EAS Journal of Pharmacy and Pharmacology
Abbreviated Key Title: EAS J Pharm Pharmacol
ISSN 2663-0990 (Print) & 2663-6719 (Online)
Published By East African Scholars Publisher, Kenya

OPEN ACCESS

Volume-1 | Issue-5 | Sept-Oct-2019 |

Review Article

Phytochemical Information and Pharmacological Activities of Eggplant (*Solanum Melongena L.*): A Comprehensive Review

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Abstract: The eggplant (*Solanum melongena* L.) is a herbaceous, vegetable crop with coarsely lobed leaves, white to purple flowers, fruit is berry and are grown around the world mainly for food representing one of the best dietary sources of biologically active polyphenolic compounds, vitamins, antioxidants and medicinal requirements. The plant contains flavonoids, tropane, glycoalkaloids, arginine, lanosterol, gramisterol, aspartic acid as important constituents. Metabolomics and metabolic profiling are important platforms for assessing the chemical composition of plants and breeders are increasingly concerned about the nutritional and health benefits of crops. The plant is reported to have analgesic, antipyretic, antioxidant, anti-inflammatory, antiasthmatic, hypolipidemic, hypotensive, antiplatelet, intraocular pressure reducing, and CNS depressant and anaphylactic reaction inhibitory activities. In this review, an overview mainly on the historical background, phytochemistry and pharmacology are discussed.

Keywords: Eggplant, *Solanum melongena* L., brinjal, vegetable crop.

1. INTRODUCTION

The therapeutic efficacy of herbal medicines in India leads to the evolution of Ayurveda. Apart from Ayurveda, the traditional system of medicine, throughout the length and breadth of the country used many common plants/plant products as household remedies. *S. melongena* var. esculentum is an economic flowering plant belonging to the family Solanaceae which contains 75 genera and over 2000 species (Biology of Brinjal, 2011) and are grown mainly for food and medicinal purposes (Igwe *et al.*, 2003). Eggplant fruit popularly known as aubergine (UK), melanzana, garden egg, brinjal, Baingan (India) and is one of the most important vegetable crops grown on over 1.7 million ha worldwide. It is an important crop of subtropics and tropics and grown extensively in India, Bangladesh, Pakistan, China, Nepal , Philippines and Srilanka accounts for about 75% of eggplant production.

The name eggplant derives from the shape of the fruit of some varieties, which are white and shaped very similarly to chicken eggs. The color, size, shape of the eggplant fruit vary significantly with the type of eggplant cultivar. (Kwon *et al.*, 2007) Phytochemical studies have yielded flavonoids, alkaloids, tannins and steroids. (Kwon *et al.*, 2007) It is widely distributed in India for its fruit. Various parts of the plant are useful in the treatment of inflammatory conditions, cardiac debility, neuralgias, and ulcer of nose, cholera, bronchitis and asthma. Besides, having many traditional uses, *S. melongena* is reported to exhibit many important pharmacological actions.

Taxonomical Hierarchy

Kingdom: Plantae
Subkingdom: Viridaeplantae
Infrakingdom: Streptophyta
Division: Tracheophyta
Subdivision: Spermatophytina
Infradivision: Angiospermae
Class: Magnoliopsida
Subclass: Asteridae
Order: Solanales
Family: Solanaceae
Genus: Solanum L.
Species: *Solanum melongena* Linn.

Quick Response Code

Journal homepage: http://www.easpublisher.com/easjpp/

Article History
Received: 15.09.2019
Accepted: 29.09.2019
Published: 05.10.2019

DOI: 10.36349/easjpp.2019.v01i05.001

Vernacular Names
Sanskrit: Vartaku English: Brinjal
Assamese: Bengena Hindi: Baingan
Marathi: Vangi
Bengali: Begun
Malayalam: Kathrikka
Kannada: Badane
Telugu: Vankaya
Tamil: Kathirikkai.

