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A REVIEW ON *GLYCINE* MAX (L.) MERR. (SOYBEAN)

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ABSTRACT

Alterative medication and natural remedies have been used from ancient time for the treatment and wellbeing of human. Medicinal plants are considered to be effective and for most important for the above purposes. The Mother Nature has provided us with a huge count of flora and fauna. Some of the natural medicinal plants are so common that we use them in daily life without knowing their medicinal importance. Glycine max (L.) Merr is the best example of it. The plant is commonly known as soy bean which is eatable. Bruised leaves applied to snake bites, Flowers used for blindness and corneal opacities. Green bean hulls chewed to a pulp are applied to smallpox ulcers, corneal ulcers and excoriations in children from urine, dried sprouts believed to be beneficial for hair growth and curative for ascites and rheumatism. This review article is a sincere effort to put forward the medicinal importance and chemical detail about the plant.

KEYWORDS: Glycine max, soy bean, Pharmacology, Pharmacognosy, Phytochemistry.

INTRODUCTION

Plant and plant products are being used as a source of medicine since long. According to World Health Organization (WHO) more than 80% of the world's population, mostly in developing countries depends on traditional plant based medicines for their primary healthcare needs.[1] The efficacy and safety of herbal medicine have turned the major pharmaceutical population towards medicinal plant's research. Owing to the global trend towards improved 'quality of life', there is considerable evidence of an increase in demand

from medicinal plant.[2] Use of plants for treating various ailments of both man and animal is as old practice as man himself. India is richly endowed with a wide variety of plant shaving medicinal value. These plants are widely used by all sections of the society whether directly as folk remedies or indirectly as pharmaceutical preparation of modern medicine.[3] In recent times, focus on plant research has increased all over the world and a large body of evidence has collected to show immense potential of medicinal plants used in various traditional systems (Ayurveda, Siddha and Unani)[4] and also major source of biodynamic compounds of therapeutic values.[5] Exploration of the chemical constituents of the plants and pharmacological screening may provide us the basis for developing the lead for development of novel agents. Herbs have provided us some of the very important lifesaving drugs used in the armamentarium of modern medicine. Among the estimated 4,00,000 plant species, only 6% have been studied for biological activity and about 15% have been investigated phytochemicals.[6] This shows a need for investigation of various chemical constituents, its activity and phytopharmacological evaluation of herbal drugs.

The soybean (*Glycine* max (L.) Merr) is a species of legume native to East Asia. The plant is classed as an oilseed rather than a pulse. It is an annual plant that has been used in China for 5,000 years as a food and a component of drugs. Soy contains significant amounts of all the essential amino acids for humans, and so is a good source of protein and vegetable oils. Soybeans are the primary ingredient in many processed foods, including dairy product substitutes. The plant is sometimes referred to as greater bean or edamame, though the latter is more commonly used in English when referring to a specific dish. The English word soy is derived from the Japanese pronunciation of shoyu, the Japanese word for Soya sauce; soya comes from the Dutch adaptation of the same word. The main producers of soy are the United States, Brazil, Argentina, China and India. The beans contain significant amounts of alpha-linolenic acid, omega-6 fatty acid and the isoflavones, genistein and daidzein.[7] Dry soybean contain 36% protein, 19% oil, 35% carbohydrate (17% of which dietary fiber), 5% minerals and several other components including vitamins[8], Isoflavones and saponins.[9] Whole soybeans are a good source of calcium, iron, zinc, phosphorus, magnesium, thiamine, riboflavin, niacin and folic acid.

Attention has recently focused on the possible role of soybeans in the diet for the prevention and treatment of degenerative Western diseases.[10] [11] [12] Several studies documented the hypocholesterolaemic effect,[10] anticarcinogenic effects[13] of soy beans, and the ability of

soy beans to lower the risk of osteoporosis[14], cardiovascular disease as well as relieving menopausal symptoms[15][16][17], renal disease[18] beneficial effect against diabetes[19] and anti-oxidant activity.[20]

It is also being used as a folklore medicine in a various rural parts of India against conditions like Hyperhidrosis, night sweats, confusion, hyper cholesterolemia and joint pain. *G. max* has been proved for its liver and gallbladder complaints, anemia, cerebral, nerve conditions and general debility.[21]

