



A review on pharmacological and phytochemical properties of *Aegle marmelos* (L.) Corr. Serr. (Rutaceae)

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ABSTRACT

Aegle marmelos (L.) Corr. Serr is one of the important plant with several medicinal and nutraceutical properties. *A. marmelos* is commonly known as wood apple plant. *A. marmelos* is belonging to Rutaceae family, the family of flowering plants. *A. marmelos* is known for various medicinal properties in traditional medicinal system and use to cure a variety of diseases. In last few decades, *A. marmelos* is extensively studied for its medicinal properties by advanced scientific techniques and a variety of bioactive compounds have been isolated from the different part of plant and were analysed pharmacologically. The medicinal properties of this plant represent it as a valuable source of medicinal compound. This report is a summarized information concerning the morphology, distribution, phytochemistry, traditional uses and biological activities of the *A. marmelos*.

Keywords: *Aegle marmelos*, Rutaceae, Phytochemistry.

INTRODUCTION

Plants have been utilised as a natural source of medicinal compounds since thousands of years. Human is using numerous plants and plant derived products to cures and relief from various physical and mental illness. These plants are used in traditional Chinese, Ayurveda, Siddha, Unani and Tibetan medicines. Ancient literature such as Rigveda, Yajurveda, Atharvaveda, Charak Samhita and Sushrut Samhita also describes the use of plants for the treatment of various health problems [1]. In last five decades, these plants have been extensively studied by advanced scientific techniques and reported for various medicinal properties viz, anticancer activity, antibacterial activity, antifungal activity, antidiabetic activity, antioxidant activity, hepatoprotective activity, haemolytic activity, larvicidal activity and anti-inflammatory activity etc [2-12].

A. marmelos is a native plant of India. *A. marmelos* belongs to Rutaceae family and commonly known as wood apple (Table 1). In India, *A. marmelos* is grown as a temple garden plant and the leaves are used to pray Lord Shiva. *A. marmelos* is an important medicinal plant with several ethnomedicinal applications in traditional and folk medicinal systems. Traditionally, *A. marmelos* is used in the treatment of diarrhea and dysentery. Leaves of this plant used to cause infertility/abortion in women [13]. Recently, the plant is screened for its medicinal properties by scientific techniques and reported for various medicinal properties.

The present review aims to document the morphology, distribution, phytochemistry and medicinal properties of *A. marmelos* and its future prospects for the further scientific investigation for the development of effective therapeutic compounds.

Table 1: Taxonomy of wood apple plant

Taxonomy	
Kingdom	: Plantae
Order	: Sapindales
Family	: Rutaceae
Sub family	: Aurantioideae
Genus	: <i>Aegle</i>
Species	: <i>A. marmelos</i>

The Plant

A. marmelos is a slow-growing, medium sized tree, 25 to 30 feet tall. The stem is short, thick, soft, flaking bark, and spreading, sometimes spiny branches, the lower ones drooping. Young suckers bear many stiff, straight spines. There are sharp, axial one inch long spikes on this tree. The leaflets are oval or lancet shaped, 4-10 cm long, 2-5 cm wide. Leaves composed of 3 to 5 leaflets in it. The lateral leaflets are without petiole and the terminal one has a long one. The petiole is 1 to 2.5 inch long. Mature leaves emit a peculiar fragrance when bruised. Flowers occurs in clusters of 4 to 7 along the young branchlets, have 4 recurved, fleshy petals. The flowers are greenish white in color with a peculiar fragrant. Flowering occurs during the month of May and June. Fruit is spherical or oval in shape with a diameter of 2 to 4 inch. Shell is thin, hard and woody in nature. It is greenish when unripe and upon ripening it turns into yellowish color. The pulp of the fruit has 8 to 15 segments. The pulp is yellow, soft, pasty, sweet, resinous and fragrant. Fruition occurs in the month of May and June. The seeds are embedded in the pulp. The seeds are small (nearly 1 cm in length), hard, flattened-oblong, bearing woolly hairs and each enclosed in a sac of adhesive [14].

