Journal of Medicinal Plants Studies
www.PlantsJournal.com

ISSN (E): 2320-3862
ISSN (P): 2394-0530
NAAS Rating: 3.53
JMPS 2019; 7(4): 179-185

Received: 06-05-2019
Accepted: 10-06-2019

Mohamad Hesam Shahrajabian
(a) Biotechnology Research Institute, Chinese Academy of Agricultural Sciences, Beijing 100081, China
(b) Nitrogen Fixation Laboratory, Qi Institute, Building C4, No. 555 Chuangye Road, Jiaxing 314000, Zhejiang, China

Wenli Sun
(a) Biotechnology Research Institute, Chinese Academy of Agricultural Sciences, Beijing 100081, China
(b) Nitrogen Fixation Laboratory, Qi Institute, Building C4, No. 555 Chuangye Road, Jiaxing 314000, Zhejiang, China

QI Cheng
(a) Biotechnology Research Institute, Chinese Academy of Agricultural Sciences, Beijing 100081, China
(b) Nitrogen Fixation Laboratory, Qi Institute, Building C4, No. 555 Chuangye Road, Jiaxing 314000, Zhejiang, China

Correspondence
QI Cheng
(a) Biotechnology Research Institute, Chinese Academy of Agricultural Sciences, Beijing 100081, China
(b) Nitrogen Fixation Laboratory, Qi Institute, Building C4, No. 555 Chuangye Road, Jiaxing 314000, Zhejiang, China

Modern pharmacological actions of Longan fruits and their usages in traditional herbal remedies

Mohamad Hesam Shahrajabian, Wenli Sun and QI Cheng

Abstract
Longan is an ever green tree of the *Sapindaceae* family. Longman fruit is grown commercially in many countries like China, India, Thailand, Vietnam and etc. In China, import of the longan fruit has been increasing in recent years. Longan are demanded in the market in various types such as fresh, dried, frozen and processed. Twelve important compounds longan are (1) β-sitosterol, (2) 2-phenylethanol, (3) 2-methyl-1,10-undecanediol, (4) (24R)-6β-hydroxy-24-ethyl-cholest-4-en-3-one, (4) Oleanolic acid, (5) Pinoresinol, (7) Nicotinic acid, (8) 4-hydroxybenzoic acid, (9) β-daucosterol, (10) 1-O-methyl-D-myo-inositol, (11) Uracil, and (12) Adenosine. The most important antioxidant compounds extract from longan shell are isovanillin, scopoletin, quercetin, hyperin, astragalin, and β-phenylethyl alcohol. The longan is suitable for the tropical zone subtopics in heat season. The flesh fruit is much in juicy, low in acid, high in sugar. Longan fruit has high nutritional and medicinal values and its main functional metabolites include polysaccharides, flavonoids, alkaloids and carotenoids. The functional metabolites provide medicinal, anticancer and antiaging benefits to humans. Longan fruit is used for enhancing memory, promoting blood metabolism, relieving insomnia and preventing amnesia. Its secondary metabolic products have been also shown to have anti-oxidative, anti-obesity, anti-cancer, anti-tyrosinase and immunomodulatory activities. Both longan flowers (long yan hua) and fruit (long yan rou) are used in traditional Chinese medicine and herbal preparations, but the fruit is used much more frequently. Longan contains several vitamins and minerals, including iron, magnesium, phosphorus and potassium and large amounts of vitamins A and C. In traditional Chinese medicine, longan fruits are considered warm, sweet and astringent. Many parts of the plant are used medicinally including the fruit itself, and dried fruits, relieves anxiety. The leaves are cool the system, and the flowers and seeds aid the kidneys. The roots are used to treat diabetics and to treat gonorrhea. All in all, the most important health benefits of longan are skin care, anti-aging, boosts libido, anti-anxiety, treats insomnia, blood tonic, promotes weight loss, increases energy, controls blood pressure, neuroprotection, strengthens immunity, speeds-up healing, prevents chronic diseases, aids in digestion, improves memory, vision health, useful in treating snake bites, and appropriate in dental care. The obtained findings suggest potential of longan as superfruit and its extract as an additive in the food and pharmaceutical industries. The bioactive compounds and pharmaceutical characteristics of longan should be studied to cosmetic and pharmaceutical products in the future.

