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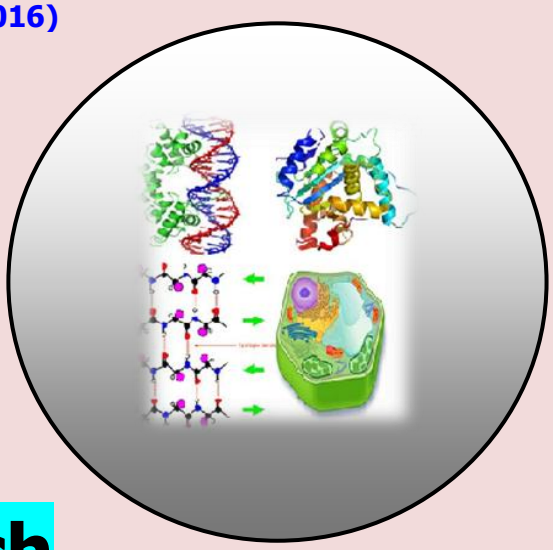

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RESEARCH PAPER

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Pharmacological aspects of Asian Natural Plant *Aegle marmelos* (L.) Correa

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ABSTRACT

Aegle marmelos (L.) Correa (Rutaceae), commonly known as Bael, belonging to family Rutaceae is a sacred tree for Hindu Religion, native to northern India, but is found widely throughout the Indian peninsula and in Ceylon, Burma, Thailand and Indo-China. All parts of the tree namely, root; leaf, trunk, fruit and seed are edible and used for treatment of many different diseases. The constituents of A. marmelos are used in heart diseases, inflammatory and wound healing. Leaves of A. marmelos have been reported as hypoglycemic effect. The essential oil from the leaves of A. marmelos is known to exhibited antifungal, antibacterial, antimicrobial, insecticidal properties. The medicinal properties of bael are well documented in the Ayurvedic texts of India. Its stem, bark, root, leaves and fruits have been valued for their, medicinal properties and bael has a long history of use as an herbal medicine to treat various ailments. The leaves of bael are bitter, astringent, laxative, febrifuge and expectorant. The leaves are used as a remedy for ophthalmic, ulcers, dropsy, cholera and beriberi associated with weakness of heart. They are also useful in ophthalmia, deafness, inflammations, catarrh, diabetes and asthmatic complaints. The unripe fruits are bitter, acrid, sour, astringent, digestive and stomachic are useful in diarrhea, dysentery and stomachalgia. Fresh aqueous and alcoholic leaf extracts of bael are reported to have a cardiotonic effect like digitalis and decrease the requirement of circulatory stimulants. Bael has also been reported to possess a cardioprotective and radioprotective effect.

Keywords: Aegle marmelos (L.) Correa, Pharmacological Aspects, Cardioprotective and Radioprotective Effect.

INTRODUCTION

Medicinal plants play fundamental role in traditional medicine. Plants are rich in a wide variety of secondary metabolites such as tannins, terpenoids, alkaloids and flavonoids, which have been found to have medicinal properties. *Aegle marmelos* commonly known as Bael/Bilva belonging to the family Rutaceae has been widely used in indigenous systems of Indian medicine due to its various medicinal properties. *Aegle marmelos* Linn. also known as Bilwa in Hindi and Bael in Bengali and Assamese. It belongs to the family Rutaceae and grows wild in dry forest, outer Himalayas and Shivaliks. It is a medium to large sized deciduous glabrous, armed tree with the axillary and 2.5 cm long alternate trifoliate leaves, short flower and globular fruits. This plant has shown various

activities including anti-diabetic, anti-inflammatory, anti-hyperlipidemic, anti-cancer and anti-viral properties (Bhavani, 2014; Benni *et al*., 2011; Vijaya *et al*., 2009; Baliga *et al*., 2012;.Badam *et al*., 2002) *Aegle marmelos* leaves contains sitosterol, aegelin, lupcol, rutin, marmesinin, eugenol, β-sitosterol, flavon, glycoside, montanine, o-isopentenyl halfordiol marmelin and phenylethyl cinnamamides (Suriyamoorthy *et al*., 2014). **'**Bael tree' is native to India and a sacred plant to Hindus. It has immense medicinal values. All the parts of the plant are useful and used in Ayurvedic medicines. Hindus use the leaves to worship Lord Shiva (Bilwa patra) and keep them on Shivling and they consider it is very auspicious and to get the blessings of Shiva. The leaves, bark, roots, fruits and seeds are used extensively in the Indian traditional system of medicine the Ayurveda and in various folk medicine to treat myriad ailments.

