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Traditional, Medicinal and Nutraceutical Values of Minor Fruit: Longan

Narayan Lal[1], Nisha Sahu[1], D. K. Jayswal[2*], Garima Diwan[3] and Khushboo Tandon[3]

[1]ICAR-Indian Institute of Soil Science, Bhopal – 462038, India.
[2]NAHEP, Krishi Anusandhan Bhawan-II, ICAR, Pusa, New Delhi -110012, India.
[3]Indira Gandhi Krishi Vishvavidyalaya, Raipur - 492012, India.

Authors' contributions

This work was carried out in collaboration among all authors. Author NL developed the concept and wrote the first draft of the manuscript. Author DKJ collected relevant literature, developed table and figures and assisted in manuscript preparation. Author NS assisted in manuscript preparation and performed critical proof-reading. Authors GD and KT assisted in the literature searches. All authors read and approved the final manuscript.

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Review Article

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ABSTRACT

This review will help to exploit the potential uses of longan, an exotic sub- tropical fruit which has high therapeutic values. In this review, traditional value, nutritional composition, bioactive compounds and other uses have been focused. Longan fruits are very tasty and its organoleptic qualities are unique because fruit has a succulent, edible and white aril, which has gained popularity. Longan fruits have immense potential in food and pharmaceutical industries. Longan aril, peel and seed extract have anti-glycated, anti-tyrosinase and anticancer properties, and memory enhancing effects which contribute to healthy human health. In China, the entire area of litchi is shifting to longan, which indicates the importance of longan crop and free from production barriers (poor fruit set, fruit drop, sun burn, fruit cracking, insect and pests) in longan cultivation make it popular among the peoples in India. This review will highlight the uses of longan for different purposes.

**Corresponding author: E-mail: dkjayswal.pomologist@gmail.com;*

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1. INTRODUCTION

Plants are natural sources of many drugs for human ailments. People have been using plants for their medicinal values from long ago. Natural occurring product played important role in discovery of useful drugs such as taxol, camptothecin, vinblastine and vincristine, which are extracted from plants. So, herbal and natural products are becoming most popular and useful as sources of anticancer compounds [1]. Recent phytochemical examination of plants and their extraction has been increased as anti-cancer drug [2]. Cancer can be prevented because it exhibition is slow, stepwise development and needs many years to become a threatening to life [3]. Brown et al. [4] have shown correlation between consumption of secondary metabolites (phenolic compounds) and reduced risk of cancer. Tea, pomegranate, pine nuts [5], litchi [6] and longan are excellent sources of polyphenols. Plants are natural reservoirs for antidiarrheal, antidiabetic, analgesic, anti-inflammatory and antipyretic agents. About 25% of the drugs are plants derivatives in developed countries [7]. Diabetes mellitus is different from hyperglycemia, glycosuria and hyperlipidaemia [8]. From the ancient time, people have been using different parts of plants in healing and prevention of numerous ailments. Traditionally, all medicinal preparations derived from plants are being extensively used as they are comparatively cheaper and safer for human being than the synthetic ones, and they are easily available. Higher consumption of fruits reduced the risk of many problems like cardiovascular disease (CVD), stroke and cancers of the mouth, pharynx, esophagus, lungs, stomach, and colon [9]. Many tropical and subtropical fruits are good sources of Vitamin-C, provitamin A, Mg, and K. Nutritional information on longan, litchi and rambutan is limited [10].

Generally, fruit are eaten for nourishment and most of the non-edible parts leave as waste and many fruits have great medicinal importance of all parts including abandoned fruit longan (Dimocarpus longan Lour.) of Sapindaceae family. Longan is commonly known as dragon eye (Fig. 1) and native to Southeast Asia, such as China, Taiwan and Thailand. China and Thailand are major longan producer. Longan germplasm are being maintained at ICAR-National Research Centre on Litchi, Muzaffarpur, Bihar, India along with litchi and centre has developed first variety of longan 'Gandaki Longan-1'. It produces edible fruit during May-August in Bihar, India.

