ejpmr, 2018,5(5), 214-219

SJIF Impact Factor 4.897

EUROPEAN JOURNAL OF PHARMACEUTICAL AND MEDICAL RESEARCH

www.ejpmr.com

Review Article

ISSN 2394-3211

EJPMR

PHARMACOLOGICAL INVESTIGATIONS ON *BAEL* (*AEGLE MARMELOS* LINN.): A UNANI MEDICINAL PLANT

[1]Fouzia Bashir*, [2]Jamal Akhtar, [3]Nighat Anjum, [4]Shah Alam and [5]Pawan Kumar

[1,4]Research Associate, Central Council for Research in Unani Medicine, New Delhi.
[2,3,5]Research Officer, Central Council for Research in Unani Medicine, New Delhi.

Corresponding Author: Dr. Fouzia Bashir

Research Associate, Central Council for Research in Unani Medicine, New Delhi.

Article Received on 15/03/2018 **Article Revised on 04/04/2018** **Article Accepted on 25/04/2018**

ABSTRACT

Nature has provided a complete storehouse of remedies to cure ailment of mankind. *(Aegle marmelos)* is an important medicinal plant used in Unani System of medicine, which is cultivated throughout India. It is popularized for having antidiarrhoeal and antidysenteric activity. Extensive investigations have been carried out on different parts of *Aegle marmelos* and as a consequence, varied classes of compound i.e. alkaloids, terpenoids, fatty acids and amino acids have been isolated from its different parts. The present paper is an attempt to summarize the pharmacological actions and medicinal uses of the *Bael* plant mentioned in Unani medical literature as well as in currently reported studies.

KEYWORDS: *Bael, Aegle marmelos*, Unani Medicine, Pharmacological.

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 have been extensively studied by advanced scientific techniques and reported for various medicinal properties viz, anti-cancerous, antibacterial, antifungal, anti diabetic, antioxidant, hepato-protective, larvicidal and anti-inflammatory activity etc. *Bael (A. marmelos)* (Linn.) Correa ex. Roxb, commonly known as *Bael* or *Bel* in Unani Medicine is a plant of Rutaceae family, the family of flowering plants.

Vernacular names

Bael (A. marmelos) is also known as *Apple wood*, *Bengal Quince* in English, *bel* in Hindi, *Kuvilam, Villuvam* in Tamil, *Maredu, Sriphalamu* in Telugu, *Bilva, Asholam* in Sanskrit, *billi* in Gujrati, and *Bela, Bilva* in Kannada.

Plant Description

It is a slow growing, medium-moderate size, slender, aromatic tree having height of 6.0 to 7.5 m and girth 90 to 120 cm with short trunk, thick, soft, light grey flaking bark, and spreading, sometimes spiny branches of 2.5 cm long, the lower ones drooping. The deciduous leaves are attenuate, trifoliolate, occasionally digitately five foliolate, with leaflets. Ovate or ovate-lanceolate, crenate, acuminate, lateral sessile, the terminal one with a long petiole of 1 to 2.5 inch. New foliage is glossy and pink-maroon. Mature leaves emit a peculiar fragrance when bruised. Flowers are large, greenish white in colour, sweet-scented in nature. They occur in clusters of 4 to 7 along the young branchlets, have 4 recurved, fleshy petals. Flowering occurs during the month of May and June. Fruit is spherical or oval in shape with a diameter of 2 to 4 inch, with small dots on the outer surface. Shell is thin and woody in nature. It is greenish when unripe and upon ripening it turns into yellowish colour. The pulp of the fruit has 8 to 15 segments which is yellow, soft, pasty, sweet, resinous and fragrant. Fruitation occurs in the month of May and June. Seeds are numerous and embedded in the pulp, flattened-oblong, bearing wooly hairs and each enclosed in a sac of adhesive.