SCIENTIFIC CLASSIFICATION
Kingdom: Plantae
(unranked): Angiosperms
(unranked): Eudicots
(unranked): Rosids
Order: Sapindales
Family: Rutaceae
Subfamily: Aurantioideae
Tribe: Clauseneae
Genus: *Aegle* **(**Corrêa)
Species: *A. marmelos*
Binomial name
Aegle marmelos (L.) Corr.Serr.

Traditional use of *Aegle marmelos*
A. marmelos is extensively described in the Vedic literature for the treatment of various diseases. *A. marmelos* is traditionally used to treat jaundice, constipation, chronic diarrhea, dysentery, stomachache, stomachic, fever, asthma, inflammations, febrile delirium, acute bronchitis, snakebite, abdominal discomfort, acidity, burning sensation, epilepsy, indigestion, leporsy, myalgia, smallpox, spermatorrhoea, leucoderma, eye disorders, ulcers, mental illnesses, nausea, sores, swelling, thirst, thyroid disorders, tumors, ulcers and upper respiratory tract infections (Lambole *et al*., 2010; Dhankhar *et al*., 2011).

Phytochemical composition of *Aegle marmelos*
Different organic extracts of the leaves of *A. marmelos* have been reported to possess alkaloids, cardiac glycosides, terpenoids, saponins, tannins, flavonoids and steroids (Venkatesan *et al*., 2009; Sivaraj *et al*., 2011a). *Aegle marmelos* fruit pulp reported for the availability of steroids, terpenoids, flavonoids, phenolic compounds, lignin, fat and oil, inulin, proteins, carbohydrates, alkaloids, cardiac glycosides and flavonoids (Rajan *et al*., 2011). In Gas Chromatography Mass Spectrophotometry (GC/MS) analysis, the essential oil of *A. marmelos* show different chemical components. The leaf essential oil of *A. marmelos* contain 15 compounds, including seven monotorpene hydrocarbons, three oxygenated monoterpenes, four sesquiterpene hydrocarbons and one phenolic compound in all of this limonene was the main constituent (Mishra *et al*., 2012; Kaur *et al*., 2006).

Nutritional value of *Aegle marmelos*
The fruit of *A. marmelos* possess high nutritional value (Table 1). The fruit is used to make juice, jam, sirup, jelly, toffee and other products. The pulp is reported to contain water, sugars, protein, fiber, fat, calcium, phosphorus, potassium, iron, minerals and vitamins (Vitamin A, Vitamin B1, Vitamin C and Riboflavin). The leaves and the shoot of the plant are used as green vegetable in Indonesia (Sharma *et al*., 2007; Rathore, 2009).

Table 1. Modern Nutritional Value of Bael Amount of Bael: 100 gms.

Nutrients Amount	Quantity
Proteins	1.8 g
Carbohydrates Total Carbohydrates	31.8 g
Fats Total Fat	0.3 g
Vitamins Riboflavin Niacin Thiamin Vitamin A Vitamin C	 1.19 mg 1.1 mg 0.13 mg 55 mg 8 to 60 mg
Minerals Calcium Phosphorus	 85 mg 50 mg
Potassium	600 mg

PHARMACOLOGICAL STUDIES

A. marmelos is one of the most widely used medicinal and nutritional plant in the family Rutaceae. In recent history this plants is reported for various medicinal properties. The present review highlights the some important pharmacological properties in traditional as well as modern practices.

