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# A Review on Therapeutic Potential and Nutritional Composition of Eggplant

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**Abstract**

*Solanum melongena L. is commonly known as eggplant. It is a world famous vegetable throughout the mediterranean, tropics and sub-tropics regions. Eggplant is also well-known to contain various antioxidants such as a-carotene, lutein, lycopene, kaempferol and myricetin. It is helpful in digestion, anaemia, lowering cholesterol and high blood pressure. This review will highlight nutritional value and health benefits of eggplant.*

**Keywords**: *Solanum melongena* L., Eggplant, Chemical composition, Health benefits

## INTRODUCTION

### Botanical classification of eggplant

*Solanum melongena* L. is commonly known as eggplant; belongs to kingdom Plantae. Its sub-kingdom is Viridiplantae, super division: Embryophyta, division: Tracheophyta, sub-class: Asteridae, class: Magnoliopsida, order: Solanales, family: Solanaceae and genus is *Solanum*.

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**The family Solanaceae**

The family Solanaceae includes the vegetables known as nightshade, contains about 2,000 various species. Their variety extends from flowers to toxic herbs but still the vegetables are important and dominant part of the family. The toxicity is caused due to presence of certain alkaloidal compounds, which are harmful for health. This family contains the commonly used species such as potato, tomato, chilli and eggplant. These vegetables are economically very important. This family is also known as potato family. Eggplant is an important part of Solanaceae family, used commonly in diet throughout the world and beneficial for human beings.

**The genus *Solanum***

*Solanum* is an important and diverse genus of flowering plants. It includes different food crops, contain high economic values. This genus includes nightshade and several plants cultivated for ornamental fruits and plants. Eggplant's genus is *Solanum,* and this genus contains about 1,500-2,000 species worldwide. Most parts of plants mainly unripe fruits and green parts are highly poisonous for human beings but several species contain some edible parts including fruits, leaves or tubers.

**History and world distribution of eggplant**

Initially eggplant belongs to the famous country India. Eggplant cultured in eastern and southern Asia since early history but later introduced to the western world no previously than ca. 1500 C.E. In middle ages, eggplant was introduced through mediterranean region by the Arabs. Botanical name *Solanum melongena* was given to eggplant from sixteenth-century. Some fruits of look like hen's eggs and some cultivars have yellow or white colour, that's why named as eggplant. It became famous as eggplant in different countries including Australia, Canada, United States and New Zealand (Figure 1). The names brinjal and aubergine of *Solanum melongena* L. are derived from Arabic and Sanskrit (Doijode, 2001). 49.4 million tones production of eggplants was reported from whole world in 2013, and 1,600,000 hectares (4,000,000 acres) are used for agriculture of eggplants. Maximum production was observed from China (57 %) whereas India (27 % of the world). Egypt, Turkey and Iran are responsible for main production and also combined with several other republics of Asia, produced up to 94 % production of eggplants in whole world. Several varieties of eggplant are described in Table-1.

**Cultivation in Pakistan**

Basically eggplant is a Kharif vegetable. Kharif crops or monsoon crops are defined as plant crops that are cultivated and harvested in South Asia throughout the rainy period, which continues from April to October dependent

on the growing area. In 2014-15, the production of eggplant is 82,999 tones in Pakistan with the area of 8,325 hectares. Eggplant mostly cultivated at Punjab province, its cities accounted for major production includes Faisalabad, Gujranwala and Multan. In Sindh, Hyderabad is important production center (Figure 2). In Khyber Pakhtunkhwa, Swat is responsible for main production whereas Quetta in Balochistan is main production region (Randhawa et al., 2016).

**Health benefits of eggplant**

Eggplant is a significant yield of tropics and sub-tropics regions. Eggplant acts as a principal component in vegetarian food due to its meaty texture. It is also known as the 'King of vegetables' due to its common use by people around the ecosphere.

**Worthy for diabetics**

Eggplant contains great amount of fiber content and fewer amount of carbohydrates. That's why eggplant recognized to be worthy for individuals having diabetes due to fiber content. Fibers monitor the glucose absorption in the body from food and therefore helpful in maintenance of blood sugar level in the body.

