Ethnological and Ethno-medicinal Importance of *Aegle marmelos* (L.) Corr (Bael) Among Indigenous People of India

Abhijit Dutta*, Neeta Lal, Musarrat Naaz, Abhijeet Ghosh and Rupa Verma

1Department of Zoology, Ranchi University, Ranchi-834008, Jharkhand, India
2R.L.S.Y college Ranchi University, Ranchi-834008, Jharkhand, India
3Department of Botany, Ranchi University, Ranchi-834008, Jharkhand, India

**ABSTRACT**

The Bael (*Aegle marmelos*) (L) Corr. is an important Indian plant, conserved since centuries by tribal communities and in sacred groves, has enormous traditional uses as a food source and against various diseases. Focus on plant research has increased in recent times with an aim towards their edible, medicinal and amelioration properties in animal welfare globally and lots of evidence has collected to show immense potential of nutritional and medicinal plants used in various ethical societies. Over the last few years, researchers have aimed at identifying and validating plant derived substances for the treatment of various diseases and amelioration of toxicity. It has been proved that various parts of plants such as Leaves, fruits, seeds, provide health and nutrition, promoting compounds in the human diet and which has enormous traditional uses against various diseases, especially the ethnic communities of Jharkhand, who suffer from malnutrition and severe health issues. The present paper aims to compile ethnobotanical and ethnomedical values of *Aegle marmelos* generated through the research activity using modern scientific approaches and innovative scientific tools.

**Keywords**- *Aegle marmelos*, Ethnomedical, Ethnobotany, Biochemical, Nutritional, Medical uses.

**INTRODUCTION**

The indigenous and ethnic people of the world have learnt to live in most hostile environmental condition in this universe. The most interesting feature associated with these indigenous and ethnic has been found that, they live in localities which are immensely rich in biodiversity. India is a country with large ethnic society and has immense wealth due to which it is rich in biodiversity. There are 45,000 species of wild plant out of which 9,500 species are ethno botanically important species. Of these 7,500 species are in medicinal use of indigenous health practices. The ethnic and
indigenous people have to depend upon several wild species for fruits, seeds, bulbs, roots and tubers which are used for edible purposes.²

The ethnic community of India has played a vital role in preserving biodiversity of several virgin forests and have conserved several flora and fauna in sacred groves of tribal, otherwise these flora and fauna might have been disappeared from natural ecosystems. A. marmelos is one of such tree which has been conserved since ages¹,³.

Apart from being a medicinal plant, Aegle marmelos Correa is a sacred tree, dedicated to Lord Shiva. The offering of bael leaves is a compulsory ritual of the worship of Lord Shiva in the hills. This importance seems largely due to its medicinal properties. All parts of this tree, viz., root, leaf, trunk, fruit and seed, are used for curing one human ailment or another⁴.

More than 70% of the tribal communities remained intermingled with the nature and traditional knowledge for thousands of years and are the custodian of numerous indigenous plants that are used for the cure of several ailments⁵. One of the principal reasons for such a practice is the lack of modern medical facilities in the remote areas of the difficult terrains of the state.

There is a widespread belief that the green medicines are healthier and more harmless or safer than synthetic ones⁸. The present study, therefore, aims to document various indigenous uses of Aegle marmelos (L.) Correa, one of the most important medicinal plants of India, for its immense low cost medical importance and to emphasize its ethno conservation for the benefit of mankind. The fruit’s medicinal value is very high when it is just beginning to ripen; therefore it is best eaten just as fresh as it ripens. The ripe fruit and unripe fruit, as well as the roots, leaves and branches have all been used in traditional medicine. In Ayurveda, the ripe fruit has been used for chronic diarrhea and dysentery, as a tonic for the heart and brain, and as adjuvant treatment of dysentery. A decoction of the root has been used to treat melancholy, intermittent fevers and palpitation; the roots have mainly been used as an ingredient of the Ayurvedic medicine, dashmool. The leaves have been given as febrifuge and as a poultice for the treatment of eye disorders and ulcer and administration of fresh leaves have been used for weakness of the heart, dropsy and beriberi.

The word bilva (bel tree) is usually used as bilva-patra (leaf of bel). It is a sacred tree having sacrificial importance. The leaves of this sacred tree are generally trifoliate. This trifoliate leaf is symbolic of Trikal (Brahma, Vishnu and Mahesh), three eyes of Lord Shiva, Trishakti (Volition, action and knowledge), three lingas and three syllables of Omkar.

The bilva tree itself is so holy and auspicious that its worship or its significance is mentioned in many Puranas and other scriptures at various instances. Born from the breasts of Goddess Lakshmi, the Bilva tree is ever dear to Mahadeva. So I ask this tree to offer a Bilva leaf to Lord Shiva. To have Darshan of the Bilva tree, and to touch it, frees one from sin. The most terrible karma is destroyed when a Bilva leaf is offered to Lord Shiva. Sri Bilva Shtakam⁹. The proportion of Sattva component is more in bilva patra and hence it has more capacity to absorb and emit Sattvik frequencies. This has various effects. One of them is the reduction of raja-tama particles present in the atmosphere. A Sattvik leaf like bilva patra when brought in proximity of a person suffering from negative energy, distress than the black energy present within him is reduced¹⁰.

In a study in the Bundu block indicated that A. marmelos can be a good cash crop, indicating that the inhabitants
earn Rs.2991/annum selling ripe fruits and approximately 30 households are involved in this business.\textsuperscript{11}

**Ethnic value of** \textit{A. marmelos}  

In India there are 68 million people, belonging to 227 ethnic groups (573 tribal communities)\textsuperscript{12}, live close in the vicinity of the forests or villages and have been able to conserve biodiversity of their localities. The forest and trees/plants not only cater their daily needs of timber and fuel wood, but also their livelihood and traditional medicines.

There are 45,000 species of wild plants out of which 9500 species are ethnobotanically important and 7500 species are used as medicinal and herbal health practices. Many of these plants are conserved and worshipped in their natural habitat due to their magical-religious belief that they are habitat of God and Goddess\textsuperscript{3}. Bael is one of them, worshipped as a symbol of Lord Shiva.

Many of these plants are conserved in sacred groves. It has been estimated that the total number of sacred groves in the country lies between 100,000 and 150,000\textsuperscript{14}. These are mainly distributed in the states of Andhra Pradesh, Bihar, Jharkhand, Orissa, Maharashtra\textsuperscript{15} Sacred Groves is an age-old tradition where a patch of forest or water body is dedicated to local deities and none is allowed to cut plants or to kill animals or any form of life (Figure 1 & 2). The institution of sacred groves dates back to the pre-agrarian hunting-gathering phase of human civilization and is known to thrive in most parts of India. \textit{A. marmelos} are an important plant of such sacred grove of Jharkhand\textsuperscript{6}.

Besides conservation of biodiversity, the role of sacred groves is also important as a life support system. The sacred groves help tribal communities by providing edible fruits, leaves, fibers and medicinal plants. Also acts as an atmosphere purifier and sinks, air pollutants and deodorizes bad air.\textsuperscript{10} An example of sacred groove is shown in a sacred grove in Panchmarhi village, where Gonds worship \textit{A. marmelos} apart from other sacred trees (Table.1).

**Occurrence, botanical description**  

\textit{A. marmelos} is one of the most important medicinal plants of India, Burma and Ceylon\textsuperscript{16}. It is found as a wild plant found all over India and cultivated in north India. The \textit{Aegle} is a small genus of three species distributed in tropical Asia and Africa. The \textit{A. marmelos} belongs to the family Rutaceae and is known as Opesheet, Ohshit. It is termed differently in different languages as well as countries\textsuperscript{17}. \textit{A. marmelos} are a subtropical species and grow best in rich, well-drained soil. It grows well in swamps, alkaline or stony soils having a pH range from 5 to 8\textsuperscript{17}. In India flowering occurs in April and May and the fruit ripens in 10 to 11 months after (March to June) of the following year\textsuperscript{17}. \textit{A. marmelos} are a slow-growing, medium sized tree, up to 12 to 15 m tall with short trunk, thick, soft, flaking bark and spreading, sometimes spiny branches. A clear, gummy sap, resembling gum Arabic, exudes from wounds branches.

**The marmelos tree**  

The deciduous, alternate leaves, borne singly or in 2's or 3's, are composed of 3 to 5 oval, pointed, shallowly toothed leaflets, 4 to 10 cm long, 2 to 5 cm wide, the terminal one with a long petiole. New foliage is pinkish-maroon and glossy. Damaged leaves emit a foul odor.