Keywords: Longan, traditional chinese medicine; modern pharmacological science

Introduction

Longan occurrence and cultivation

Traditional Asian medicine, especially traditional Chinese medicine (TCM) become more integrated into medical practice in the west [1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11]. Longan (*Dimocarpus longan* Lour.) is an important economic fruit in South and South East of China [12]. Longan is the member of Sapindaceae family, and like other important tropical fruit crops, such as lychee and rambutan, is native to Southern China. Other important edible fruit species of Sapindaceae family are lychee (*Litchi chinensis* Sonn.), rambutan (*Nephelium lappaceum* L.), guarana (*Paullinia cupana* Kunth), korlan (*Nephelium hypoleucum* Kurz), pitomba (*Talisia esculenta* Radlk), Spanish lime (*Melicoccus bijugatus* Jascq.), pulasan (*Nephelim mutabile* Blume) or ackee (*Blighia sapida* K.D. Koenig) [13]. The genus Dimocapus contained six species, out of which five species (*Dimocarpus longan*, *Dimocarpus dentatus*, *Dimocarpus gardneri*, *Dimocarpus foveolatus* and *Dimocarpus fumatus*) exists in Asian countries stretching from India to eastern Malaysia and one (*Dimocarpus australianus*) in Australia [14]. But the major cultivated longan in different areas is *Dimocarpus longan* [15]. Local names in English are lungan, longan tree, longan, dragon, s eye, in French is loganier, in German is longanbaum, in Spanish are mamoncillo chino and longan. The use of $KClO_3$ became a common practice

amongst growers, which helped considerably to overcome the problem of biennial bearing and to produce economically viable off-season longan fruit. The unique flower inducing effect of $KClO_3$ in longan within 17-28 days of treatment provides an excellent opportunity for scientists to study the physiological mechanisms during the transition process from vegetative to floral bud development [16]. Longan scientific classification is shown in Table 1.

Table 1: Longan scientific classification.

Kingdom	Plantae
Unranked	Angiosperms
Unranked	Eudicots
Unranked	Rosids
Order	Sapindales
Family	Sapindaceae
Genus	Dimocarpus
Species	*D. longan*

Longan nutritional composition and chemical constituents

Runato and Chaiwong [17] found that soluble solids content (SSC) increased rapidly in parallel with enhancing fruit size and maturity until around week 27 after floral emergence. At the end of the ripening process, it reached the maximum level at 25.07±1.21 ºBrix when the longan fruits were around 95% of the final size, and after that SSC started to significantly and quickly decrease even thought the fruit size was still slightly growing. Moreover, in his experiment, shoot content of N, P, K, Ca, Mg, Fe, Mn and Al declined with increase in soil Al, which demonstrated that longan is highly susceptible to acid soils. Prukwarun *et al*. [18] found that the quality of dried product depends on the temperature and velocity at each position in the dryer. Sodchit *et al*. [19] stated that the longan fruits treated with N-acetyl-L-cysteine tended to decrease disease incidence and lowered weight loss 2 compared with those treated with 4-hexylresorcinol. Phytochemical analysis from *Dimocarpus longan* aerial parts extract is shown in Table 2.

Table 2: Phytochemical analysis from *Dimocarpus longan* aerial parts extract [20].

Constituents	Chloroform	Ethyl acetate	Methanol 80%
Triterpenes and/or Sterols	+	+	+
Carbohydrates and/or glycosides	-	+	+
Flavonoids	-	+	+
Coumarins	-	-	-
Alkaloids and/or nitrogenous compounds	-	-	-
Tannins	-	+	+
Saponins	-	-	-

(+) presence of constituents, (-) absence of constituents

Table 3: The most important antioxidant compounds extracted from longan shell [21].

1. Isovanillin
2. Scopoletin
3. Quercetin
4. Hyperin
5. Astragalin
6. β-phenylethyl alcohol
7. Piperine

Table 4: Content of marker substance in longan seed extract [22].

Samples	Gallic acid (mg/g)	Corilagin (mg/g)	Ethyl gallate (mg/g)	Ellagic acid (mg/g)
DW	4.9	10.5	-	5.7
DL	5.7	20.8	2.4	8.9
DLP	72.8	159.2	24.8	73.6
DLPS	112.2	245.2	34.2	63.0

DW: Crude water extract; DL: Crude 50% ethanol extract; DLP: Ethyl acetate; DLPS: sub-fractions

Medicinal uses and potential health benefits of longan in traditional medicine and modern industry

