



A REVIEW ON PHARMACOLOGICAL PROPERTIES OF *Aegle marmelos* (BAEL)

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ABSTRACT

This article provides a review on the pharmacological Activity of *Aegle marmelos*. It is belonging to Rutaceae family. The *Aegle marmelos* is also known as Bael, Bilwa and wooden apple plant. It contains various bioactive components in leaves, flowers, fruits, wood, root, and bark which has different biological activities and high therapeutic importance. The phytochemical compounds which are isolated from the *Aegle marmelos* are Coumarins (Marmelosin, marmesin, imperatorin), alkaloids (Aeglin, aegelenine), Tannins (skimmianine), Carotenoids and seed oils and other miscellaneous compounds. The phytochemical components of this plant showed various pharmacological and biological activity against certain chronic diseases like cancer, cardiovascular disease, immunosuppressive disease and gastrointestinal disorder. The different parts of this plant extract possess pharmacological activities like anticonvulsant, antioxidant, anti-inflammatory, antidiabetic, antidiarrheal, antihyperglycemic, anxiolytic, antidepressant, antihistaminic, antimicrobial, hepato protective, analgesic, immuno modulatory, cardio protective and antithyroid activities. The present review articles summarizes and focused to explore the different pharmacological activities of *Aegle marmelos* plant.

Keywords: *Aegle marmelos*, alkaloids, phytochemical, coumarins, tannins and pharmacological activities.

INTRODUCTION

Thousands of years *Aegle marmelos* have been used as a natural source of medicinal compounds. Man is using numerous herbs and plant extract to cures and relief from various physical and mental illness. These herbs are used in traditional Chinese, Ayurveda, Siddha, Unani and Tibetan medicines. Ancient literature such as Rigveda,

Yajurveda, Atharvaveda, Charak Samhita and Sushrut Samhita also describe the use of herbs for the treatment of various health problems (V. Jhansi Lakshmi et al., 2021).

Aegle marmelos (L.) commonly known as Bael belonging to the family Rutaceae has been widely used in indigenous systems of Indian medicine due to its various medicinal properties. *A. marmelos* is native to Northern India, but widely found throughout the Indian Peninsula and in Ceylon, Burma, Bangladesh, Thailand and Indo. 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. Bel is a sacred tree native to India and has great aesthetic value among Hindus as tree is worshiped in rituals by masses. (Ghumare Pramila and Dattatraya Jirekar 2020).

The plant is also known by different names as stone apple or wood apple, bili, bilva patra, Bengal quince or golden apple. The plant is mentioned as Tripatra in ancient Indian scriptures such as Yajurveda and Mahabharata. Its leaves are ternate and scented named as tripatras and are used in enchantments. The plant is also figured in Aranyakas and Hindu Sahintas. This plant is as old as Hindu civilization and has great aesthetic, cultural, and medicinal value. (Guttle Sakshi Hanumanat et al.,2020).

According to the World Health Organization plant extracts or their active constituents are used as folk medicine in traditional therapies of 80% of the world's population. Over 50% of all modern clinical drugs are of natural product origin (Kirbag et al., 2009).

The leaves of *A. marmelos* are offered to Lord Shiva, whose worship cannot be completed without the leaves of this tree. It is also known as Shivadurme, the tree of Shiva. The value mentioned plant has also been found in ancient Indian scriptures like Yajurveda and Mahabharata (Asha and Krishan, 2016).



Figure 1: *Aegle marmelos* plant



Figure 2: *Aegle marmelos* leaves, Flowers and fruits

PHYTOCHEMISRY OF *Aegle marmelos*

Aegle marmelos having a variety classes of compounds like alkaloids, cardiac glycosides, saponins, steroids, coumarin's, terpenoids, phenylpropanoids, tannins, polysaccharides, vitamins, carbohydrate, coumarin, flavonoids, fati acid and essential oil which are obtained from the different parts of tree.

Various phytoconstituent found in the different part of the *Aegle marmelos* are given in The following (figure no.3) in detail.