Antioxidant Activity

Antioxidants are the compounds with free radicals scavenging activity and capable of protecting the cells from free radical mediate oxidative stress. The antioxidant compounds can be derived from natural sources such as plants. Antioxidant activity of these plants is due to the presence of flavones, isoflavones, flavonoids, anthocyanin, coumarin lignans, catechins and isocatechins. The *Aegle Marmelos* can be regarded as promising candidates for natural plant sources of antioxidants with high value (Sathya *et al*., 2013). *A. marmelos* is extensively reported to possess antioxidant activity against a variety of free radicals. Antioxidant activity and free radical scavenging activity of the ripe and unripe fruit of *Aegle marmelos* was compared by Sharmila and Devi (2011). Results indicate that the enzymatic antioxidants increased in ripe fruit when compared to unripe fruit extract (except glutathione peroxidase). The percentage of free radical inhibition was also high in unripe fruit than that of the ripe fruit (Sharmila and Devi, 2011). Methanol and aqueous extract of *A. marmelos* fruit pulp was screened for antioxidant activity by DPPH radical scavenging method, reducing power assay, nitric oxide scavenging assay, superoxide radical scavenging assay, ABTS radical scavenging assay and H_2O_2 radical scavenging assay. Both aqueous and alcoholic extract exhibited good antioxidant activity (Rajan *et al*., 2011). The aqueous extract of *A. marmelos* fruit was screened for antioxidant activity by the DPPH radical scavenging. The extract showed efficient antioxidant activity (Gheisari *et al*., 2011). Aqueous extract of *A. marmelos* leaves, was evaluated for hypoglycemic and antioxidant effect by Upadhya et al. (2004), by using alloxon induced diabetes in male albino rats and proposed *Aegle marmelos* leaves may be useful in the long-term management of diabetes. *A. marmelos* leaves were extracted with methanol (ME), ethanol (EE), water (WE) and analyzed for antioxidant activities by DPPH radical scavenging method, reducing power and *in vitro* inhibition by Fenton's reagent—induced oxidation of lipid system. The three extracts showed varying degree of efficacy in each assay in a dose dependent manner. Data indicates that potential exists for the utilization of *A. marmelos* as a natural antioxidant (Reddy and Urooj, 2013).

The antioxidant activities of extracts have been evaluated by Modi et al. (2012), using a range of *in vitro* assays and *in vivo* hepatoprotective model. The extracts of *A. marmelos* were tested for *in vivo* efficacy by carbon tetrachloride (CCl_4) induced liver damage rats in hepatoprotective model. The *in vitro* antioxidant activities of extracts showed significant activities on reducing power, DPPH, hydroxyl radical and hydrogen peroxide nearer to control group based on IC_{50} values.

Cardioprotective Effect

The leaf extract has preventing effects in isoprenaline (isoproterenol)- induced myocardial infarction in rats. The activity of creatine kinase and lactase dehydrogenase was significantly increased in serum and decreased significantly in heart of isoprenaline-treated rats (Prince and Rajadulari, 2005). Use of Bael as cardiac depressant and in palpitation has also been reported (Dhaiman, 2003; Purohit and Vyas, 2004; Parmar and Kaushal, 1982). Setty et al. (2007) investigated the cardioprotective and antilipidperoxidative effect of aqueous extract of unripe fruits of *A. marmelos* (AMUFAEt) on isoproterenol (IPL) induced myocardial infarction in rats with respect to lipid metabolism, lipid peroxidation in serum. The unripe or half ripe fruit has astringent and cardiotonic effects. Oral pre-treatment with AMUFAEt (150mg Kg -1 day -1 for 20 days) significantly prevented the isoproterenol induced myocardial infarction and maintained the rats at near normal status.

Antimicrobial Activity

A. marmelos has been traditionally used for the treatment of various infectious diseases and been extensible reported to inhibit the broad range of pathogenic microorganisms. Many *in vitro* studies proved the antimicrobial potential of *A. marmelos* extracts towards the pathogenic microorganisms including bacteria and fungi. The antimicrobial activity of the leaves of *A. marmelos* was performed by agar well diffusion method. The aqueous, petroleum ether and ethanol extract of the leaves of *A. marmelos* exhibited efficient antimicrobial activity against *Escherichia coli*, *Streptococcus pneumoniae, Salmonella typhi, Klebsiella pneumoniae* and *Proteus vulgaris.* The ethanolic extract shows activity against *Penicillium chrysogenum* and the petroleum ether and aqueous extract shows activity against *Fusarium oxysporum* (Sivaraj *et al*., 2011b). The antimicrobial activity of the leaves of *A. marmelos* was reported ((Karumaran *et al*., 2016). The antimicrobial activity was checked by disc diffusion method. The petroleum ether extract of leaves was checked against multi resistant strains of *Staphylococcus aureus*, *Bacillus subtilis, Escherichia coli, Salmonella typhi, Proteus vulgaris, Pseudomonas aeruginosa* and *Klebsiella pneumoniae.* The antimicrobial activity against gram-negative strains was higher than that of gram positive strains (Gavimath *et al*., 2008).

The antifungal activity of the leaves of *A. marmelos* was reported against clinical isolates of dermatophytes. *A. marmelos* leaf extracts and fractions were found to have fungicidal activity against *Trichophyton mentagrophytes, T. rubrum, Microsporum canis, M. gypseum, Epidermophyton floccosum* (Balakumar *et al*., 2011). The antifungal and antibacterial activity of the fruit of *A. marmelos* was reported. The antimicrobial activity was performed by tube dilution MIC method. The decoction of the fruit showed activity against *Aspergillus niger, Aspergillus fumigatus, Candida albicans* and *Staphylococcus aureus* and the MIC results for the above respective organisms were 19.5 µg/ml, 39 µg/ml, 625 µg/ml and 1.25 mg/ml (Gheisari *et al*., 2011). The antibacterial activity of the leaves, fruits and barks of *A. marmelos* was reported. The antimicrobial activity of chloroform, methanol and water was performed by disc diffusion method. The antimicrobial activity was checked against *Bacillus subtilis*, *Staphylococcus aureus*, *Klebsiella pneumoniae, Proteus mirabilis*, *Escherichia coli*, *Salmonella paratyphi* A and *Salmonella paratyphi* B. The methanol extract showed significantly high activity against above-mentioned bacteria than that of the other extracts (Poonkothari and Saravanan, 2008). The antibacterial activity of the leaves of *A. marmelos* was reported. The antibacterial activity of the different extracts was evaluated by agar well diffusion method. The hexane, cold methanol, hot methanol and ciproflaxacine extracts showed high antibacterial activity against *Escherichia coli*, *Klebsiella pneumoniae*, *Proteus vulgaris*, *Micrococcus luteus*, *Enterococcus faecalis* and *Streptococcus faecalis* (Jyothi and Rao, 2010).

The antibacterial activity of the leaves of *A. marmelos* was reported. Different solvent extracts of the leaves of *A. marmelos* was checked by disc diffusion method towards five pathogenic strains of bacteria. Methanol extract showed high antibacterial activity against the test organisms (Ulahannan *et al*., 2008). The antibacterial activity of the various solvent extracts of the *A. marmelos* leaves was reported. The antimicrobial activity of the various solvent extracts was screened by modified disc diffusion assay. Different extracts showed antibacterial activity against *Micrococcus glutamicus, Streptococcus faecalis, S. aureus, S. pyogenes, Bacillus stearothermophilus, Micrococcus luteus, E. coli* and *Pseudomonas denitrificans*. Petroleum ether extract did not resulted in any activity while ethanol and chloroform extract exhibits maximum activity (Rajasekaran *et al*., 2008).

Antidiarrheal Activity

Antidiarrheal activity is one of the major medicinal properties of *A. marmelos* and traditionally it is extensively used to control chronic diarrhea and dysentery. Recently, several *in vitro* and *in vivo* studies have been conducted to confirm the antidiarrheal property of *A. marmelos*. The *in vitro* antidiarrheal activity of dried fruit pulps of *A. marmelos* was reported. Antidiarrheal activity was performed by MIC method against the causative organisms of diarrhea. The ethanolic extract showed good activity against *Shigella boydii, S. sonnei* and *S. flexneri,* moderate against *S. dysenteriae* (Joshi *et al*., 2009). Crude aqueous extract of unripe fruits of *A. marmelos* was screened for causative agents of diarrhea. The extract was analyzed for antibacterial activity, antigiardial activity and antirotaviral activity. The extract exhibited inhibitory activity against *Giardia* and rotavirus whereas viability of none of the six bacterial strains tested was affected (Brijesh *et al*., 2009). A study was undertaken to evaluate the *in vitro* and *in vivo* antidiarrhoeal potential of chloroform extract of the root of *Aegle marmelos* (Correa) Linn. The *in vitro* activity was determined by agar dilution and disc diffusion techniques. The extract was studied *in vivo* in rats. Of the 35 tested pathogenic diarrhoea causing strains, the extract was found to be mostly active against the strains of *Vibrio cholerae*, followed by *Escherichia coli* and *Shigella* spp. The *in vitro* activity was found to be comparable to that of ciprofloxacin. Further, *A. marmelos* root extract (AMRE) treated animals showed significant inhibitory activity against castor oil-induced diarrhoea. The results so obtained thus established the efficacy of AMRE as an effective antidiarrhoeal agent (Majummder *et al*., 2006).

Antidiabetic Activity

A. marmelos has been use to control diabetes in traditional medicinal system. There are so many clinical evaluation has done for antidiabetic activity of Bael leaves (Yaheya and Ismail, 2009). Many *in vivo* scientific studies have also been conducted in animal models to evaluate the ant-diabetic activity of different organic extracts (Kamalakkannan and Prince, 2004), and fresh juice of *A. marmelos*. Antidiabetic potential of the leaves and callus of *A. marmelos* was reported in streptozotocin induced diabetic rabbits. All the extracts reduced the blood sugar level in streptozotozin diabetic rabbits, however, among the various extracts, the methanol extracts of the leaf and callus brought about the maximum anti-diabetic effect (Arumugam *et al*., 2008). The anti-diabetic activity of the leaves of *A. marmelos* was reported in alloxan diabetic rats. The methanolic extract (120 mg/kg body weight, ip) of the leaves of *A. marmelos* reduces the blood sugar level. Reduction in blood sugar could be seen from 6th day after continuous administration of the extract and on 12th day sugar levels were found to be reduced by 54% (Sabu and Kuttan, 2004).

Antiproliferative activity

The different solvent fractions of ethanolic extract of the stem barks of *A. marmelos* were reported to possess antiproliferative effects against human tumor cell lines. The results showed the inhibition of *in vitro* proliferation of human tumor cell lines, including the leukemic K562, T-lymphoid Jurkat, Blymphoid Raji, erythroleukemic HEL, melanoma Colo38, and breast cancer MCF7 and MDAMB-231 cell lines (Lampronti *et al*., 2003).

Cytoprotective Effect

The cytoprotective effect of the leaves of *A. marmelos* was reported in *Cyprinus carpio* (freshwater fish) exposed to heavy metals. *C. carpio* was exposed to heavy metals followed by the treatment with the dried powder of *A. marmelos* leaves. Treatment resulted in cytoprotective effect by stabilization of plasma membrane and modulation of antioxidant enzyme system (Vinodhini *et al*., 2009).

Hepatoprotective Effect

The hepatoprotective effect of the leaves of *A. marmelos* and were reported in alcohol induced liver injury in Albino rats. Rats were administered with 30% ethyl alcohol for a period of 40 days. The induced rats were fed with leaves of *A. marmelos* for 21 days. The TBARS values of healthy, alcohol intoxicated and herbal drug treated animals were 123.35, 235.68 and 141.85 µg/g tissue respectively. This indicates the excellent hepatoprotective effect of the leaves of *A. marmelos* (Singanan *et al*., 2007).

Peptic Ulcer

An infusion of bael leaves is regarded as an effective remedy for peptic ulcer. The leaves are soaked overnight in water. This water is strained and taken in the morning. The pain and discomfort are relieved when this treatment is continued for a few weeks. Bael leaves are rich in tannin which reduces inflammation and help in the healing of ulcers. Bael fruit taken in the form of a beverage also has great healing properties on account of its mucilage content. This forms a coating on the stomach mucosa and thus helps heal ulcers (Sharma *et al*., 2007)

Ear Problems

The root of this tree is used as a home remedy for curing ear problems. A stiff piece of the root is dipped in *neem* oil and lighted. The oil that drips from the burning end is a highly effective medicine for ear problems. The antiseptic properties of *neem* combined with the astringent extract of bael root helps in curing infection, chronic inflammation and discharge (Bakhru, 2008).

Anti stress Activity

Chidambaram (2013) evaluate the anti-stress activities of aqueous leaf extract of *Aegle marmelos* in immobilization induced stress in rats. The anti-stress activities of *A. Marmelos* were assessed by monitoring the change in the status of stress hormone, glucose, and non-enzymic antioxidants in immobilization-induced stress in rats and found that treatment with AM was found to reverse the oxidative stress in the hypothalamus caused by immobilization stress. Therefore, it is concluded that *A. Marmelos* is having high anti-stress activity.

Antifertility Effect

The antifertility effect of the aqueous extracts of leaves of *A. marmelos* was reported in male Albino rats. The rats were administered with aqueous extracts (250 mg/kg body weight) of leaves of *A. marmelos* for 45 days. Treatment resulted in reduction in the weights of testis, epididymes and seminal vesicle. The extract also resulted in reduction of testicular sperm count, epididymal sperm count and motility and abnormal sperm count (Sathiyaraj *et al*., 2010).

Insect controlling properties

Essential oil from the leaves of *A. marmelos* was reported for showing insecticidal activity against four stored grain insect pests included *Callosobruchus chinensis* (L.), *Rhyzopertha dominica* (F.), *Sitophilus oryzae* (L.) and *Tribolium castaneum*. In the study grains were infected with test insects, and were fumigated with essential oil of *A. marmelos* (500 µg/mL). The oil treatment significantly reduced the grain damage as well as weight loss in fumigated grains samples infested with all insects except *T. castaneum*. The essential oil at different doses significantly reduced oviposition and adult emergence of *C. chinensis* in treated cowpea seeds (Kumar *et al*., 2008). Essential oil from the leaves of *A. marmelos* was reported for insect repellent activity against *Sitophilous oryzae* and *Tribolium castaneum*. However *A. marmelos* essential oils didn't showed 100 % repellent activity against the test insects (Mishra and Tripathi, 2011).

Radioprotective effects

Treatment with extract of bael reduces the severity of symptoms of radiation induced sickness and increases survival in mice. In radio-protective action might be due to free-radical scavenging and arrest of lipid peroxidation accompanied by an elevation in glutathione concentration in liver, kidney, stomach and intestine (Jageita *et al*., 2004; Jageita *et al*., 2005).

Analgesic activity

Leaves of *A. marmelos* were reported to possess analgesic activity. Methanol extract of leaves of *A. marmelos* was screened for analgesic activity by Acetic acid-induced writhing test in Swiss mice. The results indicated that methanol extract significantly reduced the writhing induced by acetic acid. In tail flick test methanol extract (200 and 300 mg/kg body weight) showed significant analgesic activity in the (Shankarananth *et al*., 2007).

Antiarthritis activity

Leaves of *A. marmelos* were reported to possess antiarthritis activity against collagen induced arthritis in Wistar rats. Methanol extract treatment of rats showed the reduction of paw swelling and arthritic index. Radiological and histopathological changes were also significantly reduced in methanol extract treated rats (Trivedi *et al*., 2011).

Constipation

Ripe bael fruit is regarded as best of all laxatives. It cleans and tones up the intestines. Its regular use for two or three months helps evacuate even the old accumulated faecal matter from the bowels. For best results, it should be taken in the form of "sherbet", which is prepared from the pulp of the ripe fruit. After breaking the shell, the seeds are first removed, and contents are then taken out with a spoon and passed through a sieve. Milk and little sugar may be added to make it more palatable. The pulp of the ripe fruit can also be taken from the spoon without the addition of milk or sugar. About 60 grams of the fruit will suffice for an adult.