Distribution

A. marmelos is a subtropical plant and grows up to an altitude of 1,200 m altitude from sea level. It grows well in the dry forests on hilly and plain areas. *A. marmelos* is a widely distributed plant and found in India, Ceylon, China, Nepal, Sri Lanka, Myanmar, Pakistan, Bangladesh, Nepal, Vietnam, Laos, Cambodia, Thailand, Indonesia, Malaysia, Tibet, Sri Lanka, Java, Philippines and Fiji. In India it found in Sub-Himalayan tracts from Jhelum eastwards to West Bengal, in central and south India. It found almost in all the states of India [15]. *A. marmelos* is known by different names in different parts of world, some of them are mentioned in Table 2.

Table 2: Names of *Aegle marmelos* in different languages [16]

Name	Language
<i>Aegle marmelos</i>	: Latin
Wood/Stone apple, Bengal Quince, Indian Quince	: English
Mbau Nau, Trai Mam	: Vietnamese
Bel, Gudu	: Nepali
Toum	: Lao (Sino-Tibetan)
Bnau	: Khmer
Modjo	: Javanese
Oranger du Malabar	: French
Ohshit, opesheet	: Burmese
Mojo tree	: Indonesian
Pokok Maja Batu	: Malay
Mapin, Matum, Tum	: Thai
Shreephala, Bilva, Bilwa	: Sanskrit
Sir Phal	: Old Hindi
Bel, Shreefal	: Bengali
Kaveeth	: Marathi
Vilva Maram, Vilva Pazham	: Tamil
Maredu	: Telugu
Bel	: Urdu

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, leprosy, myalgia, smallpox, spermatorrhoea, leucoderma, eye disorders, ulcers, mental illnesses, nausea, sores, swelling, thirst, thyroid disorders, tumors, ulcers and upper respiratory tract infections [13, 17].

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 [18, 19]. *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 [20].

Nutritional value of *Aegle marmelos*

The fruit of *A. marmelos* possess high nutritional value. 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 [21, 22].

Pharmacological studies

A. marmelos is one of the most widely used medicinal and nutraceutical plant in the family Rutaceae. In recent history this plants is reported for various medicinal properties (Figure 2).

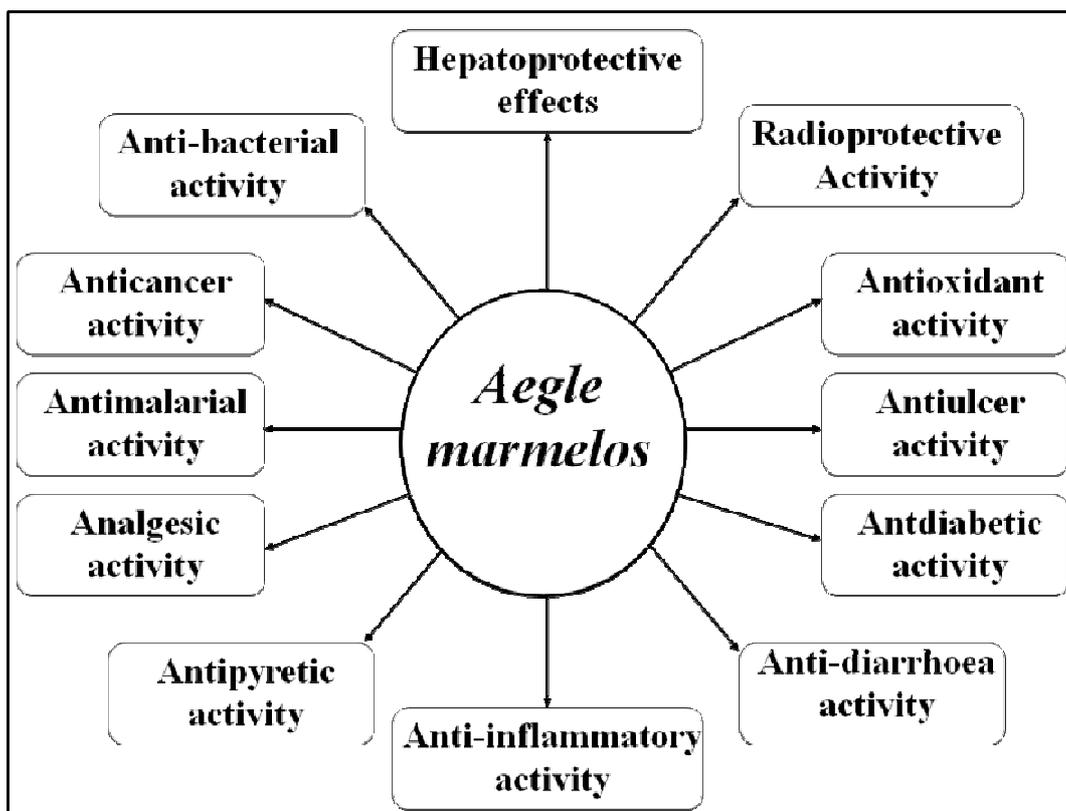


Figure 2: Medicinal properties of *Aegle marmelos*

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. *A. marmelos* is extensively reported to possess antioxidant activity against a variety of free radicals. Antioxidant activity of the fruit of *A. marmelos* was reported. Antioxidant activity and free radical scavenging activity of the ripe and unripe fruit of *Aegle marmelos* was compared. 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 [23].

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 H₂O₂ radical scavenging assay. Both aqueous and alcoholic extract exhibited good antioxidant activity [24].

The antioxidant activity of the fruit of *A. marmelos* was reported. The aqueous extract of *A. marmelos* fruit was screened for antioxidant activity by the DPPH radical scavenging. The extract showed efficient antioxidant activity [25].

Antimicrobial Activity

A. marmelos has been traditionally used for the treatment of various infectious diseases and been extensively 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 *Aegle 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* [26].

The antimicrobial activity of the leaves of *Aegle marmelos* was reported. 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 [27].

The antifungal activity of the leaves of *Aegle 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* [28].

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 [25].

The antibacterial activity of the leaves, fruits and barks of *Aegle 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 [29].

The antibacterial activity of the leaves of *Aegle marmelos* was reported. The antibacterial activity of the different extracts was evaluated by agar well diffusion method. The hexane, cold methanol, hot methanol and ciproflaxacin extracts showed high antibacterial activity against *Escherichia coli*, *Klebsiella pneumoniae*, *Proteus vulgaris*, *Micrococcus luteus*, *Enterococcus faecalis* and *Streptococcus faecalis* [30].

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 [31].

The antibacterial activity of the various solvent extracts of the *Aegle 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*, *Staphylococcus 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 [32].

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* [33].

Crude aqueous extract of unripe fruits of *A. marmelos* was screened for causative agents of diarrhea. The extract was analyzed for antibacterial activity, anti-giardial 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 [34].

Antidiabetic Activity

A. marmelos has been use to control diabetes in traditional medicinal system. Many *in vivo* scientific studies have been conducted in animal models to evaluate the ant-diabetic activity of different organic extracts 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 streptozotocin diabetic rabbits, however, among the various extracts, the methanol extracts of the leaf and callus brought about the maximum anti-diabetic effect [35].

The anti-diabetic activity of the leaves of *Aegle marmelos* was reported in alloxan diabetic rats. The methanolic extract (120 mg/kg body weight, ip) of the leaves of *Aegle 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%. [36].

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 [37].

Cytoprotective Effect

The cytoprotective effect of the leaves of *Aegle 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 *Aegle marmelos* leaves. Treatment resulted in cytoprotective effect by stabilization of plasma membrane and modulation of antioxidant enzyme system [38].

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* [39].

Antifertility Effect

The antifertility effect of the aqueous extracts of leaves of *Aegle marmelos* was reported in male Albino rats. The rats were administered with aqueous extracts (250 mg/kg body weight) of leaves of *Aegle 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 [40].

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 infested 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 [41].

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 [42].

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 [43].

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 [44].

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 inflamed rats significantly reduced the λ carrageenan induced inflammation [45].

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 LD₅₀ values, acute and subacute toxicity effects. The results revealed that LD₅₀ 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 changes noticed in the histopathological studies after 50 mg/kg body wt (daily, 14 days) [46].

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/kg body weight. At these concentrations test extract did not show 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 LD₅₀ of the test extract is more than 1250 mg/kg body weight [33].

CONCLUSION

It is quite evident from this review that *A. marmelos* an important medicinal herb and extensively used in Ayurveda, Siddha and other medicinal systems. *A. marmelos* contains a number of phytoconstituents, which are the key factors in the medicinal value of this plant. Almost all parts of this plant such as leaf, fruit, seed, bark and root are used to cure a variety of diseases. As the pharmacologists are looking forward to develop new drugs from natural sources, development of modern drugs from *A. marmelos* can be emphasized for the control of various diseases. A systemic research and development work should be undertaken for the development of products for their better economic and therapeutic utilization.

Acknowledgement

The authors wish to thank the Management and Staff of VIT University, Vellore, TN, India for supporting this study.

REFERENCES

- [1] M.J. Balunas, A.D. Kinghorn, *Life Sciences*, **2005**, 78, 431-441.
- [2] M. Shoeb, *Bangladesh J. Pharmacol.*, **2006**, 1, 35-41.
- [3] G. Kumar, L. Karthik, K.V.B. Rao, *International Journal of Pharmaceutical Sciences and Research*, **2010**, 1, 60-67.
- [4] G. Kumar, L. Karthik, K.V.B. Rao, *International Journal of Pharmaceutical Sciences Review and Research*, **2010**, 4, 141-144.
- [5] G. Kumar, L. Karthik, K.V.B. Rao, *Pharmacologyonline*, **2010**, 3, 155-163.
- [6] G. Kumar, L. Karthik, K.V.B. Rao, *Journal of Pharmacy Research*, **2010**, 3, 539-542.
- [7] R. Vadivelan, P. Umasankar, M. Dipanjan, S.P. Dhanabal, A. Shanish, M.N. Satishkumar, K. Elanko, *Der Pharmacia Sinica*, **2011**, 2, 299-304.
- [8] C.L. Priya, G. Kumar, L. Karthik, K.V.B. Rao, *Pharmacologyonline*, **2010**, 2, 228-237.
- [9] P.M. Gaikwad, S. Vidyadhara, V.V. Nimbalkar, *Der Pharmacia Sinica*, **2011**, 2, 155-160.
- [10] S. Kalita, G. Kumar, L. Karthik, K.V.B. Rao, *Pharmacologyonline*, **2011**, 1, 59-67.
- [11] A.A. Rahuman, G. Gopalakrishnan, P. Venkatesan, K. Geetha, *Parasitol. Res.*, **2008**, 102, 867-873.
- [12] S. Lakheda, R. Devalia, U.K. Jain, N. Gupta, A.S. Raghuwansi, N. Patidar, *Der Pharmacia Sinica*, **2011**, 2, 127-130.
- [13] file:///E:/Today/Aegle/Bael%20fruit%20(Aegle%20marmelos)%20%20MOM's%20Organic%20Market.htm
- [14] V.B. Lambole, K. Murti, U. Kumar, P.B. Sandipkumar, V. Gajera, *International Journal of Pharmaceutical Sciences Review and Research*, **2010**, 5, 67-72.
- [15] S. Dhankhar, S. Ruhil, M. Balhara, S. Dhankhar, A.K. Chhillar, *Journal of Medicinal Plants Research*, **2011**, 5, 1497-1507.
- [16] The Ayurvedic Pharmacopoeia of India, I Part, I Vol, Government of India, Ministry of Health and Family Welfare, Department of Ayush, India, 1999, 35-36.
- [17] <http://www.hillgreen.com/pdf/AEGLE%20MARMELOS.pdf>
- [18] D. Venkatesan, C.M. Karrunakarn, S.S. Kumar, P.T.P. Swamy, *Ethnobotanical Leaflets* **2009**, 13, 1362-1372,
- [19] R. Sivaraj, A. Balakrishnan, M. Thenmozhi, R. Venckatesh, *International Journal of Pharmaceutical Sciences and Research*, **2011**, 2, 132-136.
- [20] S. Rajan, M. Gokila, P. Jency, P. Brindha, R. K. Sujatha, *Int. J. Curr. Pharm. Res.*, **2011**, 3, 65-70.
- [21] P.C. Sharma, v. Bhatia, N. Bansal, A. Sharma, *Natural Product Radiance*, **2007**, 6, 171-178.
- [22] M. Rathore, *Journal of Horticulture and Forestry*, **2009**, 1, 103-108.
- [23] S. Sharmila, P.A.V. Devi, *Journal of Pharmacy Research*, **2011**, 4, 720-722.
- [24] S. Rajan, M. Gokila, P. Jency, P. Brindha, R.K. Sujatha, *Int. J. Curr. Pharm. Res.*, **2011**, 3, 65-70.
- [25] H.R. Gheisari, F. Amiri, Y. Zolghadri, *Int. J. Curr. Pharm. Res.*, **2011**, 3, 85-88.
- [26] R. Sivaraj, A. Balakrishnan, M. Thenmozhi, R. Venckatesh, *Journal of Pharmacy Research* **2011**, 4, 1507-1508.
- [27] C.C. Gavimath, Y.L. Ramachandra, S.P. Rai, H.V. Sudeep, P.S.S. Ganapathy, B.T. Kavitha, *Asian Journal of Bio Science*, **2008**, 3, 333-336.
- [28] S. Balakumar, S. Rajan, T. Thirunalasundari, S. Jeeva, *Asian Pacific Journal of Tropical Biomedicine*, **2011**, 1, 309-312.

- [29] M. Poonkothai, M. Saravanan, *Ancient Science of Life*, **2008**, 17, 15-18.
- [30] S.K. Jyothi, B.S. Rao, *International Journal of PharmTech Research*, **2010**, 2, 1824-1826.
- [31] K.U. Rijamol, T. Thomas, C. Sadasivan, *Int. Journal (Sciences)*, **2008**, 2, 134-138.
- [32] C. Rajasekaran, E. Meignanam, N. Premkumar, T. Kalaivani, R. Siva, V. Vijayakumar, S. Ramya, R. Jayakumararaj, *Ethnobotanical Leaflets*, **2008**, 12, 1124-1128.
- [33] P.V. Joshi, R.H. Patil, V.L. Maheshwari, *Natural Product Radiance*, **2009**, 8, 498-502.
- [34] S. Brijesh, P. Daswani, P. Tetali, N. Antia, T. Birdi, *BMC Complement Altern. Med.*, **2009**, 9, 47.
- [35] S. Arumugam, S. Kavimani, B. Kadalmani, A.B.A. Ahmed, M.A. Akbarsha, M.V. Rao, *ScienceAsia*, **2008**, 34, 317-321.
- [36] M.C. Sabu, R. Kuttan, *Indian J. Physiol. Pharmacol.*, **2003**, 48, 81-88.
- [37] I. Lampronti, D. Martello, N. Bianchi, M Borgatti, E. Lambertini, R. Piva, S. Jabbar, M. Shahabuddin Kabir Choudhuri, M. Tareq Hassan Khan, R. Gambari, *Phytomedicine*, **2003**, 10, 300-308.
- [38] R. Vinodhini, M. Narayanan, *International Journal of Integrative Biology*, **2009**, 7, 124-129.
- [39] V. Singanan, M. Singanan, H. Begum, *International Journal of Science & Technology*, **2007**, 2, 83-92.
- [40] K. Sathiyaraj, A. Sivaraj, G. Madhumitha, P.V. Kumar, A.M. Saral, K. Devi, B.S. Kumar, *Int. J. Curr. Pharm. Res.*, **2010**, 2, 26-29.
- [41] R. Kumar, A. Kumar, C.S. Prasa, N.K. Dubey, R. Samant, *Internet Journal of Food Safety*, **2008**, 10, 39-49.
- [42] B.B. Mishra, S.P. Tripathi, *Singapore Journal of scientific Research*, **2011**, 1, 173-178.
- [43] V. Shankarananth, N. Balakrishnan, D. Suresh, G. Sureshpandian, E. Edwin, E. Sheeja, *Fitoterapia* **2007**, 78, 258-259.
- [44] H.P. Trivedi, N.L. Pathak, M.G. Gavaniya, A.K. Patel, H.D. Trivedi, N.M. Panchal, *International Journal of Pharmaceutical Research and Development*, **2011**, 3, 38-45.
- [45] Cb.V. Rao, A.S.K. Ojha, S. Mehrotra, P. Pushpangadan, *Acta Pharmaceutica Turcica*, **2003**, 45, 85-91.
- [46] A. Veerappan, S. Miyazaki, M. Kadarkaraisamy, D. Ranganathan, *Phytomedicine*, **2007**, 14, 209-215.