In traditional Chinese medicine (TCM), longans are plants they belong to the Tonic herbs for Blood Deficiency category. Longans are plants that are warm in nature. Longans tase sweet and on the basis of five elements theory, sweet ingredients like longans tend to slow down acute reactions and detoxify body. The most actions of longans in traditional Chinese medicine are nourishes the blood, calms the spirit, relieves fatigue, especially mental fatigue. It is commonly combined with hers such as Dang Gui, Yuan Zhi, Suan Zao Ren and Ren Shen in formulas for heart and spleen deficiencies. Dried longan pulp has been widely used as traditional Chinese medicine for health protection mainly due to its immune-modulatory function [23]. Hsu *et al*. [24] reported that the fruit of *Dimocarpus longan* was used as a traditional Chinese medicine for different treatments, such as promoting blood metabolism, soothing nerves and relieving insomnia. Lin *et al*. [25] reported that longan flowers and seeds, two TCMs traditionally used for relieving pain and urinary diseases, and they exhibit strong anti-oxidant activity and possess rich amounts of polyphenolic species which could be applied for the treatment of diabetes and cancer. In TCM, longan flower extracts have anti-oxidant activity and effect on inflammation and metabolic disorders and anti-colorectal cancer effects of LFE [25]. Suttitanawat *et al*. [26] reported that longan has medicinal attributed and mineral salt properties that the body needs such as a slight amount copper, zinc and etc. Liu *et al*. [27] showed that longan barks and leaves not only were excellent sources of free-radical inhibitors, but also had potential use in the production of ellagic acid. They have found that the ellagic acid in longan barks and leaves exist mostly in the form of ellagitannins. The percentage yield of hot water extract in dried longan pulp was 40.36%, the total phenol and polysaccharide content is the extract was 12.15 mg/g and 58.4 mg/g, respectively [28]. Longan seeds have been found to be a rich source of antioxidant, phenolic compounds, such as gallic acid, corilagin and ellagic acid [29]. And it has been reported that gallic acid has a strong antioxidant effect, and ellagic acid has cytotoxic effect on cancer cells, but not normal human lung fibroblast cells [30]. Lee *et al*. [31] pointed out that longan seed extract is known for antioxidative, antiproliferative, anti-inflammatory, hypoglycemic and hypouremic effects. It has been reported to contain gallic acid, corilagin (an ellagitannin), ellagic acid, soyacerebrosides I and II, 1-O-β-D-glucopyranosyl-(2S,3R,4E,8E)-2-(2′-lignoceroyl amino)-4, 8-octadecadiene-1,3-diol(longan cerebroside I) and its 8 Zisomer (longan cerebroside II), momor-cerebroside I and phytolacca cerebroside [32]. Cheng *et al*. [33] found that the treated longan juice and its ethanol-

soluble sugar fraction promoted the growth of *Streptococus thermophiles*, *Lactobacillus acidophilus* and *Lactobacillus delbrueckii*, showing a good potential of the treated longan juice for producing functional foods and nutraceuticals. It has been reported that longan has ascorbic acid, and ascorbic acid is well known for its strong antioxidant activity [34], whilst gallic and ellagic acids have proven pharmacological properties such as antityrosinase, antiglycation, antifungal and anticancer [35]. Sudjaroen [36] indicated that the longan seed is the good source of chemo preventive agents for antimicrobial activity by inhibiting growth of *S. aureus*, *P. aeruginosa* and *C. albicans* and in vitro antimalarial activities to *P. falciparum*, with no evidence of cytotoxicity by in vitro cytotoxic screening assay with vero cells. They have also mentioned that gallic acid, ellagic acid and ellagitannins may play role of antimicrobial and antimalarial activities by precipitated microbial proteins. Rashed *et al*. [37] found that ethyl acetate from *Dimocarpus longan* aerial parts extract has shown anti-HIV-1 activity and the other extracts were active as anti-HIV-1 agents. In their experiment, phytochemical analysis of the plant extracts proves the presence of triterpenes, flavonoids, tannins and carbohydrate. Florenly *et al*. [38] stated that pre-treatment with *D. longan* peel fruit antidote reduced the levels of biochemical parameters and oxidative stress parameters, and the decreased levels of MDA, urea, creatinine, SGOT and SGPT were 51%, 74%, 30.26%, 31.37%, 26.74% and 67.19%, respectively. They have also found that the pre-treatment with *D. longan* peel fruit also reduced the damage in kidney tissue. Yang *et al*. [39] suggested that longan pericarp fractions possessed significant antioxidant activities and could be a promising source of natural antioxidant. Puspita *et al*. [40] confirmed that the longan leaf ethanol extract possess marked antiproliferative activity on cancer-derived cell lines. Rong *et al*. [41] noted that knowing the structural features and activities of active polysaccharide of longan gibes the insights into longan polysaccharide application as an immunomodulatory agent. Zhang *et al*. [42] showed that the aqueous extract from *longan dimocarpus* (Lour.) leaves could inhibit the occurrence of kidney calculi. Son *et al*. [43] observed that longan fruit extracts (LFE) has anti-osteoporotic activity through inhibition of osteoclast differentiation and may have potential as a herbal therapeutic or preventive agent for the treatment of osteoporosis. Huang *et al*. [44] showed the anti-inflammatory effects of the water extract of longan pericarp (WLP) maybe related to nitric oxide (NO) and tumor necrosis factor (TNF-α) suppression and associated with the increase in the activities of antioxidant enzymes, including catalase, superoxide dismutase and glutathione peroxidase. Overall, they have concluded that WLP might serve as a natural antioxidant and inflammatory inhibitor. Pan *et al*. (45) revealed that langan peel (MEL) and Soxhlet extract of Langan peel (SEL) showed excellent antioxidant, furthermore, the suitability of MEL and SEL as substitute of synthetic antioxidant 2,6-di-ter-butyl-4-methylphenol (BHT). The most important benefits of longan are skin care, anti-aging, boosts libido, flights anxiety, treats insomnia, it may use for blood tonic, promotes weight loss, increase energy, control blood pressure, strengthens immunity, it may use for neuroprotection, speeds-up healing, prevents chronic diseases, aids in digestion, improves memory, it may use for vision health, treats snake bites, dental care and etc. The most important side effects of longan are an increase risk of gastrointestinal distress and complications in pregnancy. Nutrition facts of longan fruit per 100 grams, percentage of RDA is shown in Table 5. Nutritional value of longan per 100 g fresh weight is presented in Table 6. Phytochemicals present in longan fruit pericarps and seed is shown in Table 7. Pharmacological properties in longan fruit portions is shown in Table 8.