Anti-inflammatory activity

Unripe fruit pulp of *A. marmelos* was reported to possess anti-inflammatory activity. Inflammation was induced by injecting 0.1 ml of 1% λ carrageenan into the subplaner side of left hind paw of Sprague Dawley rats. Extract treatment of the inflammated rats significantly reduced the λ carrageenan induced inflammation (Rao *et al*., 2003). Kumari *et al.* (2014) evaluated the anti-inflammatory activity of the water extract of dried flower of *Aegle marmelos* (WEAM) in Wistar rats. The WEAM showed a significant increment of rat peritoneal cell infiltration, inhibition of nitric oxide (NO) production by rat peritoneal cells and inhibition of wheal formation on the skin of the rat after injection of histamine. The WEAM protected the erythrocyte membrane from heat-induced lysis in a dose-dependent manner and showed a significant anti-oxidant effect and lipid peroxidation inhibition activity. Susanna *et al.* (2015) studied the synergistic anti-inflammatory activity of *Aegle marmelos*. Individual and synergistic anti-inflammatory activity was studied by carrageenan induced inflammation and paw edema on albino wistar rats by methanolic extracts of *Aegle marmelos*. Raju *et al.* (2016) also evaluate the antidiarrhoeal and antiinflammatory activity of *Aegle marmelos* on albino wistar rats. The ethanolic extract showed antiinflammatory and antidiarrhoeal effect in dose dependent manner when compared with the control and standard drug diclofenac sodium (10mg/kg, p.o).

Toxicity studies

A. marmelos is widely used in traditional medicinal system and fruit is usually utilized as nutritional food. However *A. marmelos* is not recommended in pregnant or breastfeeding women as the leaves of *A. marmelos* have been traditionally used to induce abortion and to sterilize women. Recently, leaves of *A. marmelos* were studied for its acute and subacute toxicity properties. The different extracts of the *A. marmelos* leaves were tested in Wistar albino rats for its LD_{50} values, acute and subacute toxicity effects. The results revealed that LD_{50} value of the different extracts, ranging from 1300 mg to 1700 mg/kg body wt.

During acute toxicity dead animals usually presented with their hearts stopped in systolic stand-still. There were no remarkable changesnoticed in the histopathological studies after 50 mg/kg body wt. (daily, 14 days) (Veerappan *et al*., 2007). Dried fruit pulp of *A. marmelos* was screened for its topological profile. Ethanolic extract of *A. marmelos* dried fruit pulp was screened for the acute oral toxicity test in Swiss albino mice at 550 and 1250 mg/kl body weight. At these concentrations test extract did not showed any sign of toxicity. No change in the behaviour and physiological activity was recorded in mice during the experiment (14 days). The results concluded that LD_{50} of the test extract is more than 1250 mg/kg body weight (Joshi *et al*., 2009). Leaf essential oil of *A. marmelos* also showing toxicity against stored-grain insect pests (Mishra *et al*., 2012; 2016).

Respiratory Affections

Medicated oil prepared from bael leaves gives relief from recurrent colds and respiratory affections. The juice extracted from bael leaves is mixed with equal quantity of sesame oil and heated thoroughly. A few seeds of black pepper and half a teaspoonful of black cumin are added to the hot oil. It is then removed from the fire and stored for use when necessary. A teaspoonful of this oil should be massaged into the scalp before a head bath. Its regular use builds up resistance against colds and coughs. A common practice in south India is to give the juice of bael leaves to bring relief from wheezing and respiratory spasm. The leaf juice, mixed in warm water with a little pepper, is give as a drink.

CONCLUSION

It is quite evident from this review that *A. marmelos* contains a number of phytoconstituents which reveals its uses for various therapeutic purposes. The plant or its individual parts can be used for the treatment of various disorders in human being such as, diabetes, liver toxicity, fungal infection, microbial infection, inflammation, pyrexia and to relieve pain. Still, so much work is required with the *A. marmelos* to investigate the mechanism of actions with other therapeutic activities.

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