Distribution

Bael (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. *Bael (A. marmelos)* is a widely distributed plant and found in India, Ceylon, China, Nepal, Sri Lanka, Myanmar, Pakistan, Bangladesh, Nepal and Vietnam. In India it is found in Sub-Himalayan tracts from Jhelum eastwards to West Bengal, in central and south India. It is extensively planted near Hindu temples for its leaves and wood that is used for worship. Its edible fruits are used in indigenous system of medicine. The tree is generally found scattered in Bahraich district (Uttar Pradesh), however, it occurs gregariously in patches of varying extent. It can withstand various types of soil, climate conditions and a pH range of 5 to 10. *Bael (A. marmelos)* is drought-hardy and is ordinarily found in dry localities unfavourable to majority of the species. It is fairly frost-

resistant and can withstand as low a temperature as -7 degree. Although it grows in open forests, it is capable of standing a fair amount of shade, temperature varies from 40 degree to 46 degree, the absolute minimum from 0 to 7 degree, and annual rainfall from 570 to 2000 mm.[1,28,48] There are no standard varieties of *bael.*[1]

PHYTO-CHEMICAL AND PHARMACOLOGICAL INVESTIGATIONS

Different organic extracts of the leaves of *Bael (A. marmelos)* have been reported to possess alkaloids, cardiac glycosides, terpenoids, saponins, tannins, flavonoids and steroids.[53,54,55] *Bael (A. 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.[53,57]

Besides the ripe and unripe fruits, the root, bark, leaf and seed of *bael (A. Marmelos)* are valued in Unani System of Medicine. Recent pharmacological and toxicological investigations have shown the safety and efficacy of the plant.

The Fruits

The Fruit are alterative, nutritive, and laxative, which are used in habitual constipation and dyspepsia.[11] The fruit is prescribed in tuberculosis and hepatitis.[28] The unripe fruits are regarded as astringent[1,11, 28,37,46], Digestive[1,11,28,37,48], Stomachic[1,11,28,37,43,48], Heart tonic[1,48,50], brain tonic[1,48,50], and appetizer[28,48]. These are used in chronic diarrhoea[1,11,14,28,37, 38,43,48,50,51], and dysentery.[1,11,14,28,37, 38,43,48,50,51] Decoction of unripe fruits with fennel seeds and ginger is used for biles.[28]

The preparations of *Bael (A. marmelos)* fruits commonly used are- the extract made from fresh unripe fruits, liquid extracts from dried slices of unripe fruit, and the powdered, dried pulp which is kept in air tight bottles. Clinical trials of unripe fruits showed antiviral activity against *Ranikhet* Diseases virus, hypoglycaemic activity and significant result against intestinal parasites, viz. *Ascartis lumbricoides* Linn., *Entamoeba histolytica* and *Girardia* sp.[1]

The ripe fruits and the pulp, diluted with water when added with requisite amount of sugar and tamarind, forms a delicious cooling drink. Green fruit is used for making a preserve (morabba).[1] It is sweet[11,28,37], aromatic[11,37,43], astringent[28,37,43], tonic[28], laxative[11,28,37,43], appetizer[28,43], febrifuge[28, 37, 43] and used in dyspepsia.[11] The astringent rind of the ripe fruit is employed in acute dysentery.[11]

Fruit exhibits antidiabetic[10, 31, 32], anti hyperlipidaemic[10] and antioxidant[10, 24] properties with protective effects on the pancreas.[10] Powder of dried pulp is given with treacle in recent dysentery with griping pain in the loins.[11] The dried ripe pulp is astringent and used in dysentery.[28] The pulp of fresh fruit is mixed with milk and administered with cubeb powder in chronic diarrhoea.[11]

Root

It is used in urinary troubles[1,37], palpitation[1,11], hypochondriasis[1,11], melancholia[1,11,28], vomiting[37] and gastric irritability especially in infants.[37] Decoction of the root bark is used in the treatment of intermittent fever[1, 11, 28, 37, 50] and snake bite.[50] Plant Root extracts shows anti diarrhoeal activity.[12] Root is also used as an ingredient of *Arq Dashmool*, a medicine regulary used in Unani System of medicine for various disorders.[49] Decoction of root is used as cardiac tonic.[50]

The Leaves

The leaves are bitter and used as febrifuge[1,11,28,37], astringent[28,37], laxative[28,37], digestive[28] and expectorant.[37] These are useful in the treatment of dropsy[1], Beriberi[1], asthma[1,37], ophthalmia[1,11,28,37], anasarca[11], deafness[28,37], cataract[1,51] and ulcers.[1] In external inflammations, the juice of the leaves is given internally to remove the supposed derangements of the humours (*Akhlat*).[28]

Leaves of *Bael (A. marmelos)* have anti-inflammatory, antipyretic and analgesic activities.[5,20]

Bael (A. marmelos) leaves possess anti hyperlipidaemic effect in rats[2,19], also possess antioxidant[4,16,25], antithyroid[4] and antidiabetic[4,16,25,36,37,50] effects.