Table 5: Nutrition facts of longan fruit per 100 grams, percentage of RDA (Recommended dietary allowance).

Vitamins	
Thiamine (B1)	(3% of RDA) 0.031 mg
Riboflavin (B2)	(12% of RDA) 0.14 mg
Niacin (B3)	(2% of RDA) 0.3 mg
Vitamin C	(101% of RDA) 84 mg
Minerals	
Calcium	(0% of RDA) 1 mg
Iron	(1% of RDA) 0.13 mg
Magnesium	(3% of RDA) 10 mg
Manganese	(2% of RDA) 0.052 mg
Phosphorus	(3% of RDA) 21 mg
Potassium	(6% of RDA) 266 mg
Sodium	(0% of RDA) 0 mg
Zinc	(1% of RDA) 0.05 mg
Protein	1.31g
Threonine	0.034 g
Isoleucine	0.026 g
Leucine	0.054 g
Lysine	0.046 g
Methionine	0.013 g
Phenylalanine	0.030 g
Tyrosine	0.025 g
Valine	0.058 g
Arginine	0.035 g
Histidine	0.012 g
Alanine	0.157 g
Aspartic acid	0.126 g
Glutamic acid	0.209 g
Glycine	0.042 g
Proline	0.042 g
Serine	0.048 g
Fat	0.1g
Energy	251 KJ (60 kcal)
Carbohydrates	15.14 g
Dietary fiber	1.1 g

Table 6: Nutritional value of longan per 100 g fresh weight [46].

	Longan
Water (g)	81
Protein (g)	1.2
Fat (g)	0.1
Carbohydrate (g)	16
Vitamin C (mg)	60
Thiamine (mg)	0.04
Niacin (mg)	1.0
Riboflavin (mg)	0.03
Phosphorus (mg)	26
Iron (mg)	0.4
Calcium (mg)	13

Table 7: Phytochemicals present in longan fruit pericarps and seeds [47].

Portion	Phytochemicals
Pericarp	Gallic acid, corilagin, (-)-epicatechin, ellagic acid and its conjugates, quercetin, flavones glycosides, 4-*O*-methylgallic acid, flavones glycosides, glycosides of quercetin and kaempferol, protocatechuic acid, brevifolin
Seed	Gallic acid, corilagin, ellagitannins corilagin, ellagic acid 4-*O*-α-L-arabinofuranoside, isomallotinic acid, geraniin, ethyl gallate, grevifolinand, 4-*O*-α-L-rhamnopyranosyl-ellagic acid, *p*-coumaric acid-glycoside, isoscopoletin, proanthocyanidins C1, 1-*O*-galloyl-D-glucopyranose, (S)-flavogallonic acid, methyl ellagic acid glucopyranoside

The pericarp and seed portions as the by-products of longan fruits are estimated to be approximately 30% of the dry weight of the whole fruit and are rich in bioactive constituents. Many biological activities such as tyrosinase inhibitory, antioxidant, anti-inflammatory, immunomodulatory, anti-glycated, and anti-cancer activities as well as memory-increasing effects, have been reported for longan pericarp and seed extracts [47]. Phytochemical analysis of the extracts of longans is shown in Table 9. The most important health benefits of longan is shown in Table 10.

Table 8: Pharmacological properties in longan fruit portions [47].

Pharmacological properties	Longan
Antioxidant activity	Pericarp and seed
Antimicrobial activity	Seed
Anti-cancer activity	
Anti-inflammatory property	
Immunomodulatory activity	Pericarp
Anti-diabetes	Pericarp
Anti-cardiovascular activity	
Anti-edema	
Anti-fragility	
Anti-liver injury	
Antiviral activity	

Table 9: Phytochemical analysis of the extracts of longans [48].

