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Aegle marmelos (L.) Correa (Bael): A Review on Ethnobotanical, Phytochemical and Pharmacological Profile

Ashwin Singh Chouhan[1], Riya Raisinghani[2], Anam Khan[3], Manish Solanki[4], Arshi Khan[5]

[1,2,3,4,5]Jai Narain Vyas University, Ratanada, Jodhpur (Rajasthan.) India 342003

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ABSTRACT

Bael unripe or half-ripe fruits of *Aegle marmelos* Corr., belonging to family Rutaceae. This is found in open sandy places, and arid regions widely distributed in Indian sub-continent. The plant is used for various conditions such drug is very popular in Ayurveda and is used in diarrhoea and dysentery.

Action is attributed to mucilage. Leaves contain alkaloids and are considered useful in diabetes and fruits useful in breast cancer. Its roots have contraceptive activity. Following various folk claims for the ailment of various diseases, efforts have been made by the researchers to verify the efficacy of this weed through scientific and biological screening.

This article features chemical constituents, pharmacological activities and the traditional uses of *Aegle marmelos*. This compilation would pave further research on *Aegle marmelos* as an important medicinal plant.

Keywords: *Aegle marmelos*, traditional uses and pharmacological properties etc.

INTRODUCTION

BAEL

Synonyms

Bael fruits, Bel, Indian Bael, Bengal Quince, Belan. [1]

Biological Source

Bael consists of the unripe or half-ripe fruits or their slices or irregular pieces of *Aegle marmelos* Corr., belonging to family Rutaceae.

Geographical Source

Sub-Himalayan tract and throughout India, especially Central and Southern India, Burma, occurring as wild and also cultivated

Collection

Tree is deciduous about 12 m in height. It is a sacred tree and the leaves known as *Bilipatra* are used for worshipping Lord Shiva. The tree has strong, straight spines, compound trifoliate leaves and berry fruit. Fruits are collected during April–May. After collection, epicarp removed and usually cut into transverse slices or irregular pieces.

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MORPHOLOGY

Odour	Aromatic
Taste	Mucillaginous
Shape and Size	Sub-spherical berry, 5–10 cm in diameter
Epicarp	Hard, woody, externally reddish-brown, smooth or granular.
Mesocarp and Endocarp	Consist of pulp which is reddish-brown and made up of 10–12 carpels. Each carpel contains several seeds with oblong, flat, multicellular, woolly white hairs. Seeds are surrounded by mucilage.

Table No 1:- Morphology of Aegle Marmelos (L.) Correa (Bael)