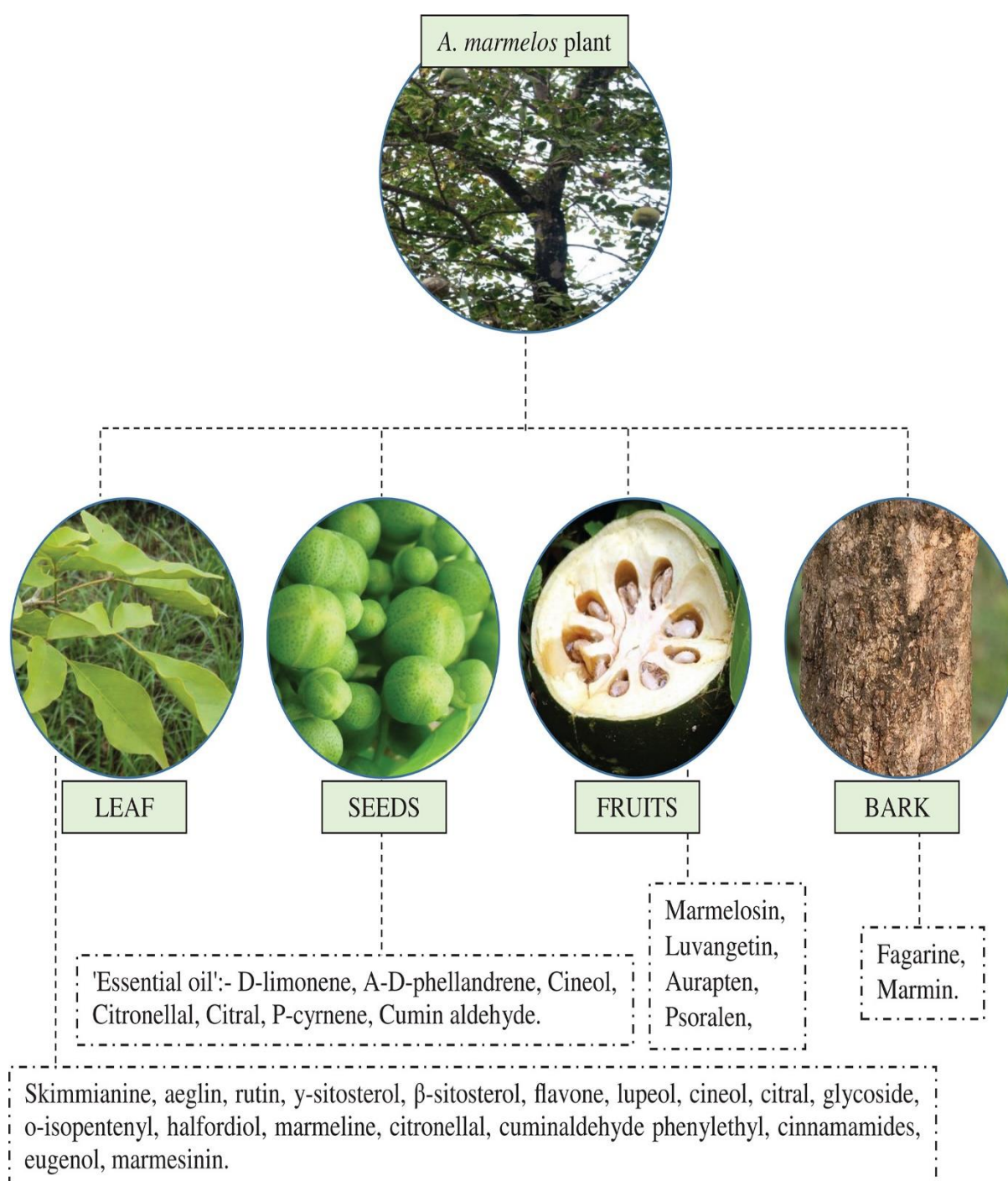