Phytoconstituents	Seed extract	Peel extract
Alkaloids	A	A
Proteins	P	P
Carbohydrates	P	P
Glycosides	P	P
Fixed oils	P	P
Tannins and Phenolic compounds	P	P
Flavonoids	P	P
Steroids	P	P

A= Absent, P = Present

Table 10: The most important health benefits of longan.

1. It can protect the brain
2. It may boost the immune system because of vitamin C
3. It may reduce inflammation
4. It may be an antioxidant
5. It can combat cancer because it is containing polyphenols
6. It may help with diabetes
7. It can help with insomnia or any sleeping disorder
8. It may reduce blood pressure
9. It can improve anemia because it is rich of iron
10. It can improve gout
11. It can help burn fat
12. It may improve memory
13. It can boost energy levels
14. It may be anti-aging
15. It can boost bone health
16. It is an excellent stress remedy
17. As Qi tonic for energy booster
18. It is good for healthy weight loss diet
19. It is a natural remedy for stomachache
20. It is good for oral health
21. It uses as wound recovery enhancer

Panyathep *et al*. [49] mentioned that in Chinese medicine, the flesh of the fruit is used a stomachic, febrifuge, vermifuge, and as an antidote for poison, and the dried longan is also used as a tonic and or the treatments of insomnia and neurasthenic neurosis. Longans and red dates together produce amazing health benefits especially in boosting the immune system and replenishing the blood. Rashed and Fouche [50] showed that petroleum extract of *D. longan* leaf has a significant anticancer effect on UACC62 (melanoma) cancer cells, so it *D. longan* leaf could be helpful in cancer prevention and treatment. Anticancer activity of *D. longan* leaf extracts.

Table 11: Anticancer activity of *D. longan* leaf extracts [50].

Extract	Con., µg/ml	Growth TK10, %	SD	Growth UACC62, %	SD	Growth MCF7, %	SD
Petroleum ether extract	100	-25.92	0.021	-77.40	0.094	24.48	0.088
Chloroform	100	-4.04	0.046	-21.79	0.002	0.92	0.007
Ethyl acetate	100	87.35	0.026	58.38	0.077	66.03	0.073
Methanol 80%	100	86.12	0.056	52.52	0.007	54.34	0.128
EMETINE	10µM	-61.35	0.007	-86.66	0.006	-46.41	-61.35

SD is standard deviation. % Growth is the net growth of the cells in treated wells compated to untreated controls over the 48h experimental period, i.e. 100% growth means there are the same amount of cells in treated wells as in untreated control wells; 0% growth means the treated wells contain the same number of cells as at the start of the incubation, time 0 (thus no increase in cell number); -100% growth means there are no cells left in the well after 48h.

Yi *et al*. [51] indicated that the amino acid-involved Maillard reactions (MR) is a promising method to modify native polysaccharides for better biological properties. Albicans to acrylic strips, which indicated that longan seed extract and its polyphenolic compounds can be used as an antifungal agent in oral care products for the treatment of opportunistic yeast infection. Li and Tao [52] found that powedered longan shell was a promising biosorbent for rapid removal of cationic dyes from aqueous solution. Park *et al*. [53] suggested that longan fruit extract (LEF) exerts its osteogenic activity through activation of the ERK signaling pathway and may have potential as an herbal therapeutic or a preventive agent for the treatment of osteoporosis. Tseng *et al*. [54] discovered that the sub-fraction of ethyl acetate extract showed antimicrobial activity on several microorganisms, which could be used as natural antimicrobial agents in skin care and human health. Yi *et al*. [55] demonstrated that the polysaccharide-protein complexes of longan pulp have medical potential as

immunotherapeutic adjuvants due to their immunomodulatory activities. Tang *et al*. [56] found that flavonoids in seed and alkaloids in pericarp had potential to be developed as anti-hyperglycemic agents. Fu *et al*. [57] indicated that longan pericarp proanthocyanidins (LPPs) are promising antioxidant which could be applied as potential functional food components. Rerk-am *et al*. [58] expressed that the crude ethanolic extracts of longan peels and seeds exhibit good antioxidant activity; the obtained extracts were consisted of polyphenolic compounds, namely gallic acid, corilagin and ellagic acid. Losuwannarak *et al*. [59] explored that longan seed extract could be beneficial for memory impairment in Alzheimer's disease in which cholinergic deficit is one of the hallmarks.

Conclusion

Longan fruits are preferably eaten fresh, and they have a delicate and sweet-tasting flesh. This fruit can also be processed to make dried pulp, canned fruit, jam, drinks and wine. This review article allowed verifying that longan is an important sources of compounds with valuable nutritional and bioactive properties, but more clinical studies may necessary to uncover the numerous substances and their effects in longan that contribute to public health.