2. Historical overview:

It was found that the earliest record of the eggplant documented in ancient Chinese literature was in a work from 59 BC. As far as is known, this is the earliest reliable and accurately dated record of eggplant in cultivation. The analysis reveals that the process of domestication of the eggplant in China involved three principal aspects of fruit quality: size, shape and taste. These traits were actively and gradually selected; fruit size changed from small to large, taste changed from not palatable to what was termed at the time sweetish, and that over time, a wider variety of fruit shapes was cultivated.

Hypotheses about the origins and evolution of eggplants have in the past been based on inference owing to the lack of archaeological evidence for origins and early domestication. (Lester and Hasan, 1991; Choudhury, 1995) suggested that the eggplant was derived from the subtropical species *S. incanum*, native to North Africa and the Middle East. They suggested that the wild progenitor developed as a garden weed, and through human selection in south-east Asia, progressively more advanced cultivars were selected. They divided *S. melongena* into a series of morphological types or gene pools, identified as A (putative wild progenitors) to G (advanced cultivars), and suggested eastwards movement of cultivated forms, with subsequent movement westwards complicating patterns of character change (Lester and Hasan, 1991).

Several candidate areas for eggplant domestication have been proposed: India and south-east China (Doganlar *et al.*, 2002*a*), China, India and Thailand (Doganlar *et al.*, 2002*b*), Burma to Indo-China (Daunay *et al.*, 2001) and south-east Asia (Lester and Hasan, 1991). Evidence for each of these is based on presence of weedy forms (putative progenitors for many authors) and literature references. The authors' field work in recent years has revealed the presence of wild, weedy forms of eggplants in southern China, supporting a south-east Asian origin, but the possibility of multiple domestication events has not yet been investigated.

Evidence for an Indian domestication has been drawn from examination of the Sanskrit literature. Khan (1979) cited common names for the eggplant from various works, with the oldest dated between the 3rd century BC and the 3rd century AD. His citation of the oldest Sanskrit work from 300 BC, however, was based on a secondary source (Monier-Williams, 1899), and the time range he estimated cannot be substantiated, due to the many revisions of the work in question over the centuries (S. Y. Ye, Peking University, China, pers. comm.).

Comparing Medicinal Uses of Eggplant and Related Solanaceae in China, India, and the Philippines Suggests the Independent Development of Uses, Cultural Diffusion, and Recent Species Substitutions.

The ways in which geographically separate communities use crops reflect the agricultural and cultural influences on each community. The eggplant (*S. melongena* L.; Solanaceae), which was domesticated in South and Southeast Asia, has long been used in a variety of medicinal and culinary preparations across many different Asian ethnolinguistic groups. Here, we report the total uses for eggplant and sixteen related species in three regions, India, southern China, and Malesia, and conduct a comparative analysis in order to form hypotheses about how influences on plant use in one region could have affected use and evolutionary trajectories in other regions. Results from literature review and 101 interviews show a total of 77 medicinal attributes for eggplant, with few similar attributes mentioned in different regions, leading us to hypothesize that largely pristine (i.e., without influence from other regions) development of uses, which could serve as selection pressures, occurred for eggplant in India, southern China, and Malaysia. Results also show that many Solanum species have been fluidly adopted into uses developed for other species in a single region. (Rachel S., *et al.*, 2014) (Fabio Cericola, *et al.*, 2014).

3. MORPHOLOGY

The plant is herbaceous annual with erect or semi-spreading habits. It develops into bushy plant with large leaves that grow to a height of 60-120 cm (Daunay *et al.*, 2004).

Leaves: The leaf pattern is opposite, large, single lobed and underside most cultivars, is covered with dense wool-like hair. The leaves may be with or without spines at the middle portion (Daunay *et al.*, 2004).