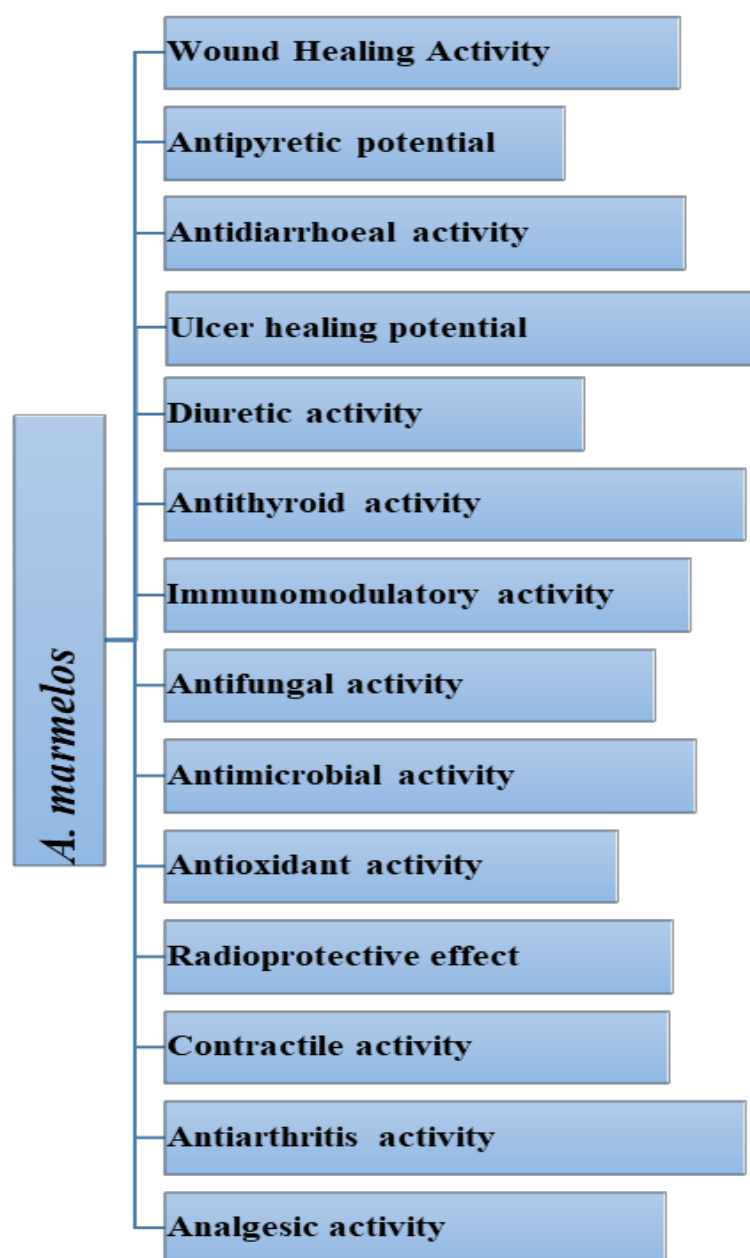