Financial disclosure: No financial disclosure was declared by the authors.

Conflict of interest: No conflict of interest was declared by the authors.

References

1. Soleymani A, Shahrajabian MH. Response of different cultivars of fennel (*Foeniculum vulgare*) to irrigation and planting dates in Isfahan, Iran. Research on Crops. 2012; 13(2):656-660.
2. Ogbaji PO, Shahrajabian MH, Xue X. Changes in germination and primarily growth of three cultivars of tomato under diatomite and soil materials in auto-irrigation system. International Journal of Biology. 2013; 5(3):80.
3. Yan ZT, Zou JW. Triptolide as an alternative to IVIG therapy for Kawasaki disease in a mouse model. Balkan Medical Journal. 2013; 30:225-228.
4. Akin Y, Young M, Elmussareh M, Charalampogiannis N, Gozen AS. The novel and minimally invasive treatment modalities for female pelvic floor muscle dysfunction; beyond the traditional. Balkan Medical Journal. 2018; 35:358-366.
5. Ogbaji PO, Li J, Xue X, Shahrajabian MH, Egrinya EA. Impact of bio-fertilizer or nutrient solution on Spinach (*Spinacea Oleracea*) growth and yield in some province soils of P.R. China. Cercetari Agronomice in Moldova. 2018; 2(174):43-52.
6. Shahrajabian MH, Sun W, Cheng Q. A review of goji berry (*Lycium barbarum*) in traditional Chinese medicine as a promising organic super food and super fruit in modern industry. Academia Journal of Medicinal Plants. 2018; 6(12):437-445.
7. Soleymani A, Shahrajabian MH. Changes in germination and seedling growth of different cultivars of cumin to drought stress. Cercetari Agronomice in Moldova. 2018; 1(173):91-100.
8. Shahrajabian MH, Sun W, Cheng Q. The power of natural Chinese medicine, ginger and ginseng root in an organic life. Middle-East Journal of Scientific Research. 2019a; 27(1):64-71.
9. Shahrajabian MH, Sun W, Cheng Q. Clinical aspects and health benefits of ginger (*Zingiber officinale*) in both traditional Chinese medicine and modern industry. Acta Agriculturae Scandinavica, Section B-Soil & Plant Science, 2019b, 1-11.
10. Shahrajabian MH, Sun W, Cheng Q. Traditional Chinese medicine and agriculture; organic life and sustainability for future. GSC Biological and Pharmaceutical Sciences. 2019c; 7(01):091-095.
11. Shahrajabian MH, Sun W, Cheng Q. A review of ginseng species in different regions as a multipurpose herb in traditional Chinese medicine, modern herbology and pharmacological science. Journal of Medicinal Plants Research. 2019d; 13(10):213-226.
12. Qiu DL. Longan Production and Research in China. Acta Hortic. 2014; 1029:39-46.
13. Pham VT, Herrero M, Hormaza JI. Fruiting pattern in longan (*Dimocarpus longan*) from pollination to aril development. Annals of Applied Biology 2016 Article in Press, First published: DOI: 10.1111/aab.12306
14. Gupta AK, Singh M, Marboh ES, Nath V, Pongener A, Anal AKD. Pollen quantity, viability and in vitro pollen germination of longan (*Dimocarpus longan* Lour.). International Journal of Current Microbiology and Applied Sciences. 2017; 6(7):270-278.
15. Pham VT, Herrero M, Hormaza JI. Effect of temperature on pollen germination and pollen tube growth in longan (*Dimocarpus longan* Lour.). Scientia Horticulturae. 2015; 197:470-475.
16. Hegele M, Manochai P, Naphrom D, Sruamsiri P, Wunsche J. Flowering in longan (*Dimocarpus longan* L.) induced by hormonal changes following $KClO_3$ applications. Europ. J. Hort. Sci. 2008; 73(2):49-54.
17. Ruanto P, Chaiwong M. Fruit size and soluble solids content in relation to growth and development of longan (*Dimocarpus longan*). International Journal of Agricultural Technology. 2018; 14(2):233-240.
18. Prukwarun W, Khumchoo W, Seancotr W, Phypaichitkun S. CFD simulation of fixed bed dryer by using porous media concepts: Unpeeled longan case. International Journal of Agricultural and Biological Engineering. 2013; 6(1):100-110.
19. Sodchit C, Kongbangkerd T, Phun WN. Prevention of enzymatic browning of postharvest longan fruit by N-acetyl-L-cysteine and 4-hexylresorcinol. Songklanakarin J. Sci. Technol. 2008; 30(1):31-35.
20. Rashed K, Luo MT, Zhang LT, Zheng YT. Anti-HIV-1 activity of *Dimocarpus longan* Lour. extracts and the main chemical content. Global Journal of Microbiology and Biochemistry. 2013; 1:1-7.
21. Li ZH, Wang QM, Pan YM. Study on the antioxidant compounds extracted from longan (*Dimocarpus longan* Lour.) shell. Asian Journal of Chemistry. 2014; 26(15):4602-4604.
22. Tseng HC, Wu WT, Huang HS, Wu MC. Quantification of fractions from longan seeds and their antimicrobial activity. International Journal of Medical Sciences and Biotechnology. 2013; 1(4):1-17.
23. Yi Y, Wang H, Zhang R, Min T, Huang F, Liu L, *et al*. Characterization of polysaccharide from longan pulp as the macrophage stimulator. RSC Adv. 2015; 5:97163-97170.
24. Hsu HY, Chen YP, Sheu SJ, *et al*. Oriental Materia