Flower:The flower is complete, actinomorphic and hermaphrodite. Calyx five lobed; Corolla-five-lobed gamopetalous with margins of lobes incurved. Inflorescences are 1 to 5 andromonoecious cymes, although most modern cultivars display solitary hermaphrodite flowers. The basic flower type is 5-merous (5 sepals, 5 petals, 5 stamens) but 6, 7, and 8-merous flowers are commonly found in globose and round fruited types. Eggplant is generally considered to be an autogamous species; however, in open fields and warm conditions, flowers are visited by insects and the rate of allogamy can reach 70% or more (Daunay *et al.*, 2004).

Fruit The fruit is fleshy berry borne singly or in clusters. The shape of the fruit varies from ovoid, oblong, obovoid or long cylindrical. The colour of the fruit is purple, purple black, yellowish, white, green variegated type of purple with white stripes, green with light green/white stripes or even combination of three colours. Anthocyanins, prickles and hairiness on vegetative parts vary quantitatively. The fruits are berries of highly variable shape (round, intermediate, long, snake-like) and size (tens of grams to more than a kilo). The absence or presence as well as the distribution pattern of two kinds of pigments, chlorophylls and anthocyanins, control a wide diversity of fruit colors (Daunay *et al.*, 2004).

Stem: The plant is woody and develops several branches according to a roughly dichotomic ramification pattern (Daunay *et al.*, 2004).

Eggplant is a diploid species, with a basic chromosome number of 12 and a genome size of approximately 956 Mbp (Bennett and Leitch 2004).

4. PHYTO CONSTITUENTS

Anthocyanins, an important group of naturally occurring pigments of red and/or purple colored fruits, are the main phenolic compounds in eggplant peel (Mazza *et al.*, 2004). Eggplant contains a higher content of free reducing sugars, anthocyanin, phenols, glycoalkaloids (solasodine) and amide proteins. Bitterness in eggplant is due to the presence of glycoalkaloids (Rai MK *et al.*, 1997). Chemical detection showed the presence of alkaloids, flavonoids, tannins, steroids, and glycosides in callus extract as compared to its contains in root and fruit extracts (Ghoson S. Saleh, 2015).

Fruits contain arginine, aspartic acid, histidine, 5–HT, delphinidine −3 bioside (nasunin), oxalic acid, solasodine, ascorbic acid, tryptophan, etc. Leaves contain chlorogenic, hydrocaffeic and protocatechuric acids (Rai MK *et al.*, 1997). Some of the alkaloids present are tropane, pyrrolidine, quinazolizidine, steroid alkaloids and glycoalkaloids.(Evans WC, 2002) Two steroidal saponins - melongoside L and melongoside M, and three new saponins melongoside N, O and P, have been isolated from seeds. (Kintia PK, 1985) Catechol oxidase has been isolated and characterised from *S. melongena* (Sharma RC *et al.*, 1980). A bioflavonoid glycoside named solanoflavone is present in the leaves and fruits of S. melongena (Shen G *et al.*, 2005).

Nasunin, a major component of anthocyanin pigment, was isolated from the eggplant peels, and its antioxidant activity was evaluated (Igarashi *et al.*, 1993; Noda *et al.*, 2000). There are two isomers of nasunin, delphinidin 3-[4-(*cis-p*-coumaroyl)-L-rhamnosyl (1–6) glucopyranoside]-5-glucopyranoside (*cis*) and delphinidin-3[4-(*trans-p*-coumaroyl)-L-rhamnosyl-(1–6)glucopyranoside]-5 glucopyranoside (*trans*) (T. Ichiyanagi, *et al.*,2005). The major anthocyanins were identified in extracts from the peels as delphinidin 3-(*p*-coumaroylrutinoside) -5-glucoside (nasunin), delphinidin 3-rutinoside , delphinidin 3-glucoside, and petunidin 3-(*p*-coumaroylrutinoside)-5-glucoside (petunidin 3RGc5G) (Keiko Azuma, 2008). Nasunin crystals showed higher antioxidant indices in Fremy's salt and LACL assays, with no detectable activity against the hydroxyl radical.(Pier Carlo Braga, *et al.*, 2016).