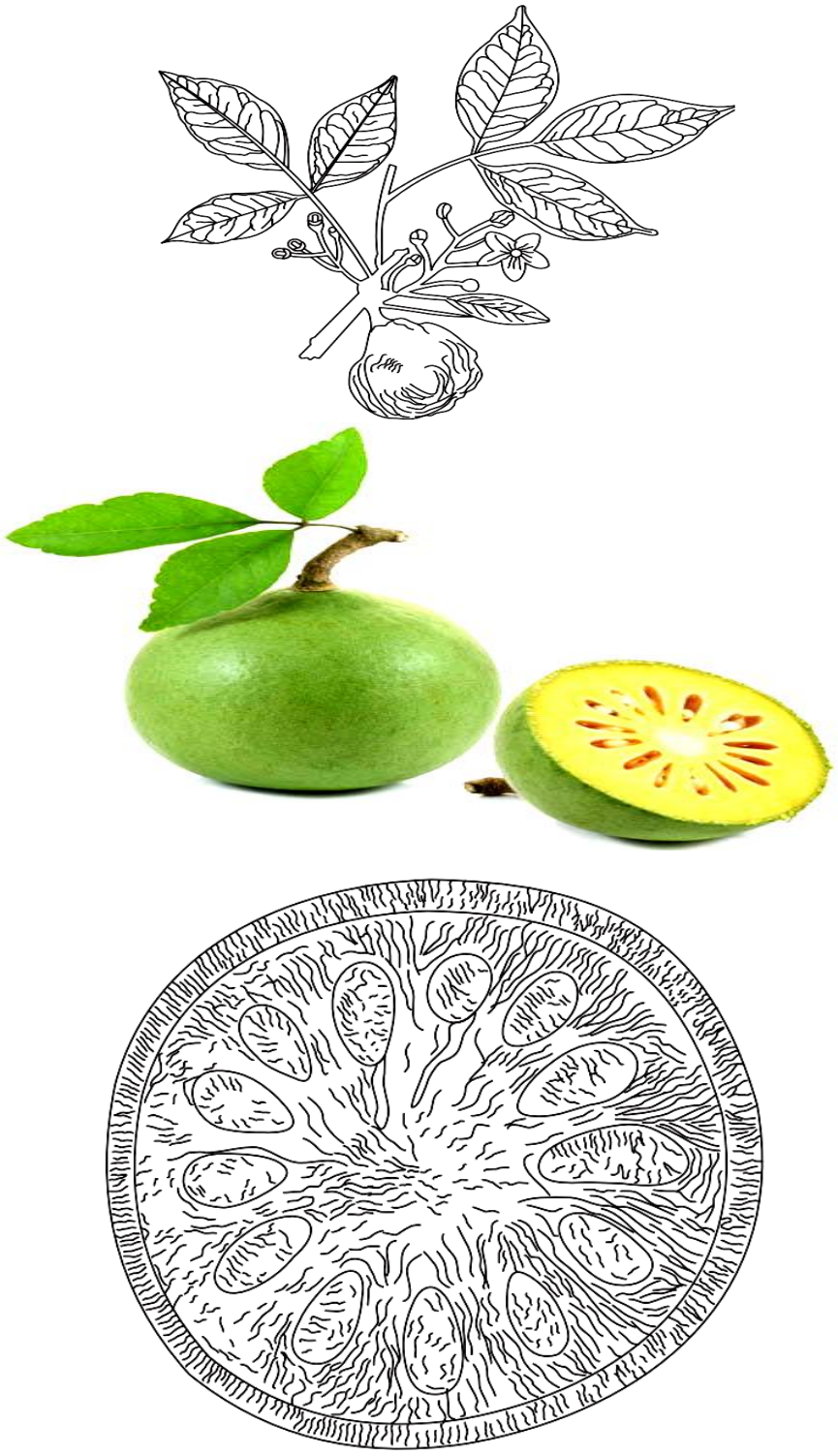
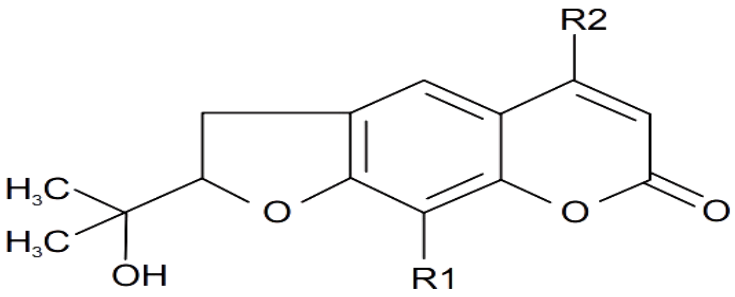


Figure No 1:- Bael Fruit (*Aegle marmelos)*

T.S. of Bael fruit
Chemical Constituents

The chief constituent of the drug is marmelosin A, B and C (0.5%), which is a furocoumarin. Other coumarins are marmesin, psoralin and umbelliferone. The drug also contains carbohydrates (11–17%), protein, volatile oil and tannins. The pulp also contains good amount of vitamins C and A. Two alkaloids O-methylhalfordinol and iso-