The color of fruit peel is brown or light-brown with white translucent flesh (Fig. 2). It is a highly attractive subtropical fruit grown in south China and also widely distributed in Southeast Asia, such as China, Taiwan, Vietnam, and Thailand. Longan is extensively grown in Southern China, India, and Southeast Asia [11]. In China, the area and production of longan has increased due to its high medicinal values and development in improved production technology [12]. Indian Council of Agricultural Research-National Research Centre on Litchi, Muzaffarpur has also good collection of longan germplasm and started work on longan improvement. Longan pericarp, which accounts 20% by weight of the whole fresh fruit, has possessed good quantity phenolic compounds [13]. Longan fruit has been used as a traditional Chinese medicine for different treatments, such as promoting blood metabolism, soothing nerves, and relieving insomnia. Longan pericarp has shown high content of bioactive compounds viz., phenolic acids, flavonoids, and polysaccharides and exhibit antiviral, antibacterial, antioxidant, anti-inflammatory and anti-carcinogenic properties [14]. The aril extracts are used in stomachic, insomnia, neurasthenic neurosis and also act as febrifuge, vermifuge and antidot [12]. The extract of aril exhibited anxiolytic-like, sedative and analgesic effects [15]. The plant extracts also found to be anti-mutagenic, anti-carcinogenic, antibacterial, cytotoxic and antioxidant effects. Ellagitannins, corilagin, acetonyl-geraniin were reported in longan seed [16]. The aril contains adenosine [15] and gallic acid [16]. Additionally, longan pericarp contains ample flavonoids and polysaccharides [17]. Longan fruit extract including aril, peel and seed exhibited excellent antioxidant properties and good anti-tyrosinase and anticancer activities [18].

Therefore, longan fruit can be used as natural source of antioxidants and possible supplement in the food and pharmaceutical industries. To better utilize the longan fruit, the paper reviews the nutritional value, bioactive compound of longan, antibacterial, antiviral, antioxidant, anti-inflammatory and anticarcinogenic properties.

Fig. 1. Overview of longan tree

Fig. 2. Fruit, pulp, seed and leaf of longan

The paper will help the readers to get more information about longan fruit and relevant farmers, and industries to better utilize this fruit in the future.

2. BIOACTIVE COMPOSITION IN LONGAN

Longan is good source of phenolics, fatty acids and proteins and about 28 volatile compounds have been identified from longan aril. The major volatiles include α -ocimene, ethyl acetate, 3,4-dimethyl-2,4,6-octatriene, allo-ocimene and 1-ethyl-6-ethylidene-cyclohexene [19] and various compounds like Lysophosphatidyl choline, phosphatidyl choline, phosphatidyl inositol, phosphatidyl serine, phosphatidyl ethanol amine, phosphatidate and phosphatidic acid glycerol have been detected in longan aril. The longan peel is good sources of phenolics ranged from 90.35-96.78 mg/g dry weight [14]. The bioactive compounds corilagin, gallic acid and ellagic acid have been found in longan which has antioxidant properties. Creams may be developed having antioxidant property which may be used as the alternative to protect skin [20]. Ellagic acid and gallic acids are present in rambutan which enhances antioxidant activity in the fruits.

Similarly, longan seed extract shows the scavenging activity [16] and MMPIs activity which

probably correlates with the high antioxidant properties [21]. Longan pericarp extract can inhibit the production of oxidation, elevated antioxidant enzymatic activities and decreased inflammatory response [22]. Longan flower and seed also possess rich amounts of polyphenols, including proanthocyanidin A2, (-)-epicatechin, gallic acid and ellagicacid, and exhibit strong antioxidant and inflammatory activities [23]. Zheng et al. [24] have identified ethyl gallate 1- ? -Ogalloyl- D-glucopyranose, methyl brevifolin carboxylate, grevifolinand4-O-? -L-rhamnopyranosyl-ellagic acid, gallic acid, corilagin and ellagic acid from longan seed. Longan aril contains lysophosphatidylcholine, phosphatidyl choline, phosphatidyl inositol, phosphatidyl serine, phosphatidyl ethanolamine, phosphatidate and phosphatidic acid glycerol [25].

3. TRADITIONAL VALUES

The longan fruit is used as a stomachic, febrifuge, vermifuge and an antidote to poison [26]. The presence of fruity aroma and freshness allow preparing an infusion from flowers. Longan flowers extract drinking Quanzhou can overcome urgency, micturition and voiding dysfunction. The powder seeds are used to treat dampness, bleeding, hernia, lymphomegaly of the neck and armpit, odour, scabies and eczema. The National Herbal Compendium of China also records that seed powder is used for stomach pain and as a styptic. Longan fruit has been used for the traditional Chinese medicine formulation to decrease the neural pain and swelling. Park et al. [27] reported that aqueous extract of fruit could enhance learning and memory.