**Control cholesterol and high blood pressure**

It contains enormous quantity of calcium, potassium, phosphorous and magnesium. These minerals support in balancing of electrolytes in the human body. Furthermore, it is useful in neutralization of sodium in the human body thus helpful in blood pressure regulation system. It was also reported that higher consumption of anthocyanins pigments, which present in significant extents in eggplant also maintain blood pressure level from high to normal. It also contains important phenolic components i.e. chlorogenic acid, which acts as a dominant antioxidant representative, decreasing cholesterol levels within the human body. Eggplant also includes great quantities of fiber, which raises the absorption of blood cholesterol through the liver for production of bile.

**Birth defect prevention**

Folates act as vital part of any food item, and folic acid is highly important and contains various beneficial effects for pregnant women. It prevents infants from defects of neural tubes, which is highly harmful for new born. Thus, the pregnant ladies maintain a diet plan contains enough amount of folic acid. Eggplants are main sources of folic acid. Eggplant creates a health beneficial and delicious snack or any other dietary items in condition of pregnancy.

**Bone health**

Consistent intake of eggplant is very helpful for handling great incidence of osteoporosis and deprivation of bone. Phenolic compounds cause pigmentation to numerous vegetable and fruits. These compounds are responsible for reducing the risk of osteoporosis and play important role in good health and for strength of bone. Eggplants contain major quantities of calcium and iron. These metals play important role in bone health. Finally, the potassium in this vegetable supports in the absorption of calcium; thus representing eggplants as an extensive and extremely useful promoter for bone health and osteoporosis (Karamati et al., 2012).

**Weight loss**

Eeggplant does not have cholesterol or fat, so eggplant has the healthy component of food for all individuals, who are trying to fight obesity complications or reduce weight. Presence of fiber content is also sufficient. They stop the releasing a hormone named ghrelin, which transport communication to human mind that they are again hungry. Only by decreasing our hunger, the risks of overeating are significantly decreased; thus efforts of decreasing weight become more effective.

**Digestion**

Eggplant is one of the extreme sources of dietary fibers, which are very vital for healthiness of gastrointestinal activity of the intestines. They support to maintain bowel activities so the food pass through the digestive system simply, though also boosting peristaltic activities, the narrowing process of the smooth and soft muscles that cause movement of food inside the body. Lastly, fibers boost the secretion process of gastric juices, which enable absorption process of nourishments and certain nutrients (Guimarães et al., 2000).

**Anaemia**

Iron insufficiency is very hazardous generally for health. It can apparent in anaemia condition. This condition is defined by migraines and headaches, depression, cognitive fault, weakness and fatigue. Nutrition intake great in iron content can beneficial to fight against anaemia. Eggplants contain significant amount of iron in edible and meaty fruit. They also contain copper which is additional vital constituent of red blood cells (RBCs). Healthier and improved RBC's are flowing over veins in body resulting in obvious improvement in strength and energy as well as elimination of feelings of exhaustion, stress or fatigue.

**Chemical composition of eggplant**

Eggplants comprises of many nutrients, which are required for body mainly for growth, repair of damaged tissues and then for protection. They are host of vitamins, minerals, dietary fibers, proteins and antioxidants (Fraikue, 2016).

**Flavonoids**

The main flavonoid constituent in eggplant is known as nasunin. It is the radish purple pigment, produced in red turnip and peel of eggplant. Previous study demonstrate that the nasunin in numerous eggplant varieties present up to 70 to 90 % of the total amount of anthocyanins in the peel part though the definite amount is still not confirmed. It acts as antioxidant that efficiently scavenges several reactive species e.g. superoxide, hydroxyl and hydrogen peroxide. It also prevents the production of hydroxyl radicals, possibly in the Fenton reaction by chelation of ferrous ions. By iron chelating activity, nasunin reduces free radical production with numerous useful effects such as protection of cholesterol of blood from peroxidation process, avoiding injury in cellular system that can stimulate cancer process; and decreasing free radical injury in joints, which is a main feature in rheumatoid arthritis (Dias, 2012).

**Phenolics**

*Solanum melongena* L. is placed among top ten vegetables in whole world. Eggplant have oxygen radical scavenging ability due to presence of phenolic components. Anthocyanins is described as a significant group of natural pigments of purple or red coloured fruit. They are chief phenolic components present in peel of eggplant (Jung et al., 2011). The main phenolic component present in all varieties is known as chlorogenic acid, which acts as powerful free radical scavengers present in tissues of plant. It has antimicrobial, antimutagenic and antiviral properties. Black Magic is a well-known cultivar of eggplant, which has three times the quantity of phenolics as compared to the several other varieties of eggplant (Dias, 2012).