Medica- A Concise Guide, Modern Drug Weekly of Taiwan, Taipei, Taiwan, 1985.
25. Lin CC, Chung YC, Hsu CP. Potential roles of longan flower and seed extract for anti-cancer. World Journal of Experimental Medicine. 2012; 2(4):78-85.
26. Suttitanawat P, Sruamsiri P, Sringarm K. Changes in cytokinins concentrations during induction period of longan cv. Dae in sand culture. Journal of Agricultural Technology. 2012; 8(7):2353-2362.
27. Liu Y, Liu L, Mo Y, Wei C, Lv L, Luo P, *et al*. Antioxidant activity of longan (*Dimocarpus longan*) barks and leaves. African Journal of Biotechnology. 2012; 11(27):7038-7045.
28. Kunworarath N, Rangkadilok N, Suriyo T. Longan (*Dimocarpus longan* Lour.) inhibits lipopolysaccharide-stimulated nitric oxide production in macrophages by suppressing NF-κB and AP-1 signaling pathways. J. Ethnopharmacol. 2016; 179:156-161.
29. Rangkadilok N, Sitthimonchai S, Worsuttayangkurn L, Mahidol C, Ruchirawat M, Satayavivad J, *et al*. Evaluation of free radical scavenging and antityrosinase activities of standardized longan fruit extract. Food Chem Toxicol. 2007; 45:328-336.
30. Jadon A, Bhadauria M, Shukla S. Protective effect of *Terminalia belerica* Roxb. and gallic acid against carbon tetrachloride induced damage in albino rats. J Ethnopharmacol. 2007; 109:214-218.
31. Lee CH, Chen YS, Hou CW, Jeng KC, Chen KS. Anti-inflammatory effect of longan seed extract in carrageenan stimulated Sprague-dawley rats. Iranian Journal of Basic Medical Sciences. 2016; 19(8):870-874.
32. Rangkadilok N, Worasuttayangkurn L, Bennett RN, Satayavivad J. Identification and quantification of polyphenolic compounds in Longan (*Euphoria longana* Lam.) fruit. J. Agric. Food chem. 2005; 53:1387-1392.
33. Cheng Y, Lan H, Zhao L, Wang K, Hu Z. Characterization and prebiotic potential of longan juice obtained by enzymatic conversion of constituent sucrose into fructo-oligosaccharides. Molecules. 2018; 23:2596.
34. Zaouay F, Salem HH, Labidi R, Mars M. Development and quality assessment of new drinks combining sweet and sour pomegranate juices. Emir. J. Food Agric. 2014; 26(1):1-8.
35. Yang B, Jiang Y, Shi J, Chen F, Ashraf M. Extraction and pharmacological properties of bioactive compounds from longan (*Cimocarpus longan* Lour.) fruit-A review. Food Res. Int. 2011; 44:1837-1842.
36. Sudajaroen Y. Screening for antimicrobial and antimalarial activities of longan (*Cimocarpus longan* Lour) seeds. Scientific Research and Essays. 2010; 8(18):718-721.
37. Rashed K, Luo MT, Zhang LT, Zheng YT. Anti-HIV-1 activity of *Dimocarpus longan* Lour. extracts and the main chemical content. Global Journal of Microbiology and Biochemistry. 2013; 1:1-7.
38. Florenly, Fachrial E, Aziz H, Syafrizayanti, Zein R. The effect of Cr (VI) in the kidney of experimental rats and utilization of longanpeel fruit (*Dimocarpus longan*) as renal protector in dentistry. Der Pharma Chemica. 2016; 8(16):144-148.
39. Yang X, Yan F, Huang S, Fu C. Antioxidant activities of fractions from longan pericarps. Food Sci. Technol, Campinas, 2014. DOI: http://dx.doi.org/10.1590/S0101-20612014005000034
40. Puspita R, Bintang M, Priosoeryanto BP. Antiproliferative activity of longan (*Dimocarpus longan* Lour.) leaf extracts. Journal of Applied Pharmaceutical Science. 2019; 9(5):102-106.
41. Rong Y, Yang R, Yang Y, Wen Y, Liu S, Li C, *et al*. Structural characterization of an active polysaccharide of longan and evaluation of immunological activity. Carbohydrate Polymers, 2019, 231. DOI: 10.1016/j.carbpol.2019.03.007