Not only Nasunin a potent antioxidant that is capable of scavenging free radicals but also a potent chelator of iron. It does not directly scavenge free radicals; rather it interferes with hydroxyl radical generation by chelating iron. (T. Ichiyanagi, *et al.*,2005); (K. Matsubara, *et al.*, 2005) Stommel and Whitaker (2003) carried out a systematic examination of the phenolic acid content of the fruit flesh of seven commercial eggplant cultivars. Optimized extraction of phenolic acids from eggplant by different solvents mixtures (Luthria, 2006), and the relationship between phenolic content and antioxidant activity of eggplant pulp were also reported (Singh *et al.*, 2009). The antioxidant vitamins, including vitamin A, vitamin C and β-carotene, were lower and some of the polyphenolic components, especially nasunin content, were higher in grilled eggplants, but they were unable to demonstrate better cardioprotective properties compared to the raw fruit.

Although, they are primarily present in their purple skin, they are equally present in our freeze-dried eggplants containing both flesh and skin. The amount of nasunin is likely to be very high in the peels of eggplants. In addition, nasunin is anti-angiogenic, (K. Matsubara, *et al.*, 2005) and hence may not be very suitable for new blood vessel formation. The increase in aortic flow observed in our study could be due to the vasodilatory action of some other polyphenols(Cao Y., *et al.*, 2002,) The grilled eggplants had higher polyphenols, including chlorogenic acid, caffeic acid and nasunin, the cardioprotective ability of the grilled fruits were identical to those of raw eggplants (S. Das, *et al.*, 2011).

The main class of phenolics in eggplant includes hydroxycinnamic acid conjugates (Whitaker and Stommel, 2003) and, of these, chlorogenic acid (5-O-caffeoylquinic acid and its isomers) typically accounts for 70% to 95% of total phenolics in eggplant fruit flesh (Stommel and Whitaker, 2003). The fact that chlorogenic acid is by far the predominant phenolic compound, suggests that an important part of the genetic variation may be the result of a few genetic factors involved in the biochemical pathways leading to the accumulation of chlorogenic acid (Niggeweg *et al.*, 2004).

Variation in total content in phenolics and in chlorogenic acid content accounted only for 18.9% and 6.0% in the variation in fruit flesh browning, and PPO activity was not significantly correlated with fruit flesh browning. Liquid extract browning was highly correlated with chlorogenic acid content (r = 0.852). Principal components analysis suggests the possibility to develop new eggplant varieties with improved functional and apparent quality. (**Mariola Plazas, 2013**) Total phenolic compounds was found to be 34.8 ± 0.8 proanthocyanidins: 29.4 ± 1.48 and trolox equivalent antioxidant capacity 0.7 ± 0.0 in Eggplant (S. melongena) (Romaric G. Bayili , et.al. 2011).

Enzymes involved in the CGA pathway are indicated: PAL, phenylalanine ammonia lyase; C4H, cinnamate 4-hydroxilase; 4CL, 4-hydroxycinnamoyl-CoA ligase; HCT, hydroxycinnamoyl-coA shikimate/quinatehydroxycinnamoil transferase; C3'H,p-coumaroyl ester 3'-hydroxilase; HQT, hydroxycinnamoyl CoA quinate hydroxycinnamoyl transferase (Comino C;2007) (Niggeweg R, 2004).

According to HPLC-DAD-MS3 analyses of the acetone extracts the major anthocyanin in eggplant was delphinidin-3-rutinoside, while the predominant pigment in violet pepper was assigned to delphinidin-3-trans coumaroyl rutinoside-5-glucoside. There is relevance of structure related activities of anthocyanins both for understanding food colour and their particular nutritional value. (E. Sadilova *et al.,* 2006)

5. CLINICAL EFFICACY AND MECHANISM OF ACTION

1.1. Antioxidant activity (Guohua Cao, *et al.*, 1996)

Eggplant is ranked as one of the top ten vegetables in terms of oxygen radical scavenging capacity due to the fruit's phenolic constituents (Cao *et al.*, 1996). The plant's antioxidant property is due to the flavonoids. (Kwon *et al.,* 2007) Antioxidant Activity carried out a study on protective activity of water-soluble component of *S. melongena* fruit on rat liver microsomes (Gazzani *et al.,* 1998).

Antioxidant property was determined in terms of protective activity (PA%) against rat liver microsomes, lipid peroxidation induced by CCl4 and measured by malondialdehyde release. The juice of *S. melongena* was found to have a protective activity of 80% against lipid peroxidation.(Gazzani *et al.*, 1998). Sudheesh *et al.*, 1999 studied the antioxidant activity of flavonoids from *S. melongena* in normal and cholesterol-fed rats in the doses of 1 mg flavonoid from brinjal. In the test it was found that concentration of malondialdehyde, hydro peroxides and conjugated dines were lowered significantly. The activity of catalase was elevated. The concentration of glutathione was also elevated (Sudheesh *et al.*, 1999). Antioxidant activity of 70% ethanolic (EE) and water extracts (WE) from different parts of eggplant shown the highest phenolic contents in peel (55.19 mg/g) and calyx (121.07 mg/g) extracts, respectively. Total flavanol contents of EE and WE were the highest in leaf (8.00 mg/g) and calyx (5.61 mg/g) extracts, respectively. The peel extract showed the highest anthocyanins content (138.05 mg %) followed by calyx (135.94 mg %), stem (110.38 mg %), leaf (97.29 mg %), and pulp (2.29 mg %) extracts. In both EE and WE, extracts of peel and calyx parts showed relatively higher DPPH radical scavenging activity and reducing power. The remarkable high SOD-like activity was detected in WE of calyx part (IC50 = 0.39±0.01 μg/ml), which is about 1,700 times stronger than WE of pulp part (IC50 = 0.69±0.01 mg/ml). This study also shows the calyx part had strong antioxidant activity. (Eun-Ju Jung, *et al.*, 2001) On assaying antioxidants from the byproduct (peel) of eggplant, using 70% methanol, 70% ethanol and 70% acetone extracts showed that 70% methanol is the best solvent for the extraction of anthocyanins (82.83 ± 1.07 mg DGE/100 g DP), whereas, 70% acetone is the best solvent for the extraction of total phenolics, flavonoids and tannins (29.3 ± 1.23 mg GAE/100 g DE; 18.5 ± 0.07 mg QE/100 g DE and 5.37 ± 0.22 mg TAE/100 g DE, respectively). Anthocyanic extracts have exhibited the higher reducing power (39 ± 2.5 mg QE/100 g DE) and scavenging activity (IC_{50} = 2.88 ± 0.02 mg/mL), whereas the phenolic extracts have shown the highest metal chelating activity (18.53 ± 0.4%). (Lila Boulekbache-Makhlouf. 2013).

The research on the antioxidant activity of eggplant with different assays was also reported by Huang *et al.,* (2004) Eggplant extracts have demonstrated potency in scavenging reactive oxygen species that are implicated in many human diseases. Highly significant differences were detected among accessions for superoxide scavenging activities with accession means ranging from 26% to 60% nitro blue tetrazolium (NBT) reduction inhibition for methanolic extract, and 40% to 81% NBT reduction inhibition for water extract evidenced by the highly significant linear correlation (0.79**) between the two assays. There was no significant linear association between ascorbic acid content and methanolic extarct (r=0.10) but there was a significant but low correlation (r=0.34*) between water extract and ascorbic acid content. Sufficient genetic diversity exists in *S. melongena* for SOS and total phenolics to justify evaluation of a larger number of accessions. High antioxidant varieties will tend to be small-fruited. (Hanson PM, 2006).

1.2. Analgesic Property

Analgesic property is because of the alkaloids. (Kwon *et al.*, 2007) Vohora *et al.*, 1984 tested the effect of crude alkaloidal fraction isolated from leaves of *S. melongena* on the central nervous system. It exhibited significant analgesic effect.(Vohora *et al.,* 1984). Mutalik *et al.*, 2003 evaluated the analgesic effect of leaves of *S. melongena* in albino mice with the doses of

100 mg, 250 mg and 500 mg/kg body weight, showed significant dose-dependant analgesic activity in acetic acid induced writhing test.(Mutalik S *et al.,* 2003)

1.3. Lungs

The terpenes (steroids) make it useful for bronchitis, asthma (Kwon *et al.,* 2007). Decoction of roots taken internally, as general stimulant and for asthma (Kwon *et al.,* 2007). Bello *et al.,* 2004 carried out a randomized double-blind placebo control, clinical trial of *S. melongena* fruit at a dose of 89 ± 0.6 g of fruit/day in moderate to severe asthmatics. It was found that after 2 weeks of daily intake, the fruit of *S. melongena* significantly improved asthma symptoms and signs and disease severity score. It was found to have a salbutamol sparing effect (Bello *et al.,* 2004).

1.4. Diabetes

Besides, having many traditional uses, *S. melongena* is reported to exhibit antidiabetic action National Diabetes Education Program of NIH, Mayo Clinic and American Diabetes Association recommend eggplant-based diet as a choice for management of type-2 diabetes. The rationale for this suggestion is the high fiber and low soluble carbohydrate content of eggplant. A more physiologically relevant explanation lies in the phenolic-linked antioxidant activity and α-glucosidase inhibitory potential of eggplant which could reduce hyperglycemia-induced pathogenesis. Phenolic-enriched extracts of eggplant with moderate free radical scavenging-linked antioxidant activity had high α-glucosidase inhibitory activity and in specific cases moderate to high angiotensin I-converting enzyme (ACE) inhibitory activity. Inhibition of these enzymes provide a strong biochemical basis for management of type 2 diabetes by controlling glucose absorption and reducing associated hypertension, respectively. This phenolic antioxidant-enriched dietary strategy also has the potential to reduce hyperglycemia-induced pathogenesis linked to cellular oxidation stress. These results provide strong rationale for further animal and clinical studies (Kwon *et al.,* 2007) (Y.I. Kwon 2008), (Mace E.S. *et al.,* 1999).

Eggplant demonstrated significant inhibitory potential against aldose reductase, with IC_{50} value at 8.06 mg/mL (Tong Wu., 2015).

1.5. Hepatoactivity

It has also been recommended as an excellent remedy for liver complaints. (Kwon *et al.,* 2007)

1.6. Cardiac Activity

Various parts of the plant are useful in the treatment of inflammatory conditions, cardiac debility (Kwon *et al.,* 2007). Shum and Chiu, 1991 investigated the cardiovascular action of *S. melongena* extract (SME) using in-vivo and in-vitro preparations. SME produced dose - dependent hypotensive responses in normotensive albino rats. The duration of response was also dose dependent (Shum and Chiu, 1991). The oral administration of eggplants can induce hypertensive effects in spontaneously hypertensive rats. These rats have genetic factors causing hypertension with ageing, and are used as a model of human essential hypertension, indicating that eggplant can be expected to exert hypotensive effects on people with similar genetic factors. Eggplant has potential as a functional food to prevent hypertension and its complications in daily life (Shohei Yamaguchia, *et al.,* 2019) (Hanson PM, *et al.,* 2006); (Salunkhe DK, et.al).