**Vitamins**

Eggplant is a very noble source of vitamins B1, B6, A, C, K, niacin and folate. The occurrence of these vitamins in major quantities clarifies the importance of vitamin quantified in this vegetable. Their beneficial effects include provision of normal visualization, cell growth and development gene expression, development of immunity role of body and maintenance of functions of epithelial cells. Numerous studies have exposed the vitamin C acts as antioxidant, which prevents cells from oxidative damage by reactive oxygen species. It is also significant for appropriate lung function and immunity (Kadiri et al., 2015).

### Carotenoids

Carotenoids contain several health benefits towards human as well as also act as pigments for photosynthesis and responsible for formation of different plant hormones. They act as strong antioxidants, and hence prevent from coronary cancers and heart diseases especially lycopene is linked with decrease the risk of diabetes and prostate cancer (Mibei et al., 2017). Eggplant also comprises carotenoids including lutein, α-carotene and lycopene (Dias, 2012).

### Minerals

Mineral occurrence is essential in living substances for their usual life processes. Eggplant has several macro- and micro-minerals, which are helpful for human health. Potassium is the plentiful mineral present in the eggplant. Its ranged from 200 to 600 mg/100 g of fresh material. Eggplant is also a good and rich source of magnesium, calcium and iron (Arivalagan et al., 2013).

### Dietary fibres

Dietary fibres comprising of lignin components and non-digestible carbohydrates, and that are essential for plants. They show a great diversity of physico-chemical activities due to presence of different macromolecules. The chief constituents involved are pectins, hemicelluloses, resistant starch, cellulose, lignin and non-digestible oligosaccharides. Eggplant is reflected as a worthy source of fibres for decreasing level of cholesterol (Jenkins et al., 2003).

## COMPOSITIONAL STUDIES OF EGGPLANT

### Physical attributes evaluation

Jha and Matsuoka (2002) investigated the changes in volume, mass and density of fresh and stored eggplants during storage period from 0 to 168 h at 15-30 °C and 90 % relative humidity in Japan. They observed that these properties were decreased at 25 °C. The storage period of 96 and 120 h was important for eggplant stored at 30 and 20-25 °C, respectively; later the decomposing of eggplant was observed whereas no change was observed at 15 °C. Concellón et al. (2007) determined the influence of low temperature (0-10 °C) during storage on physical parameters of eggplant in Argentina. They observed ultrastructural damage at 0 °C in flesh tissues.

### Chemical composition evaluation

Esteban et al. (1989) observed variations in the chemical composition of eggplant during storage of 21 days at 5, 10 or 20 °C in Spain. They concluded that titratable acidity was highly increased at 20 °C after 10 days of storage. Total and reducing sugars were risen from 4 to 14 days at 10 or 20 °C but

reduced at 5 °C whereas ascorbic acid declined (75 %) after 18 days at 10 or 20 °C.

Ossamulu et al. (2014) investigated the nutritional composition of four eggplant cultivars including *Solanum marcrocarpon* (round), *Solanum aetheopicum*, *Solanum marcrocapon* (oval), *Solanum gilo* in Nigeria. They observed that moisture content was high ranging from 88.31-91.94 % while the protein, ash, energy and fat contents were low in the cultivars although there were major differences in the fiber, moisture and ash contents among the four cultivars.

Khan et al. (2015) determined chemical composition of fruits and leaves of *Solanum melongena* L. in three brinjal genotypes shamli, black beauty and pearl long in Peshawar (Pakistan). They observed that moisture content (93 %) was higher in black beauty whereas ash content (6.4 %) in pearl long and crude fat (0.31 %), crude protein (1.51 %), fiber (1.33 %) and total sugars (4.22 %) in shamli. Marrugo-Ligardo et al. (2017) determined physico-soluble solids, ash content, brix, moisture content and pH in three types of eggplant variety including long residence, black beauty and violet long in order to determine development of a food product type based sauce eggplant (*Solanum melongena*) under different conditions in Colombia. Black beauty showed pH (5.0), brix (5.0 ºBx), moisture content (92.6 %) and ash content (0.5 %). They concluded that black beauty was better for usage based on physico-chemical and sensory analysis.