The fresh leaf extract is reported to have significantly decreased the requirement of circulatory stimulant and also reduces the period of convalescence in patients with cholera or choleric diarrhoea. Aqueous and alcoholic extracts of the leaves are reported to possess cardio-tonic[1] effects and preventive effects on myocardial infarction in rats.[15,19]

Seeds

Seeds of the plant have anti diabetic activity[6] and anti ulcer effect.[39] The flowers relieve thirst and vomiting[28] and are regarded as useful in dysentery.[28] Extracts of *Bael (A. marmelos)* show antidiabetic and hypoglycaemic activity.[3,7,9,18,21,27,35,44] It has immune stimulatory[8] and radio-protective effect in the different doses of radiation.[13,22,26,33] Methanol extracts of *Bael (A. marmelos)* show strong antibacterial activity against *Salmonella typhi*.[23]

Bael (*Aegle marmelos*) is effective against human coxsackie viruses B1-B6.[30] Extract of *Bael (A. marmelos)* is able to inhibit the *in vitro* proliferation of human tumor cells.[17,34] Ethyl acetate extracts of the stem bark of *Bael (A. marmelos)* shows insecticidal activity against *Phaedon cochleariae* and *Musca domestica*.[29]

It is also useful in acute shigellosis[41] and irritable bowel syndrome.[42] It is haemostyptic[45,50] and aphrodisiac[47]

and is useful in the treatment of hemorrhage and menorrhagia.[45,47]

PHARMACOLOGICAL STUDIES

Several evidence based researches have reported different pharmacological activities of *Bael (A. marmelos)* in various *in vitro* and *in vivo* test models which are as follows.

Antioxidant activity

In a study, it was reported that Methanol and aqueous extract of *Bael (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.[57]

Antifungal and Antibacterial activity

In a study, the *antifungal* and *antibacterial activity* of the fruit of *Bael (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.[58]

In another study, the *antibacterial activity* of the leaves of *Bael (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 Ciprofloxacine extracts showed high antibacterial activity against *Escherichia coli*, *Klebsiella pneumoniae*, *Proteus vulgaris*, *Micrococcus luteus*, *Enterococcus faecalis* and *Streptococcus faecalis*.[59]

A study was conducted in which the *antifungal activity* of the leaves of *Bael (A. marmelos)* was reported against clinical isolates of dermatophytes. *Bael (A. marmelos)* leaf extracts and fractions were found to have fungicidal activity against *Trichophyton mentagrophytes*, *T. rubrum*, *Microsporum canis*, *M. gypseum*, *Epidermophyton floccosum*.[68]

The *antifungal activity* of essential oil isolated from the leaves has been evaluated using spore germination assay. The oil exhibited variable efficacy against different fungal isolates and 100% inhibition of spore germination of all the fungi tested was observed at 500 ppm.[40]

Antidiarrheal activity

In a study, the *in vitro antidiarrheal activity* of dried fruit pulps of *Bael (A. marmelos)* was found. *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*.[59]

Crude aqueous extract of unripe fruits of *Bael (A. marmelos)* was screened for causative agents of diarrhoea. 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.[60]

Anti-inflammatory activity

Unripe fruit pulp of *Bael (A. marmelos)* was reported to possess *anti-inflammatory activity*. The analgesic and antipyretic activities were also evaluated. 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.[64] The extract also produced marked analgesic activity by reduction the early and late phases of paw licking in mice.

Antidiabetic activity

Antidiabetic potential of the leaves and callus of *Bael (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.[61]

The *anti-diabetic* activity of the leaves of *Bael (A. marmelos)* was reported in alloxan diabetic rats. The methanolic extract (120 mg/kg body weight, ip) of the leaves of *Bael (A. marmelos)* educes 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%.[62]

Hepato-protective activity

The *hepatoprotective effect* of the leaves of *Bael (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 *Bael (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 hepato-protective effect of the leaves of *Bael (A. marmelos)*.[64]

Anti-arthritic activity

Leaves of *Bael (A. marmelos)* were reported to possess *antiarthritic 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.[65]

TOXICOLOGICAL INVESTIGATIONS

Bael (A. marmelos) s is widely used in traditional medicinal system and fruit is usually utilized as nutritional food. However *Bael (A. marmelos)* is not recommended in pregnant or breastfeeding women as the leaves of *Bael (A. marmelos)* have been traditionally used to induce abortion and to sterilize women.

Recently, leaves of *Bael (A. marmelos)* were studied for its acute and subacute toxicity properties. The different extracts of the *Bael (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 changes noticed in the histopathological studies after 50 mg/kg body wt (daily, 14 days).[67]

Dried fruit pulp of *Bael (A. marmelos)* was screened for its topological profile. Ethanolic extract of *Bael (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 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.[52,60]

CONCLUSION

Bael (A. marmelos) is an important medicinal herb which has been described exhaustively in Unani Literature. Almost all parts of this plant such as leaves, fruit, seed, bark and roots are used to cure different diseases. The Unani physicians have used it for its digestive, appetizer, anti diarrhoeal, heart tonic, and anti diabetic properties and also mentioned that *Bael (A. marmelos)* can be used in Gonorrhoea, Allergic cough and as Deodarant also. Pharmacological investigations have also revealed the anti-microbial, anti-arthritic and anti oxidant properties of *Bael (A. marmelos)* but scientifically few of them have been screened. So, more pre clinical studies need to be conducted to find the hidden properties of *Bael (A. marmelos)*.

REFERENCES

1. Anonymous, (1985). *The Wealth of India, Raw Material*, Vol. I, Publication and Information Directorate, CSIR, New Delhi, 85-91.
2. Narender, T., Shweta, S., Tiwari, P., Papi Reddy, K., Khaliq, T., Prathipati, P., Puri, A., Srivastava, A.K., Chander, R., Aggarwal, S.C. and Raj, K., (2007). Antihyperglycemic and antidyslipidemic agent from *Aegle marmelos, Bioorg. Med. Chem. Lett.,* 15; 17(6): 1808-1811.
3. Narendhirakannan, R.T., Subramanian, S. and Kandaswamy, M., (2006). Biochemical evaluation of antidiabetogenic properties of some commonly used Indian plants on streptozotocin-induced diabetes in experimental rats, *Clin. Exp. Pharmacol. Physiol*, 33(12): 1150-1157.
4. Panda, S. and Kar, A., (2006). Evaluation of the antithyroid, antioxidative and antihyperglycemic activity of scopoletin from *Aegle marmelos* leaves in hyperthyroid rats, *Phytother. Res*, 20(12): 1103-1105.
5. Shankarananth, V., Balakrishnan, N., Suresh, D., Sureshpandian, G., Edwin, E. and Sheeja, E., (2007). Analgesic activity of methanol extract of *Aegle marmelos* leaves, *Fitoterapia.*
6. Kesari, A.N., Gupta, R.K., Singh, S.K., Diwakar, S. and Watal, G., (2006). Hypoglycemic and antihyperglycemic activity of *Aegle marmelos* seed extract in normal and diabetic rats, *J. Ethnopharmacol*, 11, 107(3): 374-379.
7. Anandharajan, R., Jaiganesh, S., Shankernarayanan, N.P., Viswakarma, R.A. and Balakrishnan, A., (2006). *In vitro* glucose uptake activity of *Aegle marmelos* and *Syzygium cumini* by activation of Glut-4, PI3 kinase and PPARgamma in L6 myotubes, *Phytomedicine*, 13(6): 434-441.
8. Citarasu, T., Sivaram, V., Immanuel, G., Rout, N. and Murugan, V., (2006). Influence of selected Indian immune stimulant herbs against white spot syndrome virus (WSSV) infection in black tiger shrimp, *Penaeusmonodon* with reference to haematological, biochemical and immunological changes, *Fish Shellfish Immunol*, 21(4): 372-384.
9. Kotowaroo, M.I., Mahomoodally, M.F., Gurib-Fakim, A. and Subratty, A.H., (2006). Screening of traditional antidiabetic medicinal plants of Mauritius for possible alpha-amylase inhibitory effects *in vitro*, *Phytother. Res*, 20(3): 228-231.
10. Kamalakkannan, N and Prince, P.S., (2005). The effect of *Aegle marmelos* fruit extract in streptozotocin diabetes –a histopatholocal study, *J. Herb Pharmacother*, 5(3): 87-96.
11. Nadkarni, K.M., (2004). Medicinal Plants of India, Reprint Publication, Dehradun, 20-22.
12. Mazumder, R., Bhattacharya, S., S. Mazumder, A., Pattnaik, A.K., Tiwary, P.M. and Chaudhary, S., (2006). Antidiarrhoel evaluation of *Aegle marmelos* (Correa) Linn. Root extract, *Phytother. Res*, 20(1): 82-84.
13. Jagetia, G.C. and Venkatesh, P., (2005). Radioprotection by oral administration of Aeglemarmelos (L.) Correa in vivo. J. Environ. *Pathol. Toxicol. Oncol*, 24(4): 315-332.
14. Dhuley, J.N., (2003). Investigation on the gastroprotective and antidiarrhoel properties of *Aegle marmelos* unripe fruit extract, *Hindustan Antibiot. Bull*, 45-46(1-4): 41-46.
15. Prince, P.S. and Rajadurai, M., (2005). Preventive effect of *Aegle marmelos* leaf extract on isoprenaline-induced myocardial infarction in rats: biochemical evidence, *J. Pharm. Pharmacol*, 57(10): 1353-1357.

