

# Exploring the Versatile Applications of Bael (*Aegle marmelos*): A Comprehensive Examination of Its Medicinal and Dietary Attributes

Kiran Mahajan, Ms. Vaishnavi Bhanudas Shingate, Mr. Utkarsh Ravindra Mandage,  
Dr. Gajanan Tulshiram Daphal, Dr. Swapnil Dilip Deo

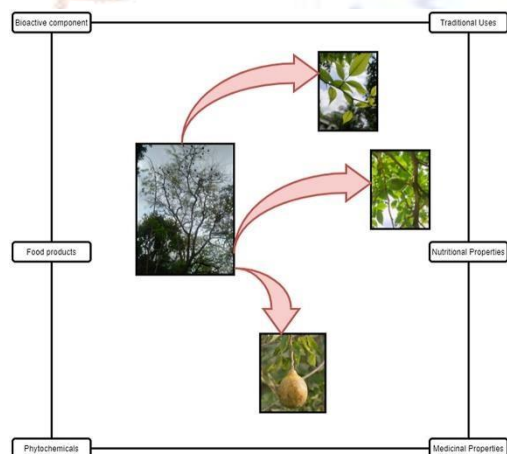
## Abstract

Bael, a tree known in India for a very long time and with important stories in mythology. Every part of this tree, like the roots, bark, fruit, leaves, and flowers, has been used in traditional medicine like Ayurveda to treat health problems. Recent scientific studies have shown that bael works as medicine because it contains special natural substances that help the body. Research has found that bael has antioxidants and can fight germs, which is good for stomach problems and heart issues. It also helps the liver, protects against radiation, controls diabetes, and helps wounds heal. This research is about understanding how each part of the tree is important in traditional culture, learning about its nutrition and natural substances, finding ways to keep the fruit fresh, and understanding how it works as medicine.

## ➤ Key Points

- Exploring the Ethnobotanical Significance of Bael (*Aegle marmelos*).
- Utilizing Bael's Nutritional Composition for Culinary Innovation.
- A Comprehensive Review of Scientific Literature on Bael's Medicinal and Nutritional Properties.
- Assessing the Pharmacological Potential of Various Components of Bael Through In-vitro and In-vivo Studies.

## Visual Summary



## Keywords

Cultural Plant Knowledge; Heritage Fruit; Culinary Applications; Healing Flora; Medicinal Properties

## 1. Introduction

The fruit known as Bael, scientifically called *Aegle marmelos* and belonging to *Rutaceae* family, [1] is a tropical fruit. [1] While it originally comes from northern India, it's now grown in various places like Thailand, Bangladesh, Pakistan, Sri Lanka, and Burma [2]. Bael has different names in different languages, such as Bilva and Shivaphala in Sanskrit, Belo in Oriya, Bel in Assamese and Marathi, and Vilva marum in Tamil in India. It's also called Be Li in Sinhalese, Matoom in Thai, and Bela in Spanish [3]. Bael has been used for its medicinal properties in traditional Indian medicine systems for a long time. It's also considered sacred in Hindu religion and its leaves, known as Tripatra, are used in offerings to Lord Shiva. [1] Every part of the Bael tree – the root, bark, leaf, flower, and fruit – can be used in various ways. There are different types of Bael fruit, and some are more commonly grown for commercial purposes [1]. Traditional Indian medicine systems like Siddha, Unani, and Ayurveda have recognized the potential health effects of Bael. Studies have shown that Bael is rich in various nutrients and natural compounds like phenolic acids, flavonoids, alkaloids, tannins, and coumarins. It also contains amino acids, fatty acids, organic acids, minerals, carbohydrates, vitamins, and fiber, making it a highly

nutritious fruit with numerous health benefits. Bael has been found to help with gastrointestinal problems, diabetes, cardiac issues, and inflammation-related ailments. It also offers protection against wounds, radiation, microbes, free radicals, and even depression. However, Bael is a seasonal fruit and is usually available in May and June, so it's not accessible all year round. To make the most of Bael's benefits, various products can be made from it. These include juices, beverages, jams, slabs, Bael powder, wine, and tea. Creating these products can be economically profitable. While there have been many studies on different aspects of Bael, like its botany, nutritional composition, phytochemical content, health benefits, and products made from it, this study aims to provide a comprehensive overview of all these aspects. So, the goal of this study is to cover various aspects of Bael, including its botanical description, traditional uses, nutritional content, phytochemicals, different products made from it, and its extensive use in medicine [1, 2, 3]

## 2. Botanical Description

This slow-growing tree is of medium height, reaching around 762 cm. The bael tree has various parts, including its bark, leaves, flowers, fruits, and seeds. It has thorny branches on its stem [4]. The leaves are arranged alternately and typically come in groups of three to five leaflets. They are 4 to 10 cm long and 2 to 5 cm wide. Young leaves are light green and turn dark green as they mature [4]. The bark of the tree is thick and tends to flake, often with thorns. When the bark is injured, it secretes a gum that thickens upon exposure to air [4]. Bael flowers are greenish-white, have a sweet scent, and are bisexual, without bracts, and positioned below the ovary. Clusters of ten flowers can be found in the leaf axils [1,5]. Bael fruits are usually yellowish-green, with a diameter of 5.3 to 7.2 cm, weighing approximately 77.2 g. They have a volume of 73.7 mL and are about 93.72% spherical in shape. The fruit pulp is yellow and slimy, containing small dots on the outer surface. It also contains numerous hard seeds covered in white thread-like hairs [5].