History

Soybean is one of the most profitable legume species in the world. In China, its origin dates back over 13,000 years. The Chinese name for soybean means "better bean".[22] Soybeans were first introduced to Europe in the 18th century and to North America in 1765 by Samuel Bowen. They were first cultivated in Canada in 1855 and were introduced to Ontario by Charles A. Zavitz.[23] Prior to World War II soybeans were mainly used for industrial applications and as a forage crop until breeding made it an edible food commodity. Southern Ontario is the main soybean producing area in Canada with other growing areas being Quebec, Manitoba, Alberta and Prince Edward Island. In 2008/2009 Canada was the 7th largest soybean producing country in the world with a total of 3.060 metric tons produced (1.3% of the world production).[24] On average, Canada grows close to 3 million acres annually and approximately 981,400 hectares were seeded in Ontario in 2011 (Agriculture and Agri-Food Canada, 2012).[27] Canada is one of the leaders for premium food grade soybeans, which are exported mainly to Japan, Malaysia, and Singapore. Food grade uses include soy beverage, miso, tofu, natto and soy sauce.[23,25]

Taxonomy

Scientific name: *Glycine max* (L.) Merr

Kingdom: Plantae

Phylum: Magnoliophyta

Class: Magnoliopsida

Order: Fabales

Family: Fabaceae

Subfamily: Faboideae

Genus: *Glycine*

Species: *G. max*

Common Names: Soyabean, Raam Kurthi, Bhat

Synonyms

Glycine angustifolia, *Glycine gracilis*, *Glycine hispida* maxim, *Glycine soja* sensu, *Soja angustifolia, Soja max.*

English name: Soybean, Soya.

Other vernacular names

Arabic: Ful suyah.

Burmese: Lasi, Pengapi, Peryatpym.

Chinese: Da dou, Huang dou, Huang da dou, Mao dou.

French: Haricot soja, Soja, Pois soja.

German: Sojasusbohne.

Italian: Soia, Fava soja, Soja.

Japanese: Daizu.

Thai: Thua lueang (Thuaa leuuang), Thuarae.

Turkish: Soya lubyasi, Cin lubyasi.

Origin and Distribution

Soybean is native to Eastern Asia, mainly China, Korea and Japan, from where it spread to Europe and America and other parts of the world in the 18th century.[26] Evidence in Chinese history indicates its existence more than 5,000 year ago, being used as food and a component of drugs.[27] Some researchers have suggested Australia and Eastern Africa as other possible centers of origin of the genus *Glycine*.[28] It is widely grown on large scale in both the temperate and tropical regions such as China, Thailand, Indonesia, Brazil, the USA and Japan; where it has become a major agricultural crop and a significant export commodity.[29]

Soybean was first introduced to Africa in the early 19th century, through Southern Africa[26] and is now widespread across the continent.[30] However,[24] have stated that, it might have been introduced at an earlier date in East Africa, since that region had long traded with the Chinese. The same report indicates that soybean has been under cultivation in Tanzania in 1907 and Malawi in 1909.

In Ghana, the Portuguese missionaries were the first to introduce the soybean in 1909. This early introduction did not flourish because of the temperate origin of the crop.[31] However,

serious attempts to establish the production of the crop in Ghana started in the early 1970s. This was as a result of collaborative breeding 7 efforts of Ghana's Ministry of Food and Agriculture[32] and the International Institute of Tropical Agriculture (IITA).[33]

Habitat

Native to South East Asia; now cultivated as pulse crop mainly in Punjab, Haryana, Uttar Pradesh, Himachal Pradesh, Maharashtra, Gujarat, Naga Hills, Manipur and Kashmir and also in cultivated in United States, Brazil, Argentina and China.

Cultivation

Soybeans are a globally important crop, providing oil and protein. Cultivation is successful in climates with hot summers, with optimum growing conditions in mean temperatures of 20 to 30 ^{0}C (68 to 86 ^{0}F); temperatures of below 20 ^{0}C and over 40 ^{0}C (68 ^{0}F, 104 ^{0}F) stunt growth significantly. They can grow in a wide range of soils, with optimum growth in moist alluvial soils with a good organic content. Soybeans, like most legumes, perform nitrogen fixation by establishing a symbiotic relationship with the bacterium *Bradyrhizobium japonicum* (syn. *Rhizobium japonicum*; Jordan 1982). For best results, though, an inoculum of the correct strain of bacteria should be mixed with the soybean seed before planting. Modern crop cultivators generally reach a height of around 1m (3.3ft) and take 80–120days from sowing to harvesting.

The U.S., Argentina, Brazil, China and India are the world's largest soybean producers and represent more than 90% of global soybean production.[34]

The average worldwide yield for soybean crops in 2010 was 2.5 tons per hectare. The three largest producers had an average nationwide soybean crop yield of about 3 tons per hectare. The most productive soybean farms in the world in 2010 were in Turkey, with a nationwide average farm yield of 3.7 tons per hectare. The world record for soybean yield is 10.8 tons per hectare, demonstrated in 2010 by Kip Cullers, a farmer in Purdy, Missouri.[35]

Morphological description

Soy varies in growth and habit. The height of the plant varies from less than 0.2 to 2.0 m (0.66 to 6.56 ft).The pods, stems and leaves are covered with fine brown or gray hairs.

The leaves are trifoliate, having three to four leaflets per leaf, and the leaflets are 6–15 cm (2.4–5.9 in) long and 2–7 cm (0.79–2.76 in) broad. The leaves fall before the seeds are

mature. The inconspicuous, self-fertile flowers are borne in the axil of the leaf and are white, pink or purple.

Soybean leaf

Figure: 1.

small, purple soybean flowers

Figure: 2.

Soybean Seeds

Figure: 3. **Figure: 4.**

The fruit is a hairy pod that grows in clusters of three to five, each pod is 3–8 cm long (1–3 in) and usually contains two to four (rarely more) seeds[36] 5–11 mm in diameter.

Soybeans occur in various sizes, and in many hull or seed coat colors, including black, brown, blue, yellow, green and mottled. The hull of the mature bean is hard, water-resistant and protects the cotyledon and hypocotyl (or "germ") from damage.[37] If the seed coat is cracked, the seed will not germinate. The scar, visible on the seed coat, is called the hilum (colors include black, brown, buff, gray and yellow) and at one end of the hilum is the micropyle, or small opening in the seed coat which can allow the absorption of water for sprouting.

Gary and Dale, (1997) have described soybean growth and development in two main stages: the vegetative stage and the reproductive stage. The vegetative stage starts with the 9

emergence of seedlings, unfolding of unifoliate leaves, through to fully develop trifoliate leaves, nodes formation on main stem, nodulation and the formation of branches. While the reproductive stage begins with flower bud formation, through full bloom flowering, pod formation, pod filling to full maturity.

Chemical composition of the seed

Proteins

Soybean contains 35–40% protein on a dry-weight basis, of which, 90% is comprised of two storage globulins, 11*S* glycinin and 7*S* β-conglycinin.[38] These proteins contain all amino acids such as Isoleucine, Leucine, Lysine, Methionine, Cystine, Phenylalanine, Tyrosine, Threonine, Tryptophan, valine, which are essential to human nutrition. Soybean also contains the biologically active protein components hemagglutinin, trypsin inhibitors, α-amylase and lipoxygenases. As per the FDA's 'Protein Digestibility Corrected Amino Acid' source method, soybean is not only high quality protein, but it is now thought to play preventive and therapeutic roles for several diseases.[39]

Oil

Soybean contains roughly 19% oil, of which the triglycerides are the major component. Soy oil is characterized by relatively large amounts of the polyunsaturated fatty acids (PUFA), *i.e.*, 55% linoleic acid (essential fatty acid) and 8% α-linolenic acid, of total fatty acids (40). Saturated fatty acid - Palmitic acid, Stearic acid and unsaturated fatty acid - Oleic acid. The minor components of crude soybean oil are phospholipids, collectively called lecithin, as well as phytosterols and tocopherols.