16. Upadhya, S., Shanbhag, K.K., Suneetha, G., Balachandra Naidu, M. and Upadhya, S., (2004). A study of hypoglycaemic and antioxidant activity of *Aegle marmelos* in alloxan-induced diabetic rats, *Indian J. Physiol. Pharmacol*, 48(4): 476-480.
17. Costa-Lotufo, L.V., Khan M.T. Ather, A., Wilke, D.V., Jimenez, P.C., Pessoa, C., de Moraes, M.E. and de Moraes, M.O., (2005). Studies of the anticancer potential of plants used in Bangladeshi folk medicine, *J Ethnopharmacol*, 99(1): 21-30.
18. Narendhirakannan, R.T., Subramanian, S and Kandaswamy, M., (2005). Mineral content of some medicinal plants used in the treatment of diabetes mellitus, *Biol. Trace Elem. Res*, 103(2): 109-115.
19. Rajadurai, M and Prince, P.S., (2005). Comparative effects of *Aegle marmelos* extract and alpha-tocopherol on serum lipids, lipid peroxides and cardiac enzyme levels in rats with isoproterenol-induced myocardial infarction, *Singapore Med. J*, 46(2): 78-81.
20. Arul, V., Miyazaki, S. and Dhananjayan, R., (2005). Studies on the anti-inflammatory, antipyretic and analgesic properties of the leaves of *Aegle marmelos* Corr., *J. Ethnopharmacol*, 96(1-2): 159-163.
21. Gholap, S. and Kar, A., (2004). Hypoglycaemic effects of some plant extracts are possibly mediated through inhibition in corticosteroid concentration, *Pharmazie*, 59(11): 876-878.
22. Jagetia, G.C., Venkatesh, P. and Baliga, M.S., (2004). Fruit extract of *Aegle marmelos* protects mice against radiation-induced lethality, *Integr. Cancer Ther*, 3(4): 323-332.
23. Rani, P and Khullar, N., (2004). Antimicrobial evaluation of some medicinal plant for their anti-enteric potential against multi-drug resistant *Salmonella typhi*, *Phytother. Res*, 18(8): 670-673.
24. Kamalakkannan, N and Stanely Mainzen Prince, P., (2003). Effect of *Aegle marmelos* Correa. (Bael) fruit extract on tissue antioxidants in streptozotocin-induced diabetic rats, *Indian J. Exp. Biol*, 41(11): 1285-1288.
25. Sabu, M.C. and Kuttan, R., (2004). Antidiabetic activity of Aeglemarmelos and its relationship with its antioxidant properties. *Indian J. Physiol. Pharmacol*, 48(1): 81-88.
26. Jagetia, G.C., Venkatesh, P. and Baliga, M.S., (2004). Evaluation of the radioprotective effect of bael leaf (*Aegle marmelos*) extract in mice, *Int. J Radiat. Biol*, 80(4): 281-290.
27. Saxena, A. and Vikram, N.K., (2004). Role of selected Indian plants in management of type 2 diabetes: a review, *J Alten. Complement med*, 10(2): 369-378.
28. Kirtikar, K.R. and Basu, B.D., (1975). *Indian Medicinal Plants*, Vol. I, Periodical Experts, New Delhi, 499-502.
29. Samarasekera, J.K., Khambay, B.P. and Hemalal, K.P., (2004). A new insecticidal protolimonoid from *Aegle marmelos*, *Nat. Prod. Res*, 18(2): 117-122.