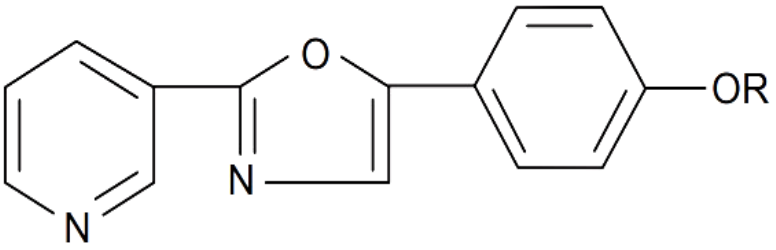
pentylhalfordinol have been isolated from fruits. Other alkaloids reported in the drug are angelenine, marmeline and dictamine. [1]



	R1	R2
Marmelosin A	H	H
Marmelosin B	H	CH_3
Marmelosin C	CH_3	H

Figure No 2:- Chemical Structure of Marmelosin

Figure No 3:- Chemical Structure of halfordinol



O-Methylhalfordinol $R = CH_3$

Isopentylhalfordinol $R = CH_2 – CH = CH – CH_3$ (CH_3, CH_3)

Figure No 3:- Chemical Structure of halfordinol

Uses

Drug is very popular in Ayurveda and is used in diarrhoea and dysentery. Action is attributed to mucilage. Leaves contain alkaloids and are considered useful in diabetes. The oil obtained from seeds possesses antibacterial, antiprotozoal and antifungal properties. The root of *bael* is one of the constituents of well-known Ayurvedic preparation Dasmula.

In large doses it may lead to abortion, therefore, it can be used as abortifacient agent and hence it should not be used in pregnant women. [1]

Substitute

Mangosteen fruits: Garcinia mangostana Linn (Guttiferae) is a substitute for this fruit, and it can be identified by the darker rind and the wedge shaped radiate stigmas.

Wood apple: Limonia acidissima Coor (Rutaceae) is a five lobed fruit with rough exterior part.

Pomegranate rind: Punica granatum Linn (Punicaceae) contain triangular impressions on the seeds and has astrin-gent taste. [1]

Marketed Products

It is one of the ingredients of the preparations known as Lukol for leucorrhoea; Chyawanprash (Himalaya Drug Company); Isabbeal and Bilwadi churna (Baidyanath Company); Madhushantak (Jamuna Pharma) and Sage bilwa churn (Sage Herbals).[1]

Phytochemistry of *Aegle marmelos*

Various chemical constituents like alkaloids, coumarins (marmelosin, marmesin, marmin, imperatorin, scopoletin), steroids, polysaccharides, phenylpropenoids, tannins, flavonoids, carotenoids, saponin, etc have been isolated from various parts of tree such as leaves, fruits, wood, root and bark.

The leaves contain γ-sitosterol, aegelin, skimmianine (tannin), lupeol, rutin, marmesinin, β- sitosterol, flavone, glycoside, Limonene and phenylethyl cinnamamides. Fresh leaves contain alkaloid Shahidine, halfordino, ethylcinnamamide and marmeline. [2] Recently, series of phenylethyl cinnamides (anhydromarmeline, aegelinosides A and B), were isolated from *Aegle marmelos* leaves which are α-glucosidase inhibitors. Rutin flavon, flavon glycosides and flavon-3-ols are the major flavonoids of *A. marmelos* leaves. α-Phellandrene (Terpenoid) was found to be the common constituent of leaves, twigs and fruits.

The fruits comprise tannin (skimmianine also known as 4, 7, 8-trimethoxyfuro-quinoline), phenylpropanoids (hydroxycoumarins, phenylpropenes and lignans), Aegeline, Marmelosin, luvangetin, Aurapten, Psoralen, Marmelide, p-cymene. [3]

The seed oil incorporate palmitic, Stearic, oleic, linoleic and linolenic acid. Some of minerals, viz. phosphorus, potassium, calcium, magnesium and iron. The roots of the tree have also been found to contain psoralen, xathotoxinscoploletin, tembamide, containpsoralen, xathotoxinscoploletin and tembamide.[4,5] The bark exhibited the presence of Marmin, Skimmiamine Mature, Fagarine.[6] The structure of some isolated compounds are displayed in Fig 1.