42. Zhang LY, Ye D, Lou ZH. Inhibitory effects of aqueous extract from longan (*Dimocarpus longan* Lour) leaves on kidney calculi. Modern Food Science and Technology. 2018; 34(2):25-31.
43. Son Y, Lee EM, Lee DY, Lee JH, Oh S. Longan fruit increase bone mineral density in zebrafish and ovariectomized rat by suppressing RANKL-induced osteoclast differentiation. Phytomedicine. 2019; 59:152910.
44. Huang GJ, Wang BS, Lin WC, Huang SS, Lee CY, Yen MT, *et al*. Antioxidant and anti-inflammatory properties of longan (*Dimocarpus longan* Lour.) pericarp. Hindawi Publishing Corporation, Evidence-Based Complementary and Alternative Medicine. Article ID 709483, 10, 2012.
45. Pan Y, Wang K, Huang S, Wang H, Mu X, He C, *et al*. Antioxidant activity of microwave-assisted extract of longan (*Dimocarpus longan* Lour.) peel. Food Chemistry. 2008; 106:1264-1270.
46. Deng XM, Han ZH, Li SH. Fruit tree biology. Higher Education Press, Beijing, China, 141, 1999.
47. Zhu XR, Wang H, Sun J, Yang B, Duan XW, Jiang YM, *et al*. Pericarp and seed of litchi and longan fruits: constituents, extraction, bioactive activity, and potential utilization. Journal of Zhejiang University-Science B (Biomedicine & Biotechnology). 2019; 20(6):503-512.
48. Muthukumarasamy R, Ilyana A, Fithriyaani NA, Najihah NA, Asyiqin N, Sekar M, *et al*. Formulation and evaluation of natural antioxidant cream comprising methanolic peel extract of *Dimocarpus longan*. International Journal of Pharmaceutical and Clinical Research. 2016; 8(9):1305-1309.
49. Panyathep A, Chewonarin T, Taneyhill K, Vinitketkumnuen U. Antioxidant and anti-matrix metalloproteinases activities of dried longan (*Euphoria longana*) seed extract. Science Asia. 2013; 39:12-18.
50. Rashed KN, Fouche G. Anticancer activity of *Dimocarpus longan* Lour. leaf extracts in vitro and phytochemical profile. Greener Journal of Medicinal Plant Research. 2013; 1(1):001-005.
51. Yi Y, Han MM, Huang F, Wang LM, Min T, Wang HX, *et al*. Effects of a lysine-involved maillard reaction on the structure and in vitro activities of polysaccharides from longan pulp. Molecules. 2019; 24:972.
52. Li S, Tao M. Removal of cationic dyes from aqueous solutions by a low-cost biosorbent longan shell. Dealination and Water Treatment. 2016; 57:5193-5199.
53. Park S, Kim JH, Son Y, Goh S, Oh S. Longan (*Dimocarpus longan* Lour.) fruit extract stimulates osteoblast differentiation via ErK1/2-Dependent RUNX2 activation. J. Microbiol. Biotechnol. 2016; 26(6):1063-1066.
54. Tseng HC, Wu WT, Huang HS, Wu MC. Quantification of fractions from longan seeds and their antimicrobial activity. International Journal of Medical Sciences and Biotechnology. 2013; 1(4):1-17.
55. Yi Y, Liao ST, Zhang MW, Shi J, Zhang RF, Deng YY, *et al*. Physiochemical characteristics and

immunomodulatory activities of three polysaccharide-protein complexes of longan pulp. Molecules. 2011; 16:6148-6164.
56. Tang YY, He XM, Sun J, Li CB, Li L, Sheng JF, *et al*. Polyphenols and alkaloids in byproducts of longan fruits (*Dimocarpus longan* Lour.) and their bioactivities. Molecules. 2019; 24:1186.
57. Fu C, Yang X, Lai S, Liu C, Huang S, Yang H. Structure, antioxidant and α-amylase inhibitory activities of longan pericarp pronathocyanidins. Journal of Functional Foods. 2015; 14:23-32.
58. Rerk-am U, Runglert K, Eiamwat J, Kongsombat B, Sematong T, Tangsatirapakdee S, *et al*. Thai Journal of Pharmaceutical Sciences. 2016; 40:120-122.
59. Losuwannarak N, Pasadhika C, Tantisira MH, Tantisira B. Effects of longan seed extract on scopolamine-induced learning and memory deficit in mice. Thai Journal of Pharmaceutical Sciences. 2009; 33:31-38.