Carbohydrates

Soybean contains 35% carbohydrates, most of which is nonstarch polysaccharides such as cellulose, hemicelluloses, and pectin. It also contains Disaccharide - Sucrose (range 2.5–8.2%), oligosaccharides[39] such as, stachyose (4%) and raffinose (1.1%). In addition to use as a dietary fiber supplement, soluble polysaccharides have been used to modify the physical properties of various foods.[41]

Vitamins and minerals

Soybean is a better source of B-vitamins (8) compared to cereals, although it lacks B12 and vitamin C. Soybean oil also contains tocopherols[42], which are excellent natural antioxidants. Soybean oil contains α-tocopherol, β-tocopherol, γ-tocopherol, and δ-tocopherol in trace amount (mg/kg). Soybean also contains 5% minerals. It is relatively rich in Na, K, P, Ca, Mg, Zn and Fe. Soy ferritin can supplement reasonable quantities of iron.

Isoflavones

Isoflavones is a sub-group of heterocyclic plant phenolic category called flavonoids. Besides isoflavones, the other subclasses of flavonoids include flavones, flavonols, flavanols, aurones, red and blue anthocynin pigments and chalcones. The soybean is most abundant source[43] of isoflavones (up to 3 mg/g dry weight) in the nature. Soybean contains three types of isoflavone aglycone *viz.*, daidzein, genistein and glycitein.

Phytosterols

Soybean oil contains about 300 to 400 mg of plant sterols per 100 g. The major components of soy sterols are β-sitosterol (53 to 56%), campesterol (20 to 23%) and stigmasterol (17 to 21%).[44]

Phospholipids

Soybean oil contains 1-3% phospholipids,[42] of which 35% phosphatidyl choline, 25% phosphatidyl ethanolamine, 15% phosphatidyl inositol, 5-10% phosphatidic acid. The phospholipids are removed from the oil mainly during the ‘degumming’ process and are used as a natural food emulsifier.

Saponins

Soybean also contains 2% soy saponins (triterpene glycosides) which are currently attracting lot of scientific attention. The total 30 soy saponins are reported, but their presence and quantity differ from genetic and agronomical variation. Soy saponins are found to have several biological activities[45] such as hepatoprotective, anti-hyperlipidemic, anti-cancer, anti-oxidative and anti-HIV *etc.*

Ferritins

Soybean contains ferritin, a multimeric iron storage protein.[46] It is now well proven that the iron from soybean ferritin is as much absorbed and bio-available as much it is from the

animal products. Therefore, soybean is recommended to be incorporated in the diet of people suffering from anemia.

Pharmacological activities Potential anticarcinogenic effects

The observation of[47] that both raw and autoclaved soy beans inhibited chemically induced mammary cancer in rats, was important because the protease inhibitors in soy beans, which are thought to be potent chemopreventive agents, are destroyed by autoclaving.[48] The data of Barnes *et al* suggested that the isoflavones in soy beans were responsible for tumour inhibition. *In vitro* genistein inhibits tyrosine protein kinases, DNA topo-isomerases and S6 kinases.[49] The activity of these enzymes is enhanced in oncogene-transformed cells. Isoflavones may consequently have a role to play in preventing a wide range of cancers.

Bone-Strengthening effect

There are indications that soy beans reduce the incidence of postmenopausal osteoporosis. Genistein in low doses maintained bone mass in ovariectomised rat models[10,50] reported improvement in femoral bone density in rats that were fed soy protein isolate for 35 days compared to rats fed a casein-based diet. However, he recommends additional long-term studies to determine the effects of soy beans on maintaining bone health.[14] Suggest that isoflavonoids may to some degree inhibit osteoporosis but may be insufficient for complete protection as single prevention strategy.

Antidiabetic and Antihyperlipidemic Activity[51]

Glycine max seeds are used as an ethno medicine for treating diabetes by tribal people. The present study validated the effect of extract of *Glycine max* seed as hypoglycemic agent in streptozotocin induced diabetic wistar mice models. Extract of *Glycine max* at (200 and 500 mg/kg) exhibited a dose dependent significant anti-hyperglycemic activity on 21st day of post treatment. The serum urea and serum creatinine decreased significantly with increase in the dose.

Treatment with extract for 3 weeks showed a significant reduction in levels of Total Cholesterol, Triglycerides, Low density lipoprotein and Very low density Lipoprotein. Restoration of normal cells of islets and enlarged size of endocrine islets with hyperplasia was evidenced by administering 200mg/kg and 500 mg/kg of *Glycine max* seed extract. The study concluded that seed extracts of *Glyceine max* possess significant antidiabetic activity as well as antihyperlipidemic activity.

Antinociceptive and Anti-Inflammatory Effect[52]

The *in vivo* potential of ethanolic extracts of *Glycine max* (L.) Merr. seeds as natural anti-nociceptive and anti-inflammatory agents. To assess the anti-nociceptive and anti-inflammatory potential, the ethanolic extracts of *Glycine max* (L.) Merr seeds were tested in arachidonic acid-induced ear edema, carrageenan induced paw edema, formalin-induced licking time, acetic acid induced writhing and hot plate-induced thermal stimulation in mice. The administration of ethanolic extracts of *Glycine max* (L.) Merr (100mg/kg and 200mg/kg orally) seeds evoked a significant effect of anti-nociceptive and anti-inflammatory activities as compared to standards aminopyrine and indomethacin. The ear edema, paw edema, paw licking time, pain and writhes in mice were significantly reduced ($p < 0.05$) as compared to the control. The results obtained in this study indicate that soybeans possesses potential anti-nociceptive and anti-inflammatory activities.

Antiarthritic activity[53]

The antiarthritic activity of *Glycine max* seeds in adjuvant induced arthritis in rats. Antiarthritic activity was assessed based on the paw volume, biochemical parameters, haematological parameters and histological parameters. The changes in the above said parameters were reversed by the *G.max* seed extract administered at the dose of 60 mg/kg orally.

Antimicrobial Activity[54]

The antimicrobial activity of ferritin extracted from Soyabean (*Glycine max (L.) Merr.*) against Gram-negative microorganisms (*Escherichia coli, Pseudomonas aeruginosa, Klebsiella pneumoniae, Proteus vulgaris*), as well as Gram-positive microorganism (*Staphylococcus aureus, Staphylococcus epidermidis*) and fungus *Candida albicans.* Agar well diffusion method was adapted to determine antibacterial activity against all the test microorganisms. Zone of inhibition of the crude and pure extracts were tested. Among all the test pathogens *E. coli* was found susceptible with zone of inhibition 9mm. to the crude and purified ferritin extract. The present study successfully isolated and purified the single unit of *Glycine max* (L.) Merr ferritin with 28- kDa units. It also reveals the least susceptibility of the microorganisms towards the ferritin isolated from seeds of *Glycine max (L.) Merr.*

Cardioprotective activity[55]

The study evaluated metal chelating activity of Glycine max seed extract on Doxorubicin (DOX) induced cardiotoxicity in rats. In this study twenty four male Albino Wistar rats

weighing between 200-250g were used. The animals were treated as follows. Group I: Animals served as vehicle control and received 0.5% tween 80 (10 ml/kg, p.o). Group II: Animal received Ammonium Ferric Citrate (0.6 mg/kg/day, p.o for 14 days) followed by doxorubicin (10mg/kg, i.v; once 48 hr before sacrifice), Group III: Animal received Deferoxamine 20 mg/kg, p.o. for 14 days followed by ferrous + doxorubicin, Group IV: Animal received Glycine max alcoholic extract 200 mg/kg, p.o for 14 days followed by ferrous + doxorubicin. In each group, body wt of rats were taken before and after doxorubicin administration. After 48 hrs of doxorubicin administration blood was collected for serum CK-MB and LDH estimation. Isolated hearts were dried and weighed. In heart tissues superoxide dismutase (SOD) & catalase (CAT), glutathione (GSH) and malondialdehyde (MDA) were estimated. Results showed that mean heart weight/body weight (HW/BW) ratio in group 2 was significantly ($p<0.001$) decreased, CKMB ($p<0.01$), LDH ($p<0.05$), MDAm ($p<0.01$) increased, GSH ($p<0.01$), SOD and CAT ($p<0.01$) were decreased as compared to group 1. Group 3 & 4 has shown significant ($p<0.01$) increase in (HW/BW) ratio, decrease in CKMB ($p<0.01$), LDH ($p<0.05$), MDA ($p<0.01$), GSH ($p<0.05$), SOD ($p<0.01$) and CAT ($p<0.01$) increased as compared to group 2. It may be concluded that Glycine max alcoholic extract posseses cardioprotective and metal chelating activity in Doxorubicin induced cardiotoxicity in rats.

Anti-obesity effect[56]

The effect of anthocyanins extracted from black soybean (Glycine max L.) seed coats on body weight, adipose tissue weight and serum lipids was evaluated in rats fed a high fat diet (HFD). Rats were raised on a normal diet (ND) (based on the AIN-93M diet), HFD (ND supplemented with 16% lard oil), HFD containing 10% black soybean and HFD containing 0.037% black soybean anthocyanins (equivalent to that in the 10% black soybean diet). Weight gain was significantly lowered in the rats fed HFD plus black soybean anthocyanins compared with the rats fed HFD alone ($P <0 .05$) and reversed to the level of the rats fed ND. The black soybean diet also decreased body weight gain compared with the HFD ($P <0 .05$). The black soybean anthocyanins-added diet suppressed the HFD-induced weight gain in liver intermediately and tended to decrease the weights of epididymal and perirenal fat pads. The black soybean anthocyanins were also effective in improving the lipid profile. They significantly reduced the levels of serum triglyceride and cholesterol ($P <0 .05$), while they markedly increased the high-density lipoprotein-cholesterol concentration, which was decreased in the rats fed HFD ($P <0 .05$). These results indicate that the anthocyanins in black

soybean seed coats have an anti-obesity effect, which can reverse the effects of HFD on body weight, adipose tissue weight and serum lipid contents.

Antioxidant Activity[57]

The ability of extract to scavenge DPPH radicals was measured according to the procedure described by Mansour and Khalil 2000; Liu *et al*., 2009. Three ml of plant extract (soybean) at a concentration of 100µg/ml were mixed well with 1 ml of (0.1mM of 1,1-diphenyl-2-picrylhydrazyl; DPPH) in methanol. The mixture was then shaken and left for 30 min in the dark at room temperature. Absorbance was measured at 517 nm against the blank using UV/VIS spectrophotometer. Ascorbic acid was used as a reference standard. Controls contain only solvent and DPPH without any extract. Free radical scavenging activity (antioxidant activity) of soya extract is expressed as the percentage of DPPH decrease. It was expressed as SC50 which is defined as the concentration of plant extract required for scavenging of 50% of DPPH radicals compared with that of ascorbic acid. The lower SC50 value is an indication of higher scavenging activity or higher antioxidant activity of plant extract. The methanolic extract of *G.max* has the highest radical-scavenging activity. The results revealed that the high DPPH scavenging activity was associated with the high phenolic content of extract of *G.max.*

Health benefits of soybean[42]

- Hypertension.
- Hypercholesterolemia.
- Atherosclerosis.
- Menopause.
- Reducing the risk of osteoporosis.
- Reducing the duration of diarrhea in infants.
- Preventing and treating diabetic nerve problems.
- Providing nutrition to infants who can't digest milk sugars.
- Reducing protein in the urine of people with kidney disease.
- Soy may also offer some relief for the pain, swelling & nausea.

Folkloric

- Bruised leaves applied to snake bites.
- Flowers used for blindness and corneal opacities.

- Green bean hulls chewed to a pulp are applied to smallpox ulcers, corneal ulcers and excoriations in children from urine.
- Black beans are considered to provide vigor and strength and considered a counter poison against most vegetable poisons, ie., Aconite and Croton tiglii.
- Dried sprouts believed to be beneficial for hair growth and curative for ascites and rheumatism.
- Dried sprouts, without the hulls, are considered laxative, resolvent and constructive.
- Oil used for ulcers and skin diseases and for removing bandoline from the hair.

Other uses

-Typically consumed as a protein drink.

-Soy oil is widely used in cooking, as well as in cosmetics.

-The soy meal that remains after oil is extracted is used to make fiber, textiles and adhesives

-Soy oil is also used in industrial paint, varnishes, linoleum, printing inks, soaps, disinfectant and other products.

-Used in making ice-cream.

CONCLUSION

The plant ***Glycine* max (L.) Merr** (Soybean) has a wide array of pharmacological activities. It is widely used in various traditional system of medicine as a medicine. It has been used since centuries as a food and a component of drugs. Recent research carried out for other uses such as hypocholesterolemia, anti-carcinogenic, osteoporosis, cardiovascular, menopausal symptoms, renal diseases, Antidiabetic and Antioxidant. The plant soybean is an important source of various types of compounds with diverse chemical constituents as well as pharmacological activities. However, very less work has been done on this plant and there is a wide scope for investigation.

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