Flowers are fragrant, found in clusters of 4 to 7 along the young branchlets, have 4 fleshy petals, green outside, yellowish inside, and 50 or more greenish-yellow stamens. Fruit is round, pyriform, oval or oblong, 5 to 20cm in diameter, may have a thin, hard, woody shell, gray-green when immature but turns yellowish when
fully ripe. Inside, there is a hard central core and 8 to 20 faintly defined triangular segments, with thin, dark-orange walls, filled with aromatic, pale orange, pasty, sweet, resinous, astringent pulp 10 to 15 flattened-oblong seeds remain embedded in the pulp. The seeds are about 1 cm long, covered with woolly hairs and each enclosed in a sac of adhesive, transparent mucilage that solidifies on drying (Figure 3a & 3b).

The Ethnomedicinal importance of *A. marmelos*

This plant is used in traditional medicine treatments, such as intermittent fever, intestinal ailments, fertility control and treatment after childbirth and fish poison. British pharmacopoeia has included *A. marmelos* fruit because of its effectiveness against diarrhoea and dysentery. Moreover, Chopra (1982) has appropriately stated that “No drug has been longer and better known, nor more appreciated by the inhabitants of India than the Bael fruit”.

Leaves

Extracts of leaves are efficient to treat ulcers, abscess, backache, vomiting, cuts, weakness of heart, acute bronchitis, blood sugars, diarrhea, dropsy, beriberi, injuries caused by animals. Juice prepared from the leaf extract acts as a laxative agent and is helpful for treating ophthalmic infections and asthmatic complaints. Medicated oil prepared from the leaves of the plant not only helps to prevent cold, cough and other respiratory ailments, but is also a good hair tonic when mixed with cumin seeds and massaged on the scalp.

Leaves are also used as a veterinary medicine for wound and fodder for animals and stimulation of denervated nictitating membrane in anesthetized cats. Farooq (2005) reported presence of marmelosin, marmesin, imperatorin, marmin, alloimperatorin, methyl ether, xanthotoxol, scopoletin, scoparone, ...

Root bark

The root bark is used in remission of intermittent fevers, 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, anti-amoebic, rheumatism.

Flower

Extracts of distilled flower are used as a tonic for the stomach, intestine, anti-dysenteric, anti-diabetic, diaphoretic and local anesthetic. As an expectorant it is used to cure epilepsy.

Fruit

Eaten during diarrhea, dysentery and convalescence. It acts as a mild astringency. Dry powder mixed with mustard oil is used to treat burn cases. Fruits are used in diarrhea, dysentery, gastric troubles, constipation, laxative, tonic, digestive, brain and heart tonic, ulcer, intestinal parasites, gonorrhea, epilepsy. 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*.

Phytochemical constituents isolated from *A. marmelos*

Various chemical constituents like alkaloids, coumarins and steroids have been isolated and identified from different parts of the tree. The biological activities of the phenolic compounds present in *A. marmelos* is shown in Figure 4, indicating the widespread therapeutic effect of the plant.

Coumarins

Farooq, (2005) reported presence of marmelosin, marmesin, imperatorin, marmin, alloimperatorin, methyl ether, xanthotoxol, scopoletin, scoparone,
umbelliferone, psoralen and marmelid. Marmenol, a 7-geranyloxycoumarin [7-(2, 6-dihydroxy-7-methoxy-7-methyl-3-octenyl) Coumarins][31].

Alkaloids  

Polysaccharides  
Galactose, arabinose, uronic acid and L-rhamanose are obtained on hydrolysis[35]. Seed oil composed of palmitic, stearic, oleic, linoleic and linolenic acid[33].

Tannins  
Tannin content is maximum in the bael fruit in the month of January. There is as much as 9% tannin in the pulp of wild fruits, less in cultivated type. Tannin is also present in leaves as skimmianine, it is also named as 4, 7, 8-trimethoxyfuro, quinoline.

The pale color of the fruit is because of the presence of carotenoids. The therapeutically Carotenoids active principles of bael plant are due to the presence of marmelosin, skimmianine and umbelliferone are. The small amount of ascorbic acid, sitosterol, crude fibers, tannins, α-amyrin, carotenoids and crude proteins are also present. The Roots contain psoralen, xanthotoxin scopoletin[33] and also compounds like praeraltin D, trans-cinnamic acid, 4-methoxy benzoic acid, betulunic acid and montanin[36]. Bael tree also possess a large number of bioactive compounds in its various parts as shown in Table 3. The structures of some of these bioactive compounds are presented in Figure 4.