4. NUTRITIONAL, CULINARY AND MEDICINAL VALUES

The longan fruit is normally eaten fresh like litchi but it can be used dry or cooked also. The taste of longan is equals or is superior to that of litchi and edible portion ranges from 67 to 78%. The energy value averages 458 kJ/ 100 g. Raw longan fruit contains many nutrients like Thiamin, Riboflavin, Niacin, Ascorbic acid, protein, Iron, magnesium, Phosphorus, Potassium, Copper, manganese, Fats, Fibre, Calories, carbohydrates, acid etc. It has been reported that TSS, total sugar and ascorbic acid of aril increases and total acid decreases during fruit ripening [28]. Longan is good source of K (324.9 mg/100 g) and Cu (0.26 mg/100 g) [29]. Total sugars increase in aril during ripening and vary with cultivar and stage of maturity [30]. The major organic acid in pulp are succinic acid, malic acid and citric acid (10:5:1) and it also contains malic and tartaric acids [31]. Since ancient times, longan fruit pericarp has been used as a traditional Chinese medicine for enhancement of human immunity [32]. The principal nutritional component of aril is presented in Table 1 [31].

Table 1. Nutritional composition per 100 g of longan fruit aril

Moisture (%)	81.4 (%)
Total carbohydrate	12.38–22.55
Carotene (µg)	20
Vitamin K (mg)	196.5
Reducing sugar (%)	3.85–10.16
Retinol (µg	3
Protein (g)	1.2
Riboflavin (mg)	0.14
Fibre (g)	0.4
Ascorbic acid (mg)	43.12–163.7
Fat (%)	0.1
Nicotinic acid (mg)	1.3
Ash (g)	0.7
Thiamine (mg)	0.01

It can also be used as snacks, desserts and either fresh or dried, sometimes canned with syrup. The boiled seed are eaten with a distinctive nutty flavour. Dried longan is often used in Chinese cuisine and Chinese sweet dessert soups and much likes in medicine than the litchi, is considered a warm fruit. The flesh is administered as a stomachic, febrifuge and vermifuge and is an antidote for poison. Dried flesh can be used for treatment of insomnia and neurasthenic neurosis. Longan seed absorb the venom and is used against snakebite. Dried leaves which contain quercetin and quercitrin and flower of longan are also sold as ingredients in Chinese herbal medicine. It improves wound healing, prevent cell from damages, gums health, teeth health, Immune system, lungs health, prevent from frequent colds, protect from frequent infection, protect from free radicals, reducing ageing, lowers risks of cancer, improve iron absorption, reduces sensitivity to light, improves skin around eyes, reduces oral sores and cracks, reduce skin nerve function, improve muscle function, reduces confusion, irritability, fatigue, lower chance of heart problem, lower chance of high blood pressure, protect from chronic diarrhea and improve exercise ability.

5. ANTI-INFLAMMARY ACTIVITY

Inflammation is localized protective reaction of tissue to injury caused by pain, redness, and swelling. It involves many physiological systems which plays important role human health [33]. Many enzymes up regulated and signaling proteins in affected areas due to chronic inflammation. The enzymes nitric oxide synthase (iNOS) and cyclooxygenase-2 (COX-2) are responsible for elevated levels of nitric oxide (NO) and prostaglandins (PGs), respectively [34]. Lerouet et al. [35] reported that inflammation correlates with an increase in iNOS activity. Cochran et al. [36] found that NO works as a mediator of tissue injury has shown from studies on an animal arthritis model, human osteoarthritis, and rheumatoid arthritis.

Antioxidant enzymes *viz*., superoxide dismutase (SOD), catalase (CAT), and glutathione peroxidase (GPx) are helpful in intracellular protective mechanisms against these inflammatory stresses. Valko et al. [37] shown that faulty cellular antioxidant systems develop a series of inflammatory and cancer diseases in organism. Valko et al. [38] stated that enzymatic antioxidants are very important to protect organisms against oxidative stress in the process of inflammation. Grape seed extracts rich in proantho cyaniding have been used as preventive measure against cardiovascular disease and cancer [39]. The consumption of Longan Flesh Extract (LFE) reduced the blood pressure and oxidative markers such as plasma thiobarbituric acid and liver antioxidant enzyme activity in fructose-fed rats. The effect of LFE on overcoming insulin resistance in rat has been shown [40]. Lin et al. [41] has also reported that feeding of LFE results in reduction of body weight, size of epididymal fat, serum triglycerides and atherogenic index. The main mechanism is down regulation of pancreas lipase, sterol regulatory element binding protein-1c and fatty acid synthase, and up regulation of low-density lipoprotein receptor and peroxisome proliferator-activated-receptor α expression, as well as promotion of fecal triglyceride excretion [42]. These studies reveal that LFE can be used in urinary disorders as well as for treatment of metabolic diseases.

6. ANTIOXIDANT ACTIVITY

Reactive oxygen species (ROS), such as the superoxide anion (H_2O_2), hydroxyl radicals (OH-) and superoxide (O2-) are liberated by normal cellular metabolism and exogenous agents [43]. They are highly unstable and cause heart diseases, cancer, Parkinson's disease [44]. However, the effect of active oxygen and free radicals can be balanced by antioxidant defenses system with help of antioxidant compounds [45]. Synthetic compounds such as butylated hydroxyl toluene (BHT), butylated hydroxyl anisole (BHA) and tertiary butyl hydro quinone (TBHQ) are widely used as preservatives in food and pharmaceutical industry now a day [46], but they have adverse effects on synthetic antioxidants such as toxicity and carcinogenicity [47]. Longan fruit is good source of phenolic compound (Table 2) as potential antioxidant [48] and antioxidant activity depend on the content of phenolic compounds. Guo et al. [49] exhibited the antioxidant activities of pulp, peel and seed of longan fruit using the FRAP assay and Prasad et al. [13] have shown that polyphenol-rich longan extract can strongly inhibit linoleic acid oxidation and exhibit a dose-dependent free-radical scavenging activity against DPPH radicals, superoxide anion and hydroxyl radicals. Longan polysaccharides showed good antioxidant activity in in vitro [50]. However, methylation of polysaccharides from longan pericarp reduced radical scavenging activity [51]. In addition, phenolics from longan pericarp exhibited excellent reducing power [52]. Yang et al. [53] used different solvent namely diethyl ether fraction (LPDF), ethyl acetate fraction (LPEF), n-butyl alcohol fraction (LPBF) and residue fraction (LPR) and reported that total phenolic content of five fractions was ranged from 68.327 to 230.816 mg/g, expressed as gallic acid equivalents ($P < 0.05$) and obtained highest total phenolic from LPEF (230.816±2.001 mg/g), while the lowest was found in LPR (68.327±1.364 mg/g). TPC for five fractions from longan pericarp was decreased in the following order LPEF > LPDF > LPBF > LPCE > LPR. Several reports have shown a close relationship between total phenolic content and antioxidant activity [52,54,55]. Sarikurkcu et al. [56] reported that phenolic compounds are health-benefit due to their antioxidant properties. Longan flower extract suppresses nitric oxide and prostaglandin E2 production in lipopolysaccharide -stimulated macrophage cell line and are potential source of natural dietary anti-oxidants and anti-inflammatory agent [57]. The longan flower extract (LFE) exhibits a strong anti-oxidant activity, which is mainly due to (-) epicatechin and proanthocyanidin A2 [58].

Table 2. Total antioxidant capacities and total phenolic contents of arils of different longan cultivars [48]

Cultivar	Antioxidant activity (FRAP value, mmol/L)	Total phenolics (gallic acid equivalents, mg/L juice)
Shixia	15.82	629.12
Qingkebaoyuan	3.73	396.65
Kusan No. 2	4.19	179.25
Zhuliang	11.18	401.64
Dawuyuan	10.03	565.82
Baihuamu	10.39	662.77
Luosanmu	14.04	558.87
Taobeimu	9.54	510.44
Hualuguangyan	15.38	749.95
Sanlimu	5.50	80.63
Jiruanyan	6.70	13.02
Honghe	13	111.25
Shuiyan	7.32	51.67
Dapulong	10.29	76.71
Houkangben	10.83	346.36
Wulonglin	11.39	370.82

7. DPPH FREE RADICAL-SCAVENGING ACTIVITY

DPPH accept an electron or hydrogen radical to become a stable diamagnetic molecule [59] and DPPH radical scavenging assay is most commonly used method to estimate free radical scavenging activities of antioxidants [14]. Yang et al. [53] observed that the DPPH radical-scavenging activity increased as the concentration of the extract increased. Zhong et al. [60] has also been determined the scavenging effect of longan pulp extracts reached to 85.74% at 20 mg/mL and obtained complete scavenging effect. Zheng et al. [24] characterized eight polyphenols from longan seeds and determined the eight polyphenols exhibited scavenging activity towards DPPH. The antioxidant activity of methanolic extracts of peels and seeds were assessed [61] using DPPH radical scavenging activity. The highest radical scavenging activity was recorded in the peels extract. Peels extract had the lowest concentration to exhibit 50% of the percentage inhibition when compared to that of seeds extract. Moreover, when compared to ascorbic acid, the ascorbic acid had higher antioxidant properties with 11.50 µg /ml compared to peels 23.50 µg/ml and 32.13µg/ml of seeds.

8. HYDROXYL RADICALS-SCAVENGING ACTIVITY

Hydroxyl radical is the most reactive radical among all oxygen radicals and can cause severe damage bio-molecules in the human being and causes many problems like ageing, cancer and several diseases [62]. The removal of these radicals is one of the most effective ways to defense several diseases. Yang et al. [53] found that hydroxyl radical scavenging activities depend on doses of extract (Table 3). Longan pulp have excellent scavenging activity on the hydroxyl radicals and a, a-diphenyl-1-picrylhydrazyl (DPPH) radicals [60]. Zheng et al. [24] isolated and characterized eight polyphenols from longan seeds and determined the eight polyphenols exhibited scavenging activity towards DPPH radicals with SC50 values of 0.80-5.91 µg/mL and towards superoxide radicals with SC50 values of 1.04-7.03 µg/L. Sudjaroen et al. [63] also proved that longan seed has antioxidants property which are useful not only improving the shelf life of foods by preventing lipid peroxidation but also for protecting against oxidative damage in living organism by scavenging reactive oxygen radicals.

9. ABTS RADICAL CATION-SCAVENGING ACTIVITY

ABTS radical cation scavenging activities increased as the concentration of samples increased. Yang et al. [53] reported ABTS radical cation scavenging was in the order at the concentration of 0.1 mg/mL: LPEF (26.37%) > LPBF (18.53%) > LPDF (17.95%) > LPCE (11.96%). At the concentration of 1.2 mg/mL, the

Table 3. EC50 values and total phenols contents of longan pericarp fractions [53]

	EC_{50} value (mg extract/mL)				Total phenols
Longan pericarp fractions	DPPH radical	Hydroxyl radical	ABTS radicals cation	Reducing poer	(mg/g)
LPCE	0.794±0.009	5.694±0.162	0.495±0.005	0.498±0.006	89.511±1.681
LPDF	0.523±0.004	4.752±0.087	0.296±0.003	0.260±0.020	132.209±4.070
LPEF	0.506±0.010	4.489±0.027	0.228±0.003	0.253±0.004	230.816±2.001
LPBF	1.061±0.022	7.980±0.042	0.447±0.016	0.407±0.009	124.128±3.467
LPR	5.190±0.043	16.833±0.067	2.926±0.044	2.172±0.030	8.327±1.364
VC	0.088±0.001	0.986±0.009	0.082±0.000	0.055±0.001	

order is: LPEF (99.39%) > LPDF (99.35%) > LPBF (88.11%) >LPCE (87.80%), while LPR have an obvious effect on ABTS radical cation when the concentration reached 7 mg/mL. As positive control, VC showed a high activity to ABTS radical at a low concentration, which ranged from 10.87% to 100.00% at the concentration of 0.02 to 0.2 mg/mL. EC50 of the extracts in ABTS radical cation activity varied from 0.228 to 2.926 mg/mL. ABTS radical cation activities were ranked in the following order: ethyl acetate fraction (LPEF) > diethyl ether fraction (LPDF) > n-butyl alcohol fraction (LPBF) > crude extract (LPCE) > residue fraction (LPR). ABTS assay is being widely used to measure the antioxidant activities of varieties of substances.

10. REDUCING POWER

The reducing power assay is mostly used to evaluate the ability of an antioxidant compounds to donate an electron because of the reducing capacity of a compound can serve as an important indicator of its potential antioxidant activities [64]. The reducing power of plant extracts is related with their antioxidant activity [14]. The reducing power of LPCE, LPDF, LPEF and LPBF increased from 0.07, 0.31, 0.32 and 0.21 at 0.15 mg/ mL to 1.00, 1.62, 1.79 and 1.01 at 0.9 mg/mL. LPR showed the lowest reducing power, with an absorbance of 0.932 at the concentration of 4.2 mg/mL [53].

11. ANTI-CANCER ACTIVITY

Polyphenol-rich extracts have an important role on anti-cancer effects [26]. Colorectal cancer is most common in Taiwan since 2007, when the diets of Taiwanese became more westernized. Longan flowers is rich source of two major compounds, (-)-epicatechin and proanthocyanidin A2 [58], which are also found in grape seed extract as active anti-colorectal cancer agents [65]. Hsu et al. [66] treated two colorectal cancer (CRC) cell lines, SW480 and Colo320 DM, which are derived from Duke's B and Duke's C patients respectively, with longan fruit extract, and found an inhibitory effect on the proliferation of these two cell lines in a dose- and time-dependent manner. LFE treatment also affected the anchorage-independent growth of these two cell lines [67]. The results revealed that malignant potential of CRC cells is influenced by LFE which help in prevention and curing of colorectal cancer. The grape seed extracts rich in proanthocyanidin cease G1-phase arrest of the cell cycle and help in inhibition of proliferation of the cancer cells [68]. Cyclin A is produced during the S phase and it can inhibit the chromosomal DNA replication in the cell [69]. Prasad et al. [70] also found that peel extract of longan fruit have anticancer activity against A549, HepG2, and SGC7901 cancer cell lines. Longan seed extracts are rich in polyphenol extract also inhibited the proliferation of SW480, Colo 320 DM and HT-29 by blocking cell cycle during DNA synthesis and inducing apoptotic death, reduced the expression of cyclin A and cyclin D1, activated caspase 3 and increased the Bax/Bcl-2 ratio [18]. Result has shown that longan extract rich in polyphenol can be employed as a potential novel treatment agent for cancer. All the parts of longan are good sources of bioactive compounds that have many biological activities which are beneficial to the consumers (Tables 4 and 5).

Table 4. Bioactive compounds present in different parts of longan

Plant parts	Bioactive Compounds	Reference
Aril	Adenosine	[15]
	Gallic acid	[16]
	Lysophosphatidylcholine, phosphatidyl choline, phosphatidyl inositol, phosphatidyl serine, phosphatidylethanolamine, phosphatidate and phosphatidic acid glycerol	[25]
Pericarp	Flavonoids, and polysaccharides	[16,17]
Flower and seed	ProanthocyanidinA2, (-)-epicatechin, gallic acid and ellagicacid,	[57,16,11,23]
Seed	Ethyl gallate 1-β-Ogalloyl- D-glucopyranose, methyl brevifolin carboxylate, grevifolinand4-O-α-L-rhamnopyranosyl-ellagic acid, gallic acid, corilagin and ellagic acid	[24]
	Ellagitannins, corilagin, acetonyl-geraniin	[71,72,16]
Leave	Quercetin and quercitrin	-

Table 5. Biological activities of the different parts of longan

Plant parts	Biological Activities	References
Fruit	Stomachic, febrifuge, and vermifuge, and an antidote to poison	[23]
	Enhance learning and memory	[27]
Aril	Sedative andanalgesic effects	[15]
	DPPH radical-scavenging activity	[53,60]
Peels	Antioxidant activity	[61]
Seed	Antioxidant activity	[61]
	Treating bleeding, dampness, hernia, lymphomegaly of the neck and armpit, odour, scabies and eczema	-
Flower	Overcome micturition, urgency and voiding dysfunction	-
Leaf	Anti-mutagenic, anticarcinogenic, antibacterial, cytotoxic and antioxidant effect	[73,74,75]

12. CONCLUSION

Longan fruit contains good amounts of nutrients, polyphenolic and other compounds and it has been used in curing of many problems by human health. Aril, peel or seed extract of longan have anti-tyrosinase, anti-glycated, and anticancer properties, and memory-enhancing effects which contributed to healthy human health. Now a day minor fruit longan is becoming popular and some country shifted from litchi cultivation to longan cultivation.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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