Figure 3: Different Phytoconstituent found in *Aegel marmelos***PHARMACOLOGICAL PROPERTIES OF *Aegle marmelos***

Aegle marmelos is one of the most widely used medicinal plant in the family Rutaceae. In recent history this plant is reported for various medicinal properties. In recent history this plant is reported for various medicinal properties (Figure 3). (Kumari Anupama et al.,2020).

**Figure 4: Various pharmacological properties of *Aegle marmelos***

Various scientist carried out following different study to evaluated different pharmacological activities by using various plant part of *Aegle marmelos* and different solvent as well as various screening method.

Various study of different pharmacological activities of *Aegle marmelos* mention bellow in details.

Anticancer activity

Pritesh Rajan Das et al., (2020) investigated *the A. marmelos* can be an effective weapon to boost our healing process in fighting cancer disease. Studies showed that plant extract can inhibit the increase of leukemic K562, T-lymphoid Jurkat, B-lymphoid Raji, erythroleukemia HEL, melanoma Colo38, and breast cancer cell lines MCF 7 and MDA-MB-231. phytochemicals present in the plant such as lupeol, eugenol, citral, cineole and d-limonene present can show antineoplastic effects.

K.Sudhir Kumar et al.,(2021) reported that the Most of the potent antineoplastic drugs available are expensive, mutagenic, and teratogenic inducing drugs derived from natural sources (paclitaxel). Hence attention is being given to developing inexpensive and nontoxic drugs from alternate sources. The extracts of *A. marmelos* were tested for cytotoxicity using brine shrimp lethality assay; sea urchin eggs assay, and MTT assay using tumor cell lines.

Saliya Parveen Gulam Rasool and Mohamed Hassan Dehghan (2022) evaluated The anticancer potential of folk medicine used in Bangladeshi and used extracts of *Aegle marmelos* for cytotoxic action using brine shrimp lethality assay sea urchin eggs assay, and MTT assay using tumor cell lines. The extracts of *Aegle marmelos* were shows toxicity on all used assays.

S.Monika et al.,(2023) reported The *A.marmelos* of methanol and acetone extract of cytotoxicity against HEp-2, MDA-MB-231, and Vero cells were investigated. The IC₅₀ for the methanol extract of *A. marmelos* was 47.08 g/ml, whereas the IC for the acetone extract of *A. marmelos* was 79.62 g/ml, making HEp-2 cells more sensitive to it. Both extracts of *A. marmelos* are toxic to cancer cells however, Vero cells can survive 24 hours.

Antiulcer activity

Bramhkumari Singh et al., (2012) demonstrated Methanolic extract of unripe fruit of *Aegle marmelos* reduced gastric ulceration and prevent the oxidative stress caused by Helicobacter Pylori-Lipopolysaccharide in rats.

Salman Sakib Bin Rased et al., (2018) investigated that Bael plant also demonstrates anti-ulcer activity. In a study, the ulcer was artificially induced by using indomethacin, stress, and pylorus. Methanolic showed potential anti-ulceration impact with a significant p-value of 0.05. It even reduces gastric juice amount, free acidity and increased pH.

Guttle Sakshi Hanumant et al., (2020) concluded that ulcer is a result of the defensive failure of mucosal layer of the GIT, it is due to imbalance between defensive and attacking factor like acid. There are several factors which induced peptic ulcer like H.pylori bacteria, acid secretion, drinking of alcohol, smoking and many more Moreover the recurrence of ulcer after stopping medicine is high. About 70% of ulcer could recur. An infusion of *Aegle marmelos* leaves is an effective remedy for peptic ulcer.

Avishikta Ray et al., (2020) investigated that methanolic extract of *Aegle marmelos* fruit reduced gastric ulceration and prevented oxidative stress due to the presence of lutein and quercetin which lowers oxidative stress in the gastro duodenal mucosa.

Anti-inflammatory activity

Kumari KDKP et al., (2014) suggested that the anti-inflammatory properties of the aqueous extract of *A. marmelos* dried flowers are investigated in Wistar rats. The anti-inflammatory effects of water extract were most effective at 200 mg/kg two hours after administration.

Ghumare Pramila and Dattatraya Jirekar (2020) evaluated anti-inflammatory activity of different extracts of the leaves of *Aegle marmelos*. The extracts produced significant inhibition of the carrageenin-induced paw edema and cotton pellet granuloma in rats. The leaves exhibited anti-inflammatory property due to presence of lupeol, skimmianine.

PR Kmar et al., (2023) investigated the potential anti-inflammatory activities of the repeated extracts from *A. marmelos* leaves. An apparent analgesic effect was demonstrated in mouse models of carrageenan-induced paw edema and cotton-pellet granuloma to establish the antipyretic and analgesic activities of the leaf extracts. Additionally, the early and late phases of paw licking were diminished, and hyperpyrexia decreased.

Antidiabetic activity

Shamala R et al., (2021) concluded that the leaf extract of *A. marmelos* is an important medicine for the treatment of diabetes. Leaf extract significantly decreases the levels of blood urea and cholesterol and also decreases oxidative stress in experimental diabetic animals, it is indicated by significant reduction in lipid peroxidation, conjugated diene and hydroperoxide level and increased levels of various enzymes like superoxide dismutase, catalase, glutathione peroxidase, and glutathione levels in serum as well as liver.

Aliza Subedi and Binita Bashyal (2022) reported that the *A. marmelos* fruits were more effective at enhancing glucose uptake by yeast cells as compared to the common medicine 'metformin.'

Rahasool et al., (2022) indicated all the extracts of *Aegle marmelos* proved to be active against diabetic rabbits, however, among the various extracts, methanolic extract of leaves showed maximum anti-diabetic effect.

Antihyperglycemic activity

Ansari et al., (2017) reported that the ethanolic extract of *Aegle marmelos* leaves possess antihyperglycemic activity when administered orally at 250 and 500 mg/kg to diabetic rats. A noticeable decrease in glucose absorption and inhibition of both α amylase and intestinal disaccharidase enzyme activity were observed due to inhibition of carbohydrate digestion and absorption, and improvement of insulin action to uptake glucose in peripheral tissue.

Nigam and nambir et al., (2019) concluded The recent study revealed that leaf juice of *A. marmelos* was effective in diabetes mellitus and possibly it was due to presence of bioactive components, aegelin, scopoletin and sitosterol in the leaves.

K Sudhir kumar et al., (2021) indicated the Oral administration of aqueous extract of bael fruits and seeds separately to a dose of 250 mg/kg to streptozotocin-induced diabetic rats significantly lowered the serum and tissue lipid profile.

Mohamed Hassan Dehghan and Saliya Parveen Gulam Rasool (2022) suggested that the *Aegle marmelos* were evaluated in diet induced hyperlipidemic models of Wister albino rats at a dose of 125 and 250mg/kg dose. Aqueous extracts of fruits and seeds were applied to streptozotocin induced diabetic rats through oral administration significantly reduces tissue lipid profile and serum.

Antimicrobial activity

Karuna S et al., (2016) demonstrated that the Antimicrobia activity of the plant ingredient was tested. To test this agar wall diffusion method was followed. Constituents such as aqueous, petroleum ether and ethanol extract of the leaves presented efficient antimicrobial activity.

Tiwari R.C. et al., (2020) reported the methanol extract of bilwa has high antimicrobial activity against *Basillus subtilis*, *Staphylococcus aureus*, *Klebsiella pneumonia*, *Proteus mirabilis*, *Escherichia coli*, *Salmonella paratyphi A* and *Salmonella paratyphi B*. Also, the antimicrobial activity of different extracts was evaluated by agar well diffusion method.

M.thirumal et al., (2023) investigated that In the ethyl acetate extract of *A. marmelos* leaf, the quinine compound was identified and possessed good antibacterial activity against gram-positive and negative bacteria.

Hepatoprotective activity

Rahul Swarnkar et al., (2019) reported that leaves, seed and pulp of fruit of *A. marmelos* shows hepatoprotective activity The methanolic leaves extract of *Aegle marmelos* @500 mg/kg possess hepatoprotective activity against paracetamol induced hepatotoxicity in rats.

Rivai et al., (2020) concluded the hepatoprotective activity of *A. marmelos* aqueous extracts at different doses, which indicate toxicity in mice. Various biochemical parameters of blood and tissue such as AST, ALT, SALP, cholesterol, triglycerides, urea, LPO, GSH, ATPase, G-6-Pase, SOD, and CAT are changed after CCl₄ administration. In conclusion, the aqueous extract of *A. marmelos* may be able to cure liver damage in mice induced against CCl₄. It may also be mediated through antioxidant activity.

Laxmi et al., (2021) investigated *A. marmelos* leaf produces hepatoprotective effect for liver injury in albino rats due to alcohol consumption. Rats are injected with bacterial suspension at a dose of 5x10⁶ CFU/0.1 ml through intraperitoneal route. This experiment results indicates that *Aegle marmelos* leaves have excellent hepatoprotective effect.

