **F. Other Functions:**

808 Lychee seed is particularly effective in treating hemorrhoids (Deng, 2006). A protein
809 extracted from litchi seed has pancreatic lipase inhibitory action (Yao et al., 2021). It
810 furthermore possesses numerous health benefits, including cholesterol control,
811 neuroprotection, and renoprotection (Zhang et al., 2021). Further investigation into its
812 components and pharmacological effects is necessary to comprehend its potential for illness
813 therapy (Wu et al., 2020; Zhao et al., 2020).

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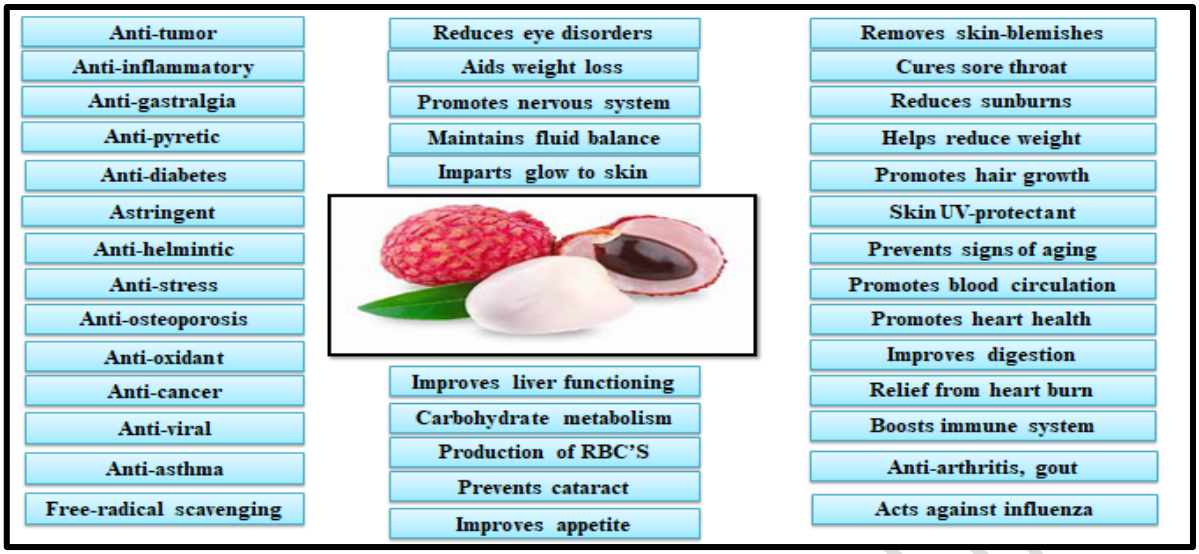

Figure 7. Pharmacological properties of litchi

13. ECONOMIC IMPORTANCE OF LITCHI:

14. Litchi fruit is typically consumed fresh; nevertheless, it has been utilized to create several products, including dried litchi, canned litchi, litchi wine, litchi honey, and litchi jelly (Yao et al., 2021). Litchi fruit polysaccharides have pronounced shear thinning properties at various concentrations, possess high viscosity, and demonstrate temperature insensitivity, making them advantageous functional attributes for the development of novel goods or cuisines (Huang et al., 2018). Litchi seeds possess similar features due to their high carbohydrate content. A primary component is starchy polysaccharides, which are extensively utilized in industry as thickeners, emulsifiers, and gelling agents. Litchi seeds have been utilized to produce sweet and fragrant wines (Punia & Kumar, 2021).

15. The litchi fruit and its by-products (pericarp and seed) has significant economic potential due to its substantial nutritional content and phytochemical profile (Castillo-Olvera et al., 2025). The litchi fruit has garnered significant attention due to its elevated levels of bioactive compounds and associated biological activities, which have been utilized across various industrial sectors, including sunscreens, shampoos, moisturizers, and ointments for skin disease treatment (Bangar et al., 2021; Sathya et al., 2023). Conversely, the elevated fatty acid concentration in the seeds is utilized in the formulation of detergents, lubricants, and dyes (Upadhyaya & Upadhyaya, 2017). Litchi is utilized commercially for hepatoprotective, cardiovascular, cytotoxic, anti-cancer, anti-viral, and anti-hyperglycemic treatments. The pharmaceutical business has a consistent need for natural medications (Srivastava et al., 2018). The pericarp of litchi, consumed as tea, is utilized for the treatment of smallpox, rashes, diarrhea, flatulence, cough, diabetes, and serves as

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an analgesic for many ailments. Litchi by-products are utilized as decoctions and powders, which may be ingested or applied topically for the therapy of various ailments (Yao et al., 2021).

Litchi functions as both a delectable fruit and a substantial agricultural resource, with considerable economic, nutritional, and health benefits. Its many applications, encompassing direct consumption, processed goods, and therapeutic purposes, highlight its significant relevance in both local and worldwide markets. The production of litchi, especially in nations such as China and India, bolsters agricultural livelihoods and enhances sustainable practices and food security. As recognition of its bioactive chemicals and possible health advantages increases, litchi's significance in the food and pharmaceutical sectors is expected to broaden, hence reinforcing its importance in agricultural and economic advancement.

16. CONCLUSION:

Litchi chinensis Sonn. is distinguished not only as a palatable fruit but also as a vital agricultural asset with several economic and health advantages. The diverse applications of litchi, ranging from direct consumption to value-added goods and traditional medicine, highlight its significance across several industries. Considering India's significant contribution to global litchi production, particularly in Bihar, further investment in litchi cultivation and research into its bioactive characteristics may improve food security, bolster livelihoods, and promote sustainable agricultural methods. The rising demand for the fruit requires continuous study into enhanced farming methods, insect control, and post-harvest management to optimize productivity and reduce losses. As recognition of its health advantages increases, the incorporation of litchi into the food and pharmaceutical sectors is expected to expand, reinforcing its value as a fruit that enhances both local economies and global markets. Consequently, forthcoming initiatives should concentrate on utilizing its therapeutic characteristics while guaranteeing sustainable agricultural practices that can accommodate climatic fluctuations. By confronting these problems, litchi can persist in thriving as a commercially significant and health-enhancing fruit.

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