Pharmacological activities of *Aegle marmelos*

Aegle marmelos is a medicinal plant and researchers scientifically documented the extract of various parts of plant demonstrated the different pharmacological activities such as Antihyperglycemic, Anti-inflammatory, antipyretic, analgesic, Anticonvulsant, Antihistaminic, Anxiolytic, antidepressant, Antioxidant, Hepatoprotective, Antimicrobial, Analgesic, Antifungal, Neuroprotective etc. Table 1 demonstrated the list of pharmacological activities till date performed on *Aegle marmelos* along with their findings.

Ethnomedicinal uses of *Aegle marmelos*

Leaves extracts of *Aegle 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, diabetes mellitus, eye disorders, ulcers, mental illnesses, nausea, sores, swelling, thirst, thyroid disorders, tumors, ulcers and upper respiratory tract infections. It is also used to treat Anaemia, Fractures, Healing of Wounds, Swollen Joints, High Blood Pressure, Diarrhoea, Healthy Mind and Brain Typhoid Troubles during Pregnancy.

Sweet drink prepared from the pulp of fruits produce a soothing effect on the patients who have just recovered from bacillary dysentery. The pulp of unripe fruit is soaked in gingelly oil for a week and this oil is smeared over the body before bathing. This oil is said to be useful in removing the peculiar burning sensation in the soles. Fresh fruit extracts lower blood pressure. Fine powder of unripe fruit can be an alternative medicine to cure intestinal parasites, like *Entamoeba histolytica, Ascaris lumbricoides*.

Root bark is used in remission of intermittent fevers fever, fish poison, remedy for heart palpitation and melancholia. Bark juice, mixed with cumin in milk, increases seminal fluid volume. Alcoholic root extracts cure hypoglycemia. It is also used in dog bite, gastric troubles, heart disorders, antiamoebic, rheumatism.

Flower extracts are used as a tonic for the stomach, intestine, antidysenteric, anti-diabetic, epilepsy, diaphoretic and local anesthetic. [54-59]

Table 2: Reported pharmacological activities of *Aegle marmelos.*

Pharmacological activity	**Plant part**	**Results**
Antihyperglycemic	Leaves	Decrease in glucose absorption and inhibition of both α amylase and intestinal disaccharidase enzyme activity due to presence of bioactive components, aegelin 2, scopoletin and sitosterol[07-09]; effective as insulin in restoration of blood glucose.[10]
Anti-inflammatory, antipyretic & analgesic	Leaves	Significant inhibit the carragenin-induced paw edema due to presence of lupeol, skimmianine.[11, 12]
Anticonvulsant	Leaves	Interfere with GABAergic mechanism to exert their anticonvulsant activity due to presence of flavonoid, Lupeollinoleate, Skimmianine, Eugenol.[13, 14]
Antihistaminic	Leaves	Inhibited the histamine release from rat leukemia cell line (RBL-2H3 cell) and also inhibit the histamine release and suppressed Ca^{2+} influx on RBL-2H3 cell line.[15-18]
Anxiolytic & antidepressant	Leaves	It enhances anxiolytic and antidepressant activity of imipramine and fluoxetine.[19, 20]
Antioxidant	Leaves	It has capability of protecting the cells in oxidative stress due to the presence of flavones, isoflavones, flavonoids, alkaloid, sterpenoids, phenolic content, anthocyanin, coumarin, lignans,
		catechins and isocatechins.[21-23]
Hepatoprotective	Leaves, Seed, Fruit	Showed significant decrease in the levels of serum markers, indicating the protection of hepatic cells against ethanol induced hepatocellular injury.[24-27]
Antimicrobial	Leaves & Fruit	Inhibit the broad range of pathogenic microorganisms. produced maximum inhibition zone of 11 mm and 9 mm.[28-30]
Analgesic	Leaves	Showed significant analgesic activity on acetic acid-induced writhing and tail flick test in mice.[31]
Antifungal	Leaves	Interfere with the Ca^{2+}-dipicolonic acid metabolism pathway and possibly inhibit the spore formation at concentration of 500 ppm.[32]
Neuroprotective	Leaves	Showed acetylcholinesterase (AChE) inhibitory activity in the brain which improves the symptoms of cognitive deficit by elevating the levels of acetylcholine.[33]
Anti-ulcer	Fruit	Reduced gastric ulceration and prevent the oxidative stress[34] due to the presence of luvangetin and quercetin which lowers oxidative stress in the gastro duodenal mucosa.[25, 35,36]
Antiviral	Fruit	Contain marmilide, which interferes with early events of replicating cycle.[37]
Anti-cancer	Leaves, Fruit & Bark	Inhibit the *in vitro* proliferation of human tumor cells, erythroleukemic HEL, melanoma colo38, MDAMB- 231 and breast cancer MCF7 cell lines.[38] Also showed antiproliferative activity against colon, breast carcinoma and leukaemia cell line.[39-41] Due to the presence of lupeol, eugenol, citral, and marmelin skimmianine.[25]

Immunomodulatory	Leaves	Stimulate cell mediated and antibody mediated immune responses in rats[42]; also high dose was best effective in humoral immunity.[43]
Antithyroid	Leaves	Decreased thyroid hormone level due to presence of scopoletin.[44]
cardioprotective effect	Leaves	Exhibited cardioprotective effect against isoproterenol induced myocardial infarction in rats due to the presence of aurapten.[45]
antidiarrhoeal	Fruit	Effective remedy for prevention of diarrhea[46] due to presence of tannins and flavonoids.[47-49]
Toxicology	Leaves	Chronic administration of leaf powder did not induce any short term toxicity. It have a high margin of drug safety.[50,51]
Anthelmintic	Fruit	Showed significant difference in paralysis and death time.[52]
Antifertility	Leaves	Showed significant reduction in the weights of testis, epididymes, seminal vesicle, testicular sperm count, epididymal sperm count and motility and abnormal sperm count.[53]

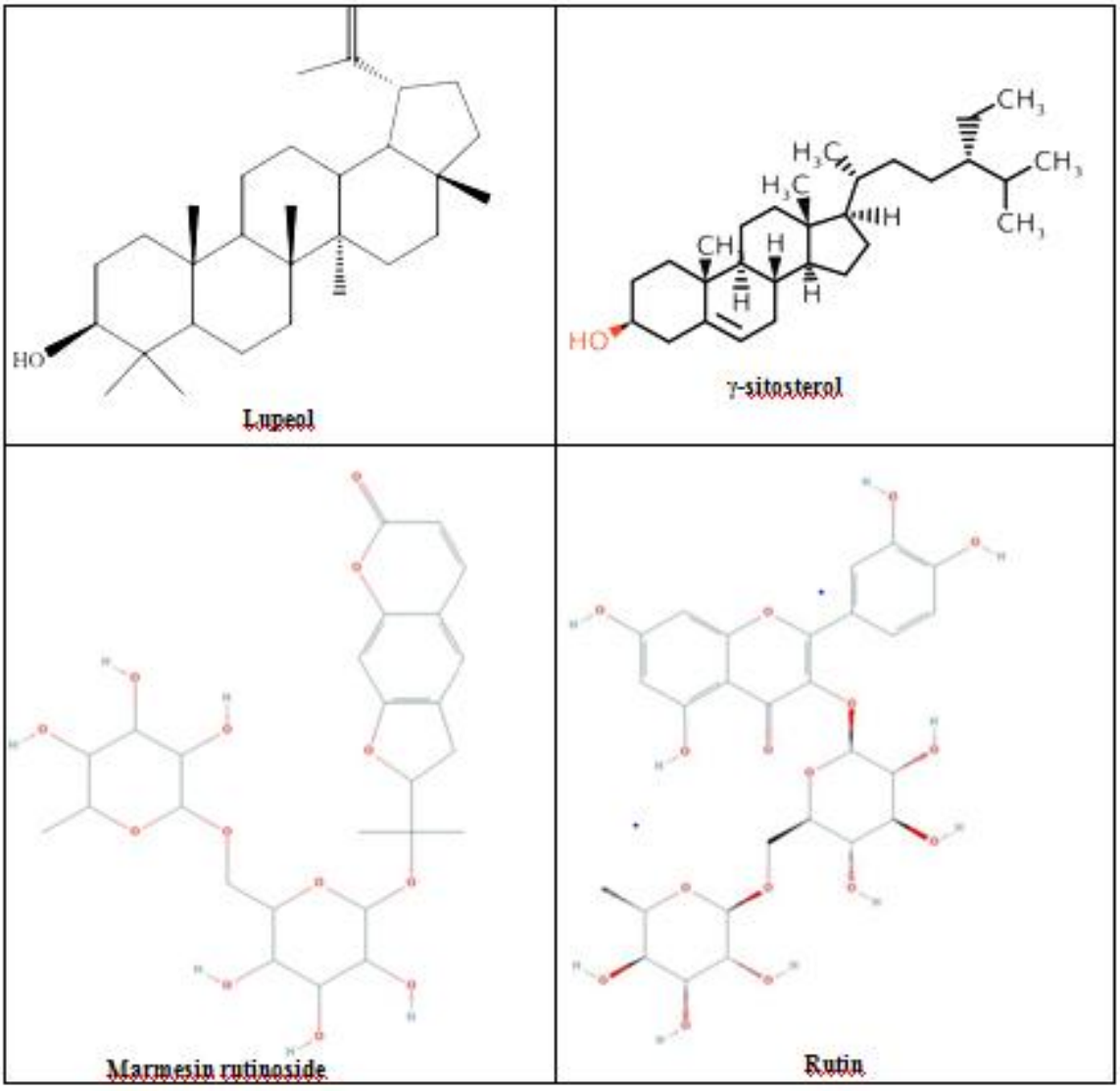


Figure No 4: Structures of Some Phytochemical Constituents Reported From *Aegle Marmelos*

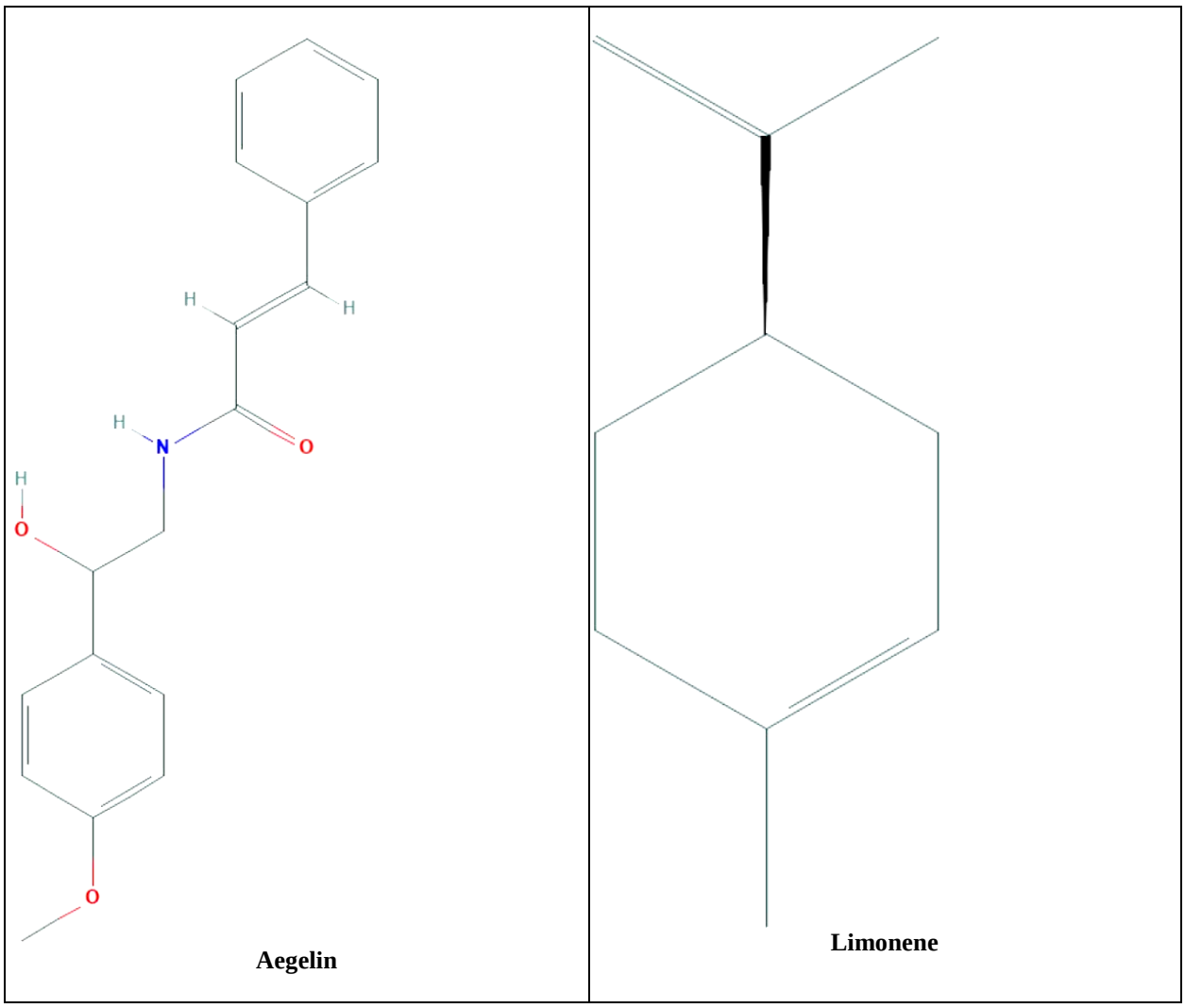


Figure No 5: Structures of Some Phytochemical Constituents Reported From *Aegle Marmelos.*

Future Prospects

This review will help the future researchers in discovering new therapeutic agents as the plant possesses propitious biological and pharmacological potentials.

From this study it is proved that extract of leaves of *Aegle marmelos* possesses potent pharmacologica activity.

Thus this pharmacologica activity of the extract of leaves *Aegle marmelos* warrants further investigation involving components of possible development of new class of pharmacological drugs.

From the result of phytochrmical study of the plant there is scope for the individual refinement of isolation process to confirm the presence of phytoconstituents which might be responsible to produce these pharmacological activities and its molecular way of action.

Since the plant possesses significant biological and pharmacological activity it should be explored for its medicinal value at molecular level by using various modern scientific techniques. The plant has a wide array of biological and pharmacological potentials and many of the isolated compounds and synthetic analogues of *Aegle marmelos* merit further research.

CONCLUSION

This review had shown that *Aegle marmelos* is a very important plant for its large number of medicinal properties as well as medicinally important chemicals like alkaloids, coumarins (marmelosin, marmesin, marmin, imperatorin, scopoletin), steroids, polysaccharides, phenylpropenoids, tannins, flavonoids, carotenoids, saponin.etc. The plant has

many traditional uses in antihyperglycemic, anti-inflammatory, antipyretic, analgesic, anticonvulsant, antihistaminic, anxiolytic, antidepressant, anticancer, antioxidant, hepatoprotective, antimicrobial, analgesic, antifungal, neuroprotective etc. Leaves contain alkaloids and are considered useful in diabetes, cancer etc. However very less work has been on this plant & there is further more scope of scientific investigation.

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