Bioactivity  
Leaves, fruits, stem and roots of A. marmelos have been used in ethno medicine due to its astringent, anti-diarrheal, anti-dysenteric, demulcent, antipyretic and anti-inflammatory activities[37]. Bioactive compounds of bael fruit contain relatively high content of dietary fiber, ascorbic acid, total phenolics, total flavonoids, total carotenoids and also strong antioxidants. The main components were monoterpenes and sesquiterpenes. Among these components, limonene was the major constituent producing the characteristic bael fruit flavor[38]. The flow chart of the Biological Activities of Phenolic Compounds is shown in Figure. 5.

Antiulcer activity  
Ulcer develops when there is an imbalance between the defensive mechanism on the mucosa resulting from either due to the presence aggravating factors and/or lowering of mucosal protection[39]. Contemporary therapeutic treatment uses proton pump inhibitors and selective H2 receptor blockers, but with several side effects and execute their actions within a limit. Bael has a prominent gastroprotective effect due to the presence of Luvangetin, a pyranocoumarin Cineole and the tannin in the fruit. Oxidative stress usually leads to gastric ulcer. Luvangetin lowers oxidative stress in the gastro-duodenal mucosa preventing ulcer formation. The phenolic compounds are potent antioxidants[40] and have powerful antiulcer activities[41].

Antioxidant activity  
Treatment with Bael leaf extracted showed dose–related increase in their
level/activity of antioxidative parameters like reduced glutathione, glutathione peroxidase, glutathione reductase, super oxide dismutase (SOD) and catalase and a decrease in lipid peroxidation. A dose of 250 mg/kg body weight of the fruit extract is more effective than glitenclamide (300 µg/kg). Leaf extract (200 mg/kg) is as effective as alpha tocopherol (60mg/kg) in isoproterenal (ISO) -treated rats. The antioxidant phytochemical such as flavonoids, alkaloids, sterols, tannins, phlobatannins and flavonoid glycosides present in the leaf extract possess this free radical scavenging activity. Diabetes causes reduction in the level of Glutathione (GSH) is in erythrocyte and increase of plasma glutathione-S-transferase (GST) and malondialdehyde (MDA) in male albino rats.

However, the antioxidant potential of Bael leaves brings back the level to normal. Figure.6 indicates the pathway of hyperglycemia-induced endothelial dysfunction and activation. (a) Hyperglycemia induces metabolic dysfunction through the mitochondrial production of superoxide, resulting in PARP activation and subsequent altered glycolytic flux to enhance diacylglycerol production (DAG), methylglyoxal production, and hexosamine and polyl pathway activity. (b) Hyperglycemia-induced oxidative stress is further enhanced by metabolic overproduction of DAG and decreases in NADH+/reduced glutathione (GSH), as well as stimulation of the RAGE receptor. Oxidative stress reduces protective mediators (NO bioavailability) and enhances inflammatory transcription factor (NF-κB) activation resulting in inflammatory gene expression and leukocyte recruitment. Eugenol and Marmesinin are potent antioxidants may be responsible for preventing oxidative stress.

Antimalarial activity
Malaria caused by Plasmodium falciparum causes about 2 million deaths annually. Moreover, the species are gradually getting resistant to existing antimalarial drugs, complicating the treatment of this dreadful disease. The alcoholic extracts of the Bael seeds and leaves have been tested in vivo and in vitro for antimalarial activity against the NK65 strain of Plasmodium berghei. The seeds have shown schizontocidal activity in both the system, whereas, the leaves have shown activity only in the in-vitro system.

Antidiabetic activity
The extracts of the plant have a multidirectional antidiabetic action that can significantly lower the levels of blood glucose and glycosylated hemoglobin and increased the plasma insulin as well as liver glycogen in diabetic rats. It has been noted that oxidative stress of the body is closely related diabetes and its related complications, as well as with cardiovascular as well as renal disorders. Administrations of the aqueous extract of Bael fruit, orally or intraperitoneal induce a hypoglycemic effect against streptozotocin induced diabetic rats.

A dose of 250 mg/kg of the fruit extract proved to be more effective than the hypoglycemic drug, glibenclamide. Coumarins in the fruit extract have the most potent antidiabetic effect, which promotes potentiate the insulin Secretion from the islets of Langerhans. A 15 days clinical trial of a leaf extract for significantly reduced blood cholesterol levels with slight lowering of blood glucose in some patients with diabetes mellitus.

Anti-inflammatory activity
Anti-inflammatory, analgesic and antipyretic activities of the organic extracts of the ball leaves have now been established, may be due to the presence of...
Lupeol and Skimmianine in the leaves. Activation of histamine receptor is essential for allergic and asthmatic manifestation. The alcoholic extract of Bael leaves, containing Lupeol and Citral antagonized the histamine–induced contractions and demonstrated positive chain, suggesting inhibition of H1-receptor activity and act through inhibition of histamine mediated signalling and relaxant effect in isolated guinea pig ileum and tracheal.

**Histamine receptor antagonism**

When histamine binds to a receptor on nerve or vascular cells, it produces the signs and symptoms of allergy. Antihistamines are inert molecules, stereochemically identical to histamines. However, antihistamines have a much greater affinity to receptors than histamine does, so they displace the histamine and shut down the allergic response. In fact, at marketed concentrations, antihistamines have a much greater affinity for H1 receptors than histamine does. That explains the ability of antihistamines to stop the allergic response (Figure. 7).

**Antifungal activity**

Essential oil extracted from the leaves of the Bael tree shows potent antifungal activity against animal and human fungi like: Trichophyton mentagrophytes, T. rubrum, Microsporum gypseum, M. audouinii, M. cookie, Epidermophyton floccosum, Aspergillus niger, A. flavus and Histoplasma capsulatum.

The oil of the seed has exhibited considerable in-vitro activity against various fungi namely: Trichophyton rubrum, T. terrestre, E. floccosum, Aspergillus fumigatus, A. niger and A. flavus. The ethanolic extract of the root has shown activity against A. fumigates and T. mentagrophytes.

The germination of any spore (that is bacterial or fungal) is linked to Ca+2–dipicolinate and/or free Ca+2 ion availability in the medium as well as within the cytoplasm of microbes. It is possible that the essential oil from the Bael leaves may interfere with the Ca+2–dipicolonic acid metabolism pathway and thereby inhibit spore germination (Figure. 8).

**Antibacterial activity**

Various extracts of A. marmelos have been found to be active against several bacterial strains. For example essential oil of the leaf inhibits the growth of Escherichia coli, Aeromonas sp., Pseudomonas salanacearum and Xanthomonas vesicatoria. The ethanolic extract of the root and seed inhibits the propagation of Vibrio cholerae, Salmonella typhimurium, Klebsiella pneumoniae, E. coli, Pseudomonas aeruginosa, Bacillus subtilis and Staphylococcus aureus. The ethanolic extract of Bael fruit have shown strong activity against multidrug resistant S. typhimurium. Methanol and aqueous extract of Bael fruit have shown strong activity against multidrug resistant S. typhimurium. Methanolic extract is more potent than the aqueous extract. The minimum inhibitory concentration (MIC) value of the methanolic extract is around 256 µg/ml.

It is, thus, evident that Baal has antimicrobial activities may be by blocking protein synthesis either at transcription or translation level and/or peptide-glycan synthesis at membrane level. The antibacterial activity of leaf extract may be due to the presence of Cuminaldehyde and Eugenol.

**Antiviral activity**

The IC50 of leaves, stem and stem bark, fruit, root and root bark and purified compound Marmelide are 1000, 500 to 1000, 250 to 500 and 62.5 µg/ml, respectively, whereas, the IC50 of Ribavirin,
a standard antiviral agent, is 2000 µg/ml for the same viruses and at the same time period\(^68\). Thus, marmelide is the most effective virucidal agent interfering with early events of its replicative cycle\(^68\). It appears that Bael extracts act upon the early stages of viral replication with minimum host cytotoxicity in contrast to ribavirin (a modern virucidal chemotherapeutic agent), that act in the later stages of viral replication with a lot of side effects\(^69\). Ranikhet disease virus can be controlled by 50% ethanolic extract of the fruits\(^70\). Fruits also contain interferon–like activity against the same virus\(^71\). Thus *A. marmelos* has a better virucidal potential and may be exploited as a potent antiviral agent in the near future.

**Anticancer activity**

Anticancer effect on the animal model of Ehrlich ascites carcinoma of hydro-alcoholic extract (400 mg/kg) of Bael leaves shows the greatest antitumor effect\(^72\). It inhibited in-vitro proliferation of human tumour cell lines including the leucenic K562, T-lymphoid jurhat, Beta lymphoid Raji, Erythro leukemic HEL\(^73\).

The plant extract exhibits cytotoxicity against tumor cell lines in brine shrimp lethality assay and methyl thiazolyl tetrazolium (MTT) based assay\(^74\). The extract also possesses anti-proliferative activity on MCF7 and MDA-MB-231 breast cancer cell lines\(^75\). Skimmianine in the leaf extract induces apoptosis thereby killing the tumor cells\(^72\). Taxol is an important anticancer drug widely used in the clinic (Figure.9). Bael also possesses an endophyte fungus *Bartalinia robillardoides* (strain AMB-9), which secretes 187.6 µg/l of Taxol, suggesting that the fungus can serve as a potential material for genetic engineering to improve the production of taxol\(^76\).

**Radioprotective activity**

Cultured human peripheral blood lymphocytes (HPBLs) were irradiated with different doses of gamma-radiation, which caused a dose-dependent increase in the frequency of lymphocytes bearing one, two and multiple micronuclei, which significantly reduced when treated with 5 µg/ml leaf extract. This radio protective effect was due to the scavenging of radiation–induced free radicals\(^77\). Identical experiment was conducted in Swiss albino male mice. The mice were administered with various intraperitoneal single doses of the extract. The optimum radio protective dose of the extract has been found to be five consecutive doses of 15 mg/kg body weight\(^72\).

Irradiation caused an elevation in the lipid peroxidation leading to dose dependent decline in the level of glutathione. Bael leaf extract arrested glutathione decline and lipid per oxidation significantly\(^31\). Symptoms of sickness and mortality of the animals are due to irradiation resulting in a dose-dependent elevation in lipid per oxidation in liver, kidney, stomach and intestine as well as depletion in GSH concentration. Treatment of the Bael fruit extract before irradiation caused a significant decrease in the lipid peroxidation accompanied by a significant elevation in the GSH concentration in liver, kidney, stomach and intestine of mice\(^72\) (Figure.10).

**Antihyperlipidaemic activity**

Pre-treatment with the Bael leaf extract at 100 mg/kg and 200 mg/kg doses for 35 days have shown significant improvement in the activities of marker enzymes, decrement of lipid peroxides, plasma lipids and lipoproteins in isoproterenol-treated rats, suggesting its antihyperlipidaemic effect\(^45\). The higher level of fatty acid and their metabolites such as acyl carnitine and long chain acyl CoA
usually interfere with \( \text{NA}^+ / \text{K}^+ \text{ATPase} \) activity level\(^54\).

Oral administration of the aqueous extract of Bael fruits and seeds separately to streptozotocin-induced diabetic rats significantly lowered the serum and tissue lipid profile\(^78\). Ethanolic extract of Bael leaves also inhibited the elevation of serum cholesterol and triglyceride level in triton treated hyperlipidemia rat\(^79\). This extract also potentiates glucose utilization.

Other activities

Leaf extract (1 gm/kg) of \textit{A. marmelos} was investigated in the regulation of thyroid hormone in male mice. While serum level of both \(T(3)\) and \(T(4)\) were inhibited by extract of \textit{A. marmelos} could decrease only \(T(3)\) concentration about 62% indicating its possible use in the regulation of hyperthyroidism\(^80\).

Effects of methanolic extract of the root bark of Bael, an Ayurvedic crude drug used for heart disease and constituents isolated from the extract on the spontaneous beating of cultured mouse myocardial cells were examined. The extract at a concentration of 100 \(\mu\text{g/ml}\) inhibited the beating rate by approximately 50%. Among the isolated constituents, Aurapten was the most potent inhibitor; the IC50 of Aurapten is 0.6 \(\mu\text{g/ml}\), which is comparable with that of Verapamil, a calcium antagonist. Addition of Aurapten at concentrations higher than 1 \(\mu\text{g/ml}\) significantly reduced the ratio of morphologically changed myocardial cells, which originated from calcium overload caused by successive treatment with calcium-free and calcium-containing solutions\(^81\).

Bioassay-directed fractionation of the ethyl acetate extract of the stem bark of \textit{A. marmelos} afforded a new compound, named Skimmiarepin C, along with Skimmiarepin A. These compounds exhibit moderate insecticidal activity against \textit{Phaedon cholera} and \textit{Musca domestica} in comparison with natural pyrethrum extract\(^82\).

The Bael plant acts as a ‘Sink’ for chemical pollutants as it absorbs poisonous gases from the atmosphere and make them inert or neutral. It is a member of the plant species group known as ‘Climate Purifiers’, which emit greater percentage of oxygen in sunlight as compared to other plants. The tree is also considered under the category of ‘Fragrant’ species, whose flowers and volatile vapors neutralize the bad smell of petrified organic matter or decaying refuge and thus save human life from bacterial attack by making them inert and deodorizing the bad odor of air\(^83\).

Toxicological studies

\textit{A. marmelos} have been used for centuries in India not only for its dietary purposes, but also for its various medicinal properties\(^84\). Hence, it is generally considered safe and few studies have been carried out with respect to its toxicity. Nevertheless aqueous extract of \textit{A. marmelos} fruit has been reported to be non mutagenic to \textit{S. typhimurium} strain TA 100 in the Ames assay\(^85\). In addition, acute toxicity studies have reported that a hydroalcoholic extract of \textit{A. marmelos} fruit is non toxic up to a dose of 6 g/kg body weight in mice\(^86\). Pharmacological studies on animal models involving repeated doses of \textit{A. marmelos} fruit extract over a period of up to 30 days have not reported any adverse effect up to a maximum dose of 250 mg/kg body weight\(^87\). There were no remarkable changes noticed in histopathological studies after 50 mg/kg body weight of the extracts of \textit{A. marmelos} when administered intraperitoneally for 14 days successively. Pathologically, neither gross abnormalities nor histopathological changes were observed. After calculation of LD (50) values using graphical methods, we found a broad therapeutic window and a high
therapeutic index value for *A. marmelos* extracts. Intraperitoneal administration of the extract of the leaves of *A. marmelos* at doses of 50 to 90 and 100 mg/kg body weight for 14 consecutive days to male and female Wistar rats did not index any short-term toxicity. Collectively, these data demonstrate that the extracts of the leaves of *A. marmelos* have a high margin of drug safety.

**CONCLUSION**

*Aegle marmelos* may impart health benefits when it is used in functional food products and should also be regarded as a potential nutraceutical resource in the future. In addition, it can be used as a food additive because of its typical color, flavor and texture. These results are useful for developing and improving the quality of bael fruit cultivate in order to provide more value added and usefulness of bael fruit.

It is quite evident from this review that *Aegle marmelos* contains a number of phytoconstituents which reveals its uses for various therapeutic purposes. The extracts of this important medicinal plant can be the main form of health care for not only the poor tribal community of Jharkhand but can also form an integrated component of mainstream health care or an alternative or complement to the main form of health care. In an era when traditional know how is getting recognized, these indigenous drugs can serve as healthy, cheap and readily available substitutes of relatively more sophisticated, expensive and ill effect causing active principle based synthetic medicines. The indigenous art of healing is waiting to be transformed into an exact science.

**REFERENCES**

2. (http://medicinalpltsinindiamp.blogspot.in/).
9. https://in.answers.yahoo.com/question/index?qid=20110718022121AAIKm1B


41. Bandyopadhyay U, Biswas K, Chatterjee R, Bandyopadhyay D, Chattopadhyay I,


Table 1. Sacred grove in panchmarhi village

<table>
<thead>
<tr>
<th>Communities</th>
<th>Name of the groove</th>
<th>Deities worshipped</th>
<th>Plants symbolized as abode of deities</th>
<th>Age of the groove (approx)</th>
<th>Groove size (approx)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gond</td>
<td>Khedapati</td>
<td>Khedapati</td>
<td>Shorea robusta, Madhuca indica, Dendrocalamus strictus Terminalia bellirica, Ficus bengalensis, Mucuna pruriens, Phyllanthus sylvestris, Phyllanthus officinalis, Buchania lanza</td>
<td>200-250</td>
<td>0.20 hectares</td>
</tr>
<tr>
<td>Gond</td>
<td>Budh Deo</td>
<td>Budha Deo</td>
<td>Aegel marmelos, Shorea robusta, Dendrocalamus strictus Ficus religiosa, Butea monosperma, Madhuca indica, Ficus bengalensis</td>
<td>Not known</td>
<td>0.10 hectares</td>
</tr>
</tbody>
</table>
Table 2. The ethnomedicinal importance of *A. marmelos*²⁸

<table>
<thead>
<tr>
<th>Part</th>
<th>Phytoconstituents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaves</td>
<td>Extracts of leaves are efficient to treat ulcers, abscess, backache, vomiting, cuts, weakness of heart, acute bronchitis, blood sugars, diarrhoea, dropsy, beri-beri, injuries caused by animals, etc²⁰. Juice prepared from leaf extract acts as laxative agent and is helpful for treating ophthalmic infections and asthmatic complaints. Medicated oil prepared from leaves of the plant not only helps to prevent cold, cough and other respiratory ailments but is also a good hair tonic when mixed with cumin seeds and massaged on the scalp. Leaves are also used as a veterinary medicine for wound and fodder for animals and stimulation of denervated nictitating membrane in anaesthetized cats²¹.</td>
</tr>
<tr>
<td>Root bark</td>
<td>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 hypoglycemia²². It is also used in dog bite, gastric troubles, heart disorders, antiamaebic, rheumatism²³.</td>
</tr>
<tr>
<td>Flower</td>
<td>Extracts of distilled flower is used as tonic for stomach, intestine, anti-dysenteric, anti-diabetic, diaphoretic and local anesthetic²⁴. As expectorant it is used to cure epilepsy.</td>
</tr>
<tr>
<td>Fruit</td>
<td>Eaten during diarrhea, dysentery and convalescence. It act as a mild astringency. Dry powder mixed with mustard oil is used to treat burn cases²⁹. Fruits are used in diarrhea, dysentery, gastric troubles, constipation, laxative, tonic, digestive, brain and heart tonic, ulcer, intestinal parasites, gonorrhea, epilepsy²³. Fresh fruit extracts lower blood pressure²⁶. Fine powder of unripe fruit can be an alternative medicine to cure intestinal parasites, like <em>Entamoeba histolitica</em>, <em>Ascaris lumbricoides</em>²⁷.</td>
</tr>
<tr>
<td>Seed</td>
<td>Seed oil exhibit antibacterial effect against <em>Vibrio cholera</em>, <em>Staphylococcus aureus</em> and <em>Escherichia coli</em>²⁹. Essential oil also exhibit antifungal activity against <em>Physallospora tucumanesis</em>, <em>Eratocystis paradoxa</em>, <em>Selerotium raffsii</em>, <em>Curvularia lunata</em>, <em>Helminthosporium sacchari</em>³⁰.</td>
</tr>
</tbody>
</table>

Table 3. Some of the important photochemical compounds isolated from different plant parts of *A. Marmelos*¹⁰

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Part</th>
<th>Phytoconstituents</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Leaf</td>
<td>Skimmianine, Aegeline, Lupeol, Cineol, Cuminaldehyde, Eugenol, Marmesinine, Citronella</td>
</tr>
<tr>
<td>2</td>
<td>Bark</td>
<td>Skimmianine, Fagarine, Marmine,</td>
</tr>
<tr>
<td>3</td>
<td>Fruit</td>
<td>Marmelosin, Luvangetin, Aurapten, Psoralen, Marmelide, Tannin</td>
</tr>
</tbody>
</table>
Figure 1. Photographs of a sacred grove plant in Ranchi. Gods worship A. marmalos in a sacred grove, named Buddha Deo (Kala, 2011)

Figure 2. Worshipping deity in the sacred grove
Figure 3a. Ripe fruit

Figure 3b. Ripe fruit dissected

Article by Niraj Traders\textsuperscript{13}
Figure 4. Biological activities of phenolic compounds
Figure 5. The structures of some of these bioactive compounds isolated from various part of the Bael trees.
Figure 6. Hyperglycemia-induced endothelial dysfunction and activation

(http://www.hindawi.com/journals/ijvm/2012/569654/fig3/)
Figure 7. The mast cell is the central cell in the allergic response. The antigen (pollen, animal dander.) cross-links to the IgE receptor and causes the mast cell to degranulate. Degranulation causes the release of histamines and other proinflammatory mediators, such as prostaglandins, tryptase and heparin. Histamine is the primary mediator that binds to the H1 receptors on the nerves (causing itching) and blood vessels (causing redness and chemosis).
Figure 8. Spore germination is a calcium dependent process or the presence of Ca+2– dipicolinate in the medium.

Figure 9. Taxol
Figure 10. Effect of various concentrations of Bael on the scavenging of various free radicals and the ABTS+ cation radical. (a) Hydroxyl radical; (b) superoxide anion; (c) DPPH radical; (d) ABTS+ cation radical; (e) nitric oxide