30. Badam, L., Bedekar, S.S., Sonawane, K.B. and Joshi, S.P., (2002). *In vitro* antiviral activity of bael (Aegle marmelos Corr.) upon human coxsackieviruses B1-B6, *J Commun. Dis*, 34(2): 88-99.
31. Kamalakkannan, N., Rajadurai, M and Prince, P.S., (2003). Effect of *Aegle marmelos* fruits on normal and streptozotocin-diabetic Wistar rats, *J. Med. Food*, 6(2): 93-98.
32. Kamalakkannan, N. and Prince, P.S., (2003). Hypoglycaemic effect of water extracts of *Aegle marmelos* fruits in streptozotocin-diabetic rats, *J. Ethnopharmacol*, 87(2-3): 207-210.
33. Jagetia, G.C., Venkatesh, P and Baliga, M.S., (2003). Evaluation of the radioprotective effect of *Aegle marmelos* (L.) Correa in cultured human peripheral blood lymphocytes exposed to different doses of gamma-radiation: a micronucles study, *Mutagenesis*, 18(4): 387-393.
34. Lampronti, I., Martello, D., Bianchi, N., Borgatti, M., Lambertini, E., Piva, R., Jabbar, S., Choudhuri, M.S., Khan, M.T. and Gambari, R., (2003). In vitro anti proliferative effects on human tumor cells lines of extracts from the Bangladeshi medicinal plant *Aegle marmelos* Correa, *Phytomedicine*, 10(4): 300-308.
35. Kar, A., Choudhary, B.K. and Bandyopadhyay, N.G., (2003). Comparative evaluation of hypoglycaemic activity of some Indian medicinal plant in alloxan-diabetic rats, *J. Ethnopharmacol*, 84(1): 105-108.
36. Sachdewa, A., Raina, D., Srivastava, A.K and Khemani, L.D., (2001). Effect of Aeglemarmelos and Hibiscus rosasinesis leaf extract on glucose tolerance in glucose-induced hyperglycaemic rats (Charles foster), *J. Environ. Biol*, 22(1): 53-57.
37. Warrier, P.K., Nambiar, V.P.K and Ramakutty, C., (1994). *Indian Medicinal plants*, part I, Orient Longman, Madras, pp. 62-66.
38. Shoba, F.G. and Thomas, M., (2001). Study of antidiarrhoel activity of four medicinal plants is castor oil induced diarrhoea, *J. Ethnopharmacol*, 76(1): 73-76.
39. Goel, R.K., Maiti, R.N., Manickam, M. and Ray A.B., (1997). Antiulcer activity of naturally occurring pyrano-coumarin and isocoumarins and their effect on prostanoid synthesis using human colonic mucosa, *Indian J. Exp. Biol*, 35(10): 1080-1083.
40. Rana, B.K., Singh, U.P. and Taneja, V., (1997). Antifungal activity and kinetics of inhibition by essential oil isolated from leaves of *Aegle marmelos*, *J. Ethnopharmacol*, 57(1): 266-270.
41. Haider, R., Khan, A.K. Aziz, K.M., Chowdhury, A. and kabir, I., (1991). Evaluation of indigenous plants in the treatment of acute shigellosis. *Trop. Geogr. Med*, 43(3): 266-270.
42. Yadav, S.K., Jain, A.K., Tripathi, S.N. and Gupta, J.P., (1989). Irritable bowel syndrome: therapeutic

evaluation of indigenous drugs, *Indian J. Med. Res*, 90: 496-503.
43. Kurup, P.N.V., (1977). *Handbook of Medicinal Plants*, Vol. I, Central Council for Research in Indian Medicine and Homeopathy, New Delhi, 20.
44. Karunanayake, E.H., Weilhinda, J., Sirimanne, S.R. and Sinnadorai, G., (1984). Oral hypoglycaemic activity of some medicinal plants of Sri Lanka, *J. Ethnopharmacol*, 11(2): 223-231.
45. Kabeeruddin, M., (YNM). *Makhzanul Mufradat*, Mohammad Basheer and Sons, Lahore, 152-153.
46. Waring, E.J., (2007). *Pharmacopoeia of India*, Asiatic Publishing House, Delhi, 441-442.
47. Hakeem, M.A., (1999). *Bustanul Mufaradat*, Zafar Book Depot, New Delhi, 104.
48. Ghani, M. N. (1998). *Khazainul Advia*, Idara Matbuat Sulaimani, Lahore, 505-509.
49. Kabeeruddin, M. (YNM). *Bayaaz-e-Kabeer*, Hamdard Kutub Khana, Lahore, 897.
50. Lubhaya, R., (1992). *Bayanul Advia*, Idara Matbuat Sulaimani, Lahore, 129-130.
51. Prasad, L. (2001). *Pak wa Hind ki Jadi Bootiyan*, Faisal Publication, New Delhi, 59-60.
52. Ezhilaras, A., Vijaya, J. J., Kaviyarasu, K., Kennedy, J. L., Ramalingam, R. J., Lohedan, H.A. (2018). Green synthesis of Nio nanoparticles using *Aegle Marmelos* leaf extract for the evaluation of in-vitro cytotoxicity, antibacterial and photo catalytic properties. *J. Photochem. Photobiol*, 39-50.
53. Chakraborty, M., Jagdish, K.V., Dipak, G., Axay, P.R., (2012). *Aegle Marmelos (Linn):* A Therapeutic Boon for Human Health, 3(2): 159-163.
54. Venkatesan, D., Karrunakaran, C.M., Kumar, S. S., Swamy, P.T.P., (2009) Ethnobotanical Leaflets, 13: 1362-1372.
55. Sivaraj R., Balakrishnan A., Thenmozhi M., Venkatesh R., (2011). *International Journal of Pharmaceutical Sciences and Research*, 2: 132-136.
56. Sharma, P.C., Bhatia, V., Bansal, N., Sharma, A., Natural Product Radiance, 2007; 6: 171-178.
57. Rajan, S., Gokila, Jency, M. P., Brindha, P., Sujatha, R.K., (2011), *Int. J. Curr. Pharm. Res*, 3: 65-70.
58. Gheisari, H.R., Amiri, F., Zolghadri, Y., (2011) *Int. J. Curr. Pharm. Res*, 3: 85-88.
59. Jyothi, S.K., Rao, B.S., (2010), International Journal of PharmTech Research, 2: 1824-1826.
60. Joshi, P.V., Patil, R.H., Maheshwari, V.L., (2009) Natural Product Radiance, 8: 498-502
61. Brijesh, S., Daswani, P., Tetali, P., Anita, N., Birdi T., (2009) BMC *Complement Altern. Med*, 9: 47.
62. Arumugam, S., Kavimani, S., Kadalmani, B., Ahmed, A.B.A., Akbarsha M.A., Rao M.V., (2008) Science Asia, 34: 317-321.
63. Sabu, M.C., Kuttan, R., (2003) *Indian J. Physiol. Pharmacol*, 48: 81-88.
64. Singanan, V., Singanan, M., Begum, H., (2007) International Journal of Science & Technology, 2: 83-92.
65. Trivedi, H.P., Pathak, N.L., Gavaniya M.G., Patel A.K., Trivedi, H.D., Panchal, N.M., (2011) *International Journal of Pharmaceutical Research and Development*, 3: 38-45.
66. Rao, Cb.V., Ojha, A. S. K., Mehrotra, S., Pushpangadan, P., (2003) *Acta Pharmaceutica Turcica*, 45: 85-91.
67. Veerappan, A., Miyazaki, S., Kadarkaraisamy, M., Ranganathan, D., (2007), *Phytomedicine*, 14: 209-215.
68. Balakumar, S., Rajan, S., Thirunalasundari, T., Jeeva, S., (2011) *Asian Pacific Journal of Tropical Biomedicine*, 1, 309-312.