Nasunin was examined in various in vitro angiogenesis models using human umbilical vein endothelial cells (HUVECs) which suppressed HUVEC proliferation in a dose-dependent manner (50−200 μM); however, it had no significant effect on HUVEC chemotaxis in a Boyden chamber assay and HUVEC tube formation on a reconstituted basement membrane. These results imply that nasunin with both antioxidant and antiangiogenic activities might be useful to prevent angiogenesis-related diseases (Kiminori Matsubara, et.al. 2005). Nasunin, delphinidin-3-(*p*-coumaroylrutinoside)-5-glucoside, an antioxidant anthocyanin isolated from eggplant peels, was demonstrated as an angiogenesis inhibitor.

On examining the role of raw and grilled eggplants on cardio protection using an isolated perfusion heart model demonstrated eggplants proved to contain potent cardioprotective compounds judging by their ability to increase left ventricular function, and reduce myocardial infarct size and cardiomyocyte apoptosis. However, there was no difference in cardioprotective ability between the raw and grilled products. Another results demonstrate the cardioprotective properties of eggplants without showing any difference between the raw and the cooked groups.

1.7. Nervous system

Various parts of the plant are useful in the treatment of neuralgias. Vohora *et al.,* 1984 studied the effect of crude alkaloid fraction of *S. melongena* leaves on the central nervous system (CNS). The result showed that it has some CNS depressant activity.(Vohora *et al.,* 1984)

1.8. Antipyretic Activity

Mutalik *et al.,* 2003 evaluated the antipyretic effect of leaves of *S. melongena* at doses of 100 mg, 250 mg and 500 mg/kg body weight. It was found to produce significant antipyretic effect in a dose-dependant manner in yeast induced pyrexia in albino rats (Mutalik S *et al.,* 2003).

1.9. Action on Anaphylactic Reactions

Lee *et al.,* 2001 investigated the effect of water extract of *S. melongena* (SMWE) on immunological and non-immunological anaphylactic reactions. Non-immunological anaphylactic reaction induced by compound 48/80 injection was completely inhibited by oral administration of SMWE at a dose of 1 g/kg body weight. Immunological anaphylactic reaction generated by sensitizing the skin with anti–dinitrophenyl IgE was significantly inhibited by SMWE at doses of 0.01-1 g/kg body weight. It also reduced TNF-α secretion from mast cells (Lee *et al.,* 2001).

1.10. Hypolipidemic Action

Sudheesh *et al.,* 1997 tested the hypolipidaemic effect of flavonoids extracted from the fruits of *S. melongena*, administered orally at a dose of 1 mg/100 g body weight/day in normal and cholesterol-fed rats. It was found that flavonoids showed significant hypolipidaemic action. (Sudheesh *et al.,* 1997) Guimaraes *et al.,* 2000 carried out a clinical trial to observe the effects of *S. melongena* on the serum cholesterol and triglycerides of 38 hypercholesterolemic human volunteers, ingesting *S. melongena* for 5 weeks.

It was observed that *S. melongena* significantly reduced the blood levels of total and LDL cholesterol and apolipoprotein B. A 2% infusion of *S. melongena* has a slight effect on the reduction of cholesterolemia and, most importantly, reduces LDL-c with no alteration in HDL-c. Steroidal saponins could be involved in the modest hypocholesterolemic effect of *S. melongena* infusion, since they were detected in both powder and infusion of *S. melongena* (Guimaraes *et al.,* 2000).

1.11. Spasmogenic Activity

Man's *et al.,* 2004 studied the spasmogenic activity of methanolic extract of *S. melongena* leaves on guinea pig tracheal chains and its possible mechanisms of action using serial dilutions between 0.0025 and 2.5 mg/ml. It was found that the extract caused a dose dependant increase in the force of muscle contraction and concomitant use of histamine increased its spasmogenic action (Mans *et al.,* 2004).