**Phenolics and antioxidant evaluation**

Asmah et al. (2007) investigated different varieties of eggplant in Cheras (Malaysia). They observed that nipples eggplant seeds showed the maximum percentage of free radical scavenging activity (95 %), followed by long eggplant (94 %), round eggplant (92 %), pipit eggplant (91 %) and nipples eggplant (89 %). The maximum value for TPC (mg GAE/100 g dry weight) was in the pipit eggplant (2,168 mg), followed by long eggplant (1,697 mg), round eggplant (1,539 mg), nipples eggplant seeds (1,434 mg) and nipples eggplant (728 mg). Tiwari et al. (2009) evaluated the phytochemical composition of crown of eggplant in India. They observed sufficient amount of various phytochemical components such as alkaloids, saponins, steroids, phenolics, flavonoids, proteins and carbohydrates. They concluded that crown of eggplant contains important components that perform pharmacological activities.

Nisha et al. (2009) performed a comparative study among different varieties of *Solanum melongena* L. in Kerala (India). They observed the highest radical scavenging activity in purple colour small size eggplant due to the presence of high TPC (106.98 mg/100 g) and anthocyanin content (0.756 mg/100 g). Okmen et al. (2009) determined the total phenolic content and antioxidant capacity in 26 different cultivars of eggplant in Turkey. They

observed significant antioxidant activity ranged (2664-8247 µmol Trolox/Kg) and total phenolic content (615-1376 mg/Kg) in different *Solanum melongena* L. cultivars.

Jung et al. (2011) investigated different parts of eggplant in Korea. They found higher total phenolic content in calyx (121.07 mg/g) whereas peel exhibited the maximum anthocyanins content (138.05 mg %). In ethanolic and water extracts, calyx and peel showed relatively greater reducing power and DPPH radical scavenging activity. Boubekri et al. (2012) studied the antioxidant activity among various parts of two types of eggplant in Algeria. They observed that peel extracts of both dark purple and white samples presented the maximum antioxidant activity (66.78 and 75.62), followed by pulp (16.54 and 30.56) and calyx (14.82 and 21.27 mg/g), respectively by using ascorbic acid equivalent. Antioxidant capacity among various parts of *Solanum melongena* L. was evaluated by Sultana et al. (2013) in Pakistan. According to their results, round brinjal contained appreciable amount of antioxidants (22.05-25.00 mg GAE/100 g DW) as compared to long brinjal whereas the highest DPPH radical scavenging activity was also observed in methanolic extract of peel of round brinjal (70.01 %) suggesting that round brinjal contains greater antioxidant potential as compared to the long cultivar.

Satam et al. (2013) investigated the *Solanum melongena* L. in Maharashtra (India) in order to quantify the flavonoid content. They observed TFC (114.24 mg QE/g) and TPC (186.56 mg GAE/g), representing the appreciable amount of flavonoid and phenolic contents, which are directly related to antioxidant capacity of *Solanum menlongena* L. Somawathie et al. (2014) investigated antioxidant activities among different types of eggplant in Sri Lanka. They observed phenolic content ranged from 48.67 to 61.11 mg GAE/100 g fresh weight. Purple brinjal with no lines was presented maximum DPPH radical scavenging activity ($IC_{50}$ = 3.51±0.62 mg/mL), showing a linear relationship with TPC. Kumaraswamy (2015) reported the antioxidant capacity and total phenolic content in *Solanum melongena* L. (purple and green coloured moderate sized) vegetables in Karnataka (India). According to his conclusion, green coloured moderate sized fruits presented the greater antioxidant activity (320 µg/500 µL) with high amount of total phenolic content. Zambrano-Moreno et al. (2015) evaluated the amount of flavonoids, polyphenols and antioxidant ability in conventionally and organically mature eggplant cultivated in USA. These eggplants exposed to three thermal preparation procedures: steaming, baking and boiling. According to their study, steamed eggplant represented higher total polyphenolic (104.84 mg GAE/100 g FW) and flavonoid contents (80.75 mg CE/100 g FW) as well as greater antioxidant capacity (68.88 µmol TE/g FW) as compared to other thermal treatments. Polyphenolic substances and antioxidant activity of two South Algerian cultivars of eggplants were estimated by Djouadi et al. (2016)

in Algeria. They concluded that the total phenolic content (ethanolic fraction: 87.82-548.77 and aqueous fraction: 41.30-82.31 mg GAE/g dry extract) and antioxidant activity (ethanolic fraction: 89.52-324.34 and aqueous fraction: 17.50-59.33 mg/g dry extract) were maximum in the peel of both cultivars whereas dark-purple eggplant had the higher antioxidant activities and total phenolic substances than white eggplant.