Anxiolytic and Antidepressant activity

Kothari et al., (2010) demonstrated The methanolic leaves extract of *A. marmelos* possess anxiolytic and antidepressant activity and it enhances anxiolytic and antidepressant activity of imipramine and fluoxetine.

Dr.S.Prassankumari et al., (2019) concluded that aqueous extract of *Aegle marmelos* possess potential antidepressant effect when comparable to that of tablet Fluoxetine The antidepressant effect of *Aegle marmelos* was evaluated using tail suspension test (TST) and the decrease in duration of immobility was compared with the standard drug Fluoxetine.

Kumar poojala and Vinay kumar sayli (2022) investigated that Fruit pulp extract (300 mg/kg) of *A. marmelos* has demonstrated maximum antidepressant activity in FST and SID models, which was comparable to standard drug.

Antifertility activity

Shahedur Rahman and Rashida Parvin (2014) Investigated That *A. marmelos* leaf, seed and fruit is known to affect male fertility in reversible manner. *A. marmelos* bark extract is a rich source of marmin and fagarine known for reducing male fertility.

Shaikh A. et al., (2017) Demonstrated *A. marmelos* bark, two chemical compounds such as marmin and fagarine are present which is claimed to be responsible for the reduction of male fertility. According to methanolic extract of *A. marmelos* reduces reproductive organ weight and serum testosterone levels.

Ranveer singh et al., (2019) evaluated 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 and 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.

Ghumare Pramila Dattatraya Jirekar (2020) suggested that According to methanolic extract of *Aegle marmelos* reduces reproductive organ weight and serum testosterone levels. It can even reduce sperm density, motility, viability and sperm acrosomal integrity. Changes of elongated spermatids, nuclear chromatin condensation and degeneration were seen and significance histopathological changes such as necrosis are seen along with testicular cytotoxicity But interestingly, on withdrawal it restores the morphological changes.

Antiviral activity

Shamla R et al., (2021) investigated that effect of various extracts of bael also acts on the late protein synthesis were studied to evaluate its degree of potentiality as an antiviral agent. The 50% ethanolic extract of the fruits has shown antiviral activity against Ranikhet disease. The fruit extract has exhibited interferon-like activity against the same virus but not showed an activity against vaccinia virus. So that the bael has better viricidal activity.

Saliya Parveen Gulam Rasool and Mohamed Hassan Dehghagan (2022) evaluated that Hydro alcoholic extract of wooden apple produces antiviral activity against Ranikhet disease virus. Interferon like activity against the same virus is also reported. Thus, wooden apple can be used as a better viricidal potential and may be exploited as a potent antiviral agent in near future.

S. Monika et al., (2023) evaluated that Different portions of the *A. marmelos* (Bael) are observed against human coxsackie viruses B1-B6 for *in-vitro* antiviral activity with ribavirin as a standard antiviral drug. Thus Marmelide possessed 32-times more potent inhibitory activity than ribavirin. *A. marmelos* extracts were shown to be effective against the white spot syndrome virus in shrimp at a dose of 150 mg/kg of animal body weight.

CONCLUSION

Aegle marmelos is an important medicinal herb and extensively used in Ayurveda, Siddha and other medicinal systems. The different parts of this plant such as leaf, fruit, seed, bark and root are used to cure a variety of diseases. The *A. marmelos* contains Number of biologically active compounds which are isolated from various parts of *A. marmelos*. The isolated compounds are Alkaloids, Terpenoids, Vitamins, Coumarins, Tannins, Carbohydrates, Flavonoids, Fatty Acids, Essential Oils and some other miscellaneous compounds. Which are responsible for various pharmacological activities such as Antioxidant, Antibacterial, Antifungal, Antidiarrheal, Antidiabetic, Cytoprotective, Hepatoprotective, Antifertility, Anticancer, Antiviral and Wound Healing along with other several medicinal propertie. It is wounder plant and will indeed be the life saving plant of the 21st century. This review mainly focused on several phytochemical and reported pharmacological studies of *Aegle marmelos*.

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