1.12. Action on the Eye

Igwe *et al.,* 2003 studied the effects of bolus consumption of 10 gm of *S. melongena* on visually active male volunteers to determine its ocular complications. Results showed miosis and lowering of intraocular pressure by 25%. It is suggested that *S. melongena* would be of benefit to patients suffering from raised intraocular pressure (glaucoma).(Igwe *et al.,* 2003)

1.13. Antiplatelet and Calcium Channel Blocking Activities

Gul *et al.,* 2011 studied antiplatelet, calcium channel blocking activity of *S. melongena*. Different solvents were used to extract the fractions. Antiplatelet activity was monitored using dual channel Lumi aggregometer, calcium channel blocking activity was tested on guinea pig ileum using isolated organ bath assembly. The results showed that aqueous fraction, ethylacetate fraction and chloroform fraction potently inhibited platelet aggregation and calcium channel blocking activity (Gul *et al.,* 2011).

1.14. Miscellaneous

Eggplant has proved activity for otitis, toothaches, cholera, dysuria, ulcer of nose, (Kwon *et al.,* 2007). Leaves are used for piles. The boiled root of the wild plant, mixed with sour milk and grain porridge, has been used for the treatment of syphilis. The juice of leaves used for throat and stomach troubles. Juice of the fruit, sometimes with pounded leaves, rubbed on suspected syphilitic eruptions of the hands. Fruit considered cooling, and bruised with vinegar. Chinese and Annamites used the roots for skin diseases (Mutalik *et al.*, 2003).

The beneficial effects on health of chlorogenic acid and related compounds present in minor quantities in eggplant are numerous, and apart from their potent antioxidant activity, they also include free radical scavenging and antitumoral activities (Sawa *et al.*, 1998; Triantis *et al.*, 2005).

DISCUSSION

Supercritical Fluid Extraction (SFE) may be a valuable alternative technique for the extraction of the flavonoids from *S. melongena* L. The optimum conditions of SC-CO_2 for flavonoid compounds, are pressure at 19.61MPa, temperature at 45°C, CO2 flow rate at 3.0mL/min and co-solvent at 11.5%. DPPH study revealed the in vitro antioxidant activity of SFE extract of *S. melongena* fruit. The presence of flavonoids and related polyphenols may be responsible for the activity. (Namrata K., 2012) The chemical detection showed the presence of alkaloids, flavonoids, tannins, steroids, and glycosides in callus extract as compared to its containts in root and fruit extracts. It would be necessary to carry out further study to confirm the true potential of *S. melongena*, so that it may be clinically applicable and commercially viable.

All parts of plant can be utilized for different phytoconstituent extraction. Eggplant contains a higher content of free reducing sugars, anthocyanin, phenols, glycoalkaloids (solasodine) and amide proteins. Besides Nasunin, a major component of anthocyanin pigment it contains arginine, aspartic acid, histidine, 5–HT, delphinidine −3 bioside (nasunin), oxalic acid, solasodine, ascorbic acid, tryptophan, chlorogenic, hydrocaffeic and protocatechuric acids, alkaloids present are tropane, pyrrolidine, quinazolizidine, steroid alkaloids and glycoalkaloids, melongoside N, O and P, Catechol oxidase, solanoflavone etc.

CONCLUSION

The present review has presented comprehensive details of *S. melongena* L. It constitutes Nasunin as major anthocyanins pigment along with various alkaloids, glycosides, saponin, chlorogenic, hydrocaffeic and protocatechuric acids. The plant exhibit many pharmacological and therapeutic benefits like antioxidant, analgesic, anti-diabetic, bronchitis, asthma, liver complaints, Cardiac activity, neuralgias, CNS depressant activity, Antipyretic Activity, Anaphylactic Reactions, Hypolipidemic Action, Spasmogenic Activity, glaucoma, Antiplatelet and Calcium Channel Blocking Activities, otitis, toothaches, cholera, dysuria, ulcer of nose etc. Further investigations are required to find active component of the extract and to confirm the mechanism of action. The toxic effect of these plants should also be elucidated.

FUNDING INFORMATION
This paper was written independently.

CONFLICT OF INTEREST
Authors have no conflict of interest to declare.

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