Fidrianny et al. (2017) investigated the different extracts of eggplant parts grown in West Java-Indonesia. They observed the highest phenolic compounds in ethanolic extract of eggplant leaves (8.87 g GAE/100 g) and the highest flavonoid components in ethyl acetate leaves extract (24.50 g QE/100 g). They concluded that phenolic compounds were the major contributor in antioxidant activities.

**Heavy metals content evaluation**

Dospatliev et al. (2012) demonstrated the heavy metals content in eggplant in Bulgaria. It was concluded that the concentrations of the heavy metals determined (Ni: 192.3, Zn: 42.4, Pb: 23.0 and Cd: 1.55 mg/Kg), were under the range of World Health Organization. Saeedifar et al. (2014) investigated heavy metals content in *Solanum melongena* L. in Tehran (Iran). They reported higher concentration of Pb in October-November as compared to August-September. A major rise was also observed in quantity of Cd in October.

Uddin et al. (2016) reported that the municipal waste and control soil may be suitable for the brinjal cultivation in Bangladesh. They also recommended that the industrial waste mixed soil may not be appropriated for the vegetable cultivation due to uptake greater concentration of heavy metals (Cu: 16.12, Zn: 21.39, Fe: 0.363 and Pb: 365.70 mg/Kg) in plant fruits and roots. Soloman et al. (2017) investigated the heavy metals content in eggplant grown in polluted areas of Jaipur (India). They observed the exceeded concentration of heavy metals (Pb: 2.03-5.83, Cd: 0.44-4.93, Ni: 5.24-6.12, Cu: 11.23-53.86 and Zn: 12.83-130.24 mg/Kg) in different areas and suggested that intake of those contaminated eggplant becomes hazardous for human health.

## CONCLUSION

Eggplant belongs to family Solanaceae. It is consumed as vegetable all over the world. The literature showed that eggplant contains beneficial bioactive secondary metabolites including flavonoids, phenolics, vitamins, minerals, carotenoids and dietary fibres, which play important role in healthy life. They can be helpful in recovery from various diseases.

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**Table-1: Varieties of eggplant in the world**

| S. No. | Name of variety | Figure | Country | Description |
|---|---|---|---|---|
| 1 | Graffiti eggplant |  | China | It has purple and white strips and these strips become disappear upon cooking. It has small and large sizes with small seeds and thin peel. |
| 2 | Italian eggplant |  | Italy | It is large and fat. Its flesh becomes tender. |

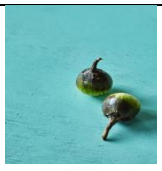
| | | | | |
|---|---|---|---|---|
| 3 | Japanese and Chinese eggplant |  | Japan and China | Extended narrow shape. Japanese eggplant have a much deeper purple colour while Chinese eggplant is typically lighter, more lavender-purple, and is occasionally even lengthier. Both have a good, thin skin, don't have plenty of seeds |
| 4 | Fairy tale eggplant |  | South Asia | They have purple and white stripes and are no larger than the palm of hand. They take some time in cooked because they are so tender. |
| 5 | White eggplant |  | India and Bangladesh | They have pure white skin but inside the same flesh is observed as other types of eggplants. |
| 6 | Indian eggplant |  | India | It is also known as baby eggplant. It is small and short and has a dark reddish-purple colour appearance. |
| 7 | Little green eggplant |  | South Asia | It is plump and round with a light green-coloured skin. It contains a slight flavour and cooks up to additional creamy. |
| 8 | Thai eggplant |  | Thailand | It is tiny, round and greenish-white in appearance. It is hard to find and is not common. |
| 9 | Thai yellow eggplant |  | Thailand | They are egg-sized fruit with bright golden-yellow in appearance. Mostly they are used in many Thai dishes and as well as garnish. |
| 10 | Santana eggplant |  | Asia | It is big, a tear-dropped shaped and dark purple eggplant. They split too quickly. They are tough and harder but good for roasting on the grill flame. |


**Figure 1: World map representing the major eggplant production countries**


**Figure 2: Map of Pakistan representing the major eggplant production areas**