## 3. Traditional Uses

The bael tree has extensive traditional uses in Ayurveda and other traditional medicine systems. Each part of the bael tree has potential health benefits [5].

### 3.1. Leaf

Bael leaves are useful in treating conditions like jaundice and asthma. They can help clear mucous secretions from bronchial tubes and are applied in conjunctivitis treatment. Bael leaves are also used to address issues like constipation, deafness, and leucorrhoea. Bael leaf powder may aid in treating beriberi and has therapeutic properties [4,6].

### 3.2. Fruits

Bael fruit extract is used to address thyroid issues in various body parts. It can be beneficial in alleviating pregnancy-related vomiting when consumed with rice water. The powder of unripe fruit pulp is helpful in treating abscesses. Starch in unripe fruit can be converted to sugar with heat treatment, and the resulting extract, when mixed with hot water and anise, can be useful in treating dysentery. Fruit pulp mixed with milk and sugar may help with urogenital disorders. Bael has potential uses as an antiscorbutic, a stomach tonic, and for treating intestinal ulcers, chronic constipation, and indigestion. It has also been employed in addressing conditions like gonorrhoea, as a heart tonic, and for epilepsy. Ripe bael fruit juice extract may help lower blood sugar levels due to its bitter taste. It has been used in the treatment of chronic gastrointestinal disorders, piles, and rectal inflammation. Regular consumption of bael in the form of sherbet may aid in clearing accumulated fecal matter from the bowels within 2-3 months [1,4]. A mixture of powdered bael fruit and mustard oil is used for burn treatment in southern Chhattisgarh [1].

### 3.3. Flower

Bael flowers possess astringent and antiseptic properties and have been used in epilepsy treatment. Marmala water, obtained through distillation from the flowers, can be beneficial in conjunctivitis treatment. Bael flower extract has been tested for its wound healing properties, as it may increase the expression of specific molecules involved in wound healing [7,8,20].

### 3.4. Root and Bark

A decoction of bael root and bark is used in treating conditions like melancholia, heart palpitations, and intermittent fever. Bael root is also an ingredient in the preparation of Ayurvedic medicine dashmula. A mixture of bael root extract, onion, and turmeric has been used to address ear secretions. Bael is included in Chyavanprash, an Ayurvedic herbal formulation. Bael root bark can be used as a fish poison and for treating fever. Bark decoction, leaf extract with honey, and bael extract are employed in the treatment of fever and febrifuge, as well as intermittent fever [9].

## 4. Nutritional Composition

Bael fruit is rich in various nutrients that are beneficial for human health. It contains carbohydrates, vitamins (including vitamin A, B group, and C), minerals (such as iron, calcium, potassium, and phosphorus), fatty acids, amino acids, fiber, glucose, and sugar. The nutritional content of bael varies depending on the part of the plant and its ripeness. Unripe fruits are particularly advantageous for medicinal purposes [10]. Bael leaves have higher moisture content compared to fruits and seeds. Bael seeds have a higher fat content, while fruit pulp and leaves have low fat content. Other compounds, including alpha-curcumin, alpha-zingiberene, mycrene,

betasquiphellandrene, and various others, have been identified in bael . Bael essential oil composition can vary with the seasons . Bael also contains a unique dimeric protein, lectin, which binds to specific sugars [3].

Table 1 summarizes the nutritional composition of bael as reported by different researchers.

Table 1. Nutritional Composition of Bael (Aegle marmelos).

Components										
Energy (Kcal)	-	138	139	142	135	137	130	129	137	
Potassium (mg)	603	-	585	610	600	590	600	600	600	
Phosphorus (mg)	51.60	-	50	52	50	50	50	50	50	
Iron (mg)	0.55	-	0.6	0.5	0.8	0.6	0.3	0.3	0.5	
Calcium (mg)	78.0	-	85.0	80.0	85.0	85.0	60.0	90.0	85.0	
Vitamin C (mg)	-	-	8.0	8.0	8.6	8.0	10.0	10.0	8.0	
Vitamin B3 (mg)	-	-	1.1	1.1	1.0	0.87	0.9	0.90	0.89	
Vitamin B2 (mg)	-	-	1200	1000	1190	-	1200	1200	-	
Vitamin B1 (mg)	-	-	13.0	12	11.9	9.0	10.0	10.0	9.0	
Vitamin A (µg)	-	-	55	55	56	55	-	186	-	
Fibre (%)	4.80	2.78	2.9	2.9	2.8	3.0	2.2	2.2	2.9	
Fat (%)	0.43	0.28	0.3	0.2	0.3	0.3	0.2	0.2	0.3	
Protein (%)	3.64	1.87	1.8	1.6	1.8	1.8	1.8	1.8	1.8	
Carbohydrate (%)	-	-	34.35	31.8	30.5	31.8	31.8	31.8	30.6	31.8
Moisture (%)	61.06	63.04	61.5	61.0	62.5	61.0	64.2	64.2	61.5	

Please note that the nutritional composition may vary slightly depending on the source and method of analysis.

### 5. Phytochemical in bael

Bael fruit contains various natural compounds that are good for your health. These compounds include polyphenols and flavonoids, which are known for their health benefits. The specific types of polyphenols and flavonoids found in bael can vary depending on how ripe the fruit is. In bael fruit pulp and juice, you can find alkaloids, coumarins, polysaccharides, carotenoids, and other beneficial compounds. These substances can help with things like preventing oxidation (which can damage your cells) and reducing the absorption of harmful cholesterol. Some of the specific phenolic compounds in bael fruit juice include caffeic acid, arbutin, chlorogenic acid, p-coumaric acid, p-coumaroyl, quinic acid, and protocatecheuic acid[10]. Bael fruit also contains terpenoids, flavonoids, saponins, tannins, and glycosides, which all have their own health benefits. Even bael leaves are packed with useful compounds like γ-sitosterol, rutin, β-sitosterol, glycosides, marmeline, aegelin, marmesinin, halfordiol, phenyl ethyl cinnamamides, and lupeol. Polyphenols, a group of natural compounds, are also present and include catechin, flavanols, flavones, lignin, tannins, and iso-flavones. Additionally, compounds called lignan glucosides have been found in the bark of the bael tree, and other compounds like 7, 8-dimethoxy-1-hydroxyl-2-methyl anthraquinone and 6-hydroxy-1-methoxy-3-methyl anthraquinone have been isolated from bael. Even the stem bark of the bael tree contains beneficial compounds like Skimmiarepin A and Skimmiarepin C[11]. In summary, bael is a treasure trove of various natural compounds that can promote good health. These compounds offer antioxidant properties and other health benefits, and they can be found in different parts of the bael fruit and tree.

Phytochemical	Where Found in Bael	Examples	How to Identify	Health Benefits
<b>Alkaloids</b>	Fruits and Leaves	Various alkaloids like marmeline and aegelin	Tests like Dragendorff's and Hager's	Anti-inflammatory, antibacterial, and pain-relief effects
<b>Coumarins</b>	Fruit, Seed, Leaves, Bark, Root	Compounds like marmelosin and imperatorin	Tests involving oxidation or color change	Anti-inflammatory, antioxidant, antidiabetic, and

				painrelief properties
<b>Terpenoids</b>	Fruit, Leaf, and Bark	Various terpenoids including limonene and linalool	Noller's test	Potential as antimalarial and anti-cancer agents
<b>Phenolic Acids</b>	Fruit	Compounds like chlorogenic acid and gallic acid	Tests like ferric chloride, LC-MS, and HPLC	Antioxidant activity
<b>Flavonoids</b>	-	Quercetin and catechin	Shinoda's test	Antioxidant activity
<b>Carotenoids</b>	Fruit	-	HPLC method	Antioxidant activity
<b>Tannins</b>	Unripe Bael Fruit	Compounds like 4, 7, 8-trimethoxyfuroquinoline	Gelatin and Goldbeater's tests	Antimicrobial properties, blood pressure and lipid level regulation
<b>Amino Acids</b>	Fruit and Bark	Amino acids like phenylalanine and leucine	Ninhydrin and Millon's tests	Improved insulin sensitivity
<b>Organic Acids</b>	Fruit	Organic acids like oxalic acid	HPLC method	Antimicrobial activity
<b>Fatty Acids</b>	Seed, Fruit, Leaf	Fatty acids like linoleic and palmitic acid	Gas chromatography	Antimicrobial activity

## 6. Bael Products

Researchers have created different products using different parts of the bael tree. Bael is full of important nutrients, but because it only grows at certain times of the year, it's important to make various bael products to have those valuable nutrients all year round. Below is a list of some of the bael products developed by researchers in Table 3.

Part of Bael Tree	Product Name	How It's Made	Purpose	Key Feature
<b>Bael Fruit Pulp</b>	Fruit Juice	Made by extracting juice using enzymes	To recover juice efficiently	82.9% juice recovered at 45°C for 475 minutes
	jam	Made from bael and apple pulp	Developed as functional food	Contains reduced ascorbic acid and phenolics
	Bael Wine	Made through yeast fermentation	Wine production	Optimum conditions: 88 hours, pH 5.5 at 25°C
<b>Unripe Pulp</b>	Bael Preserve	Preserved with syrup	Developed as Ayurvedic product	Takes 6 days to prepare with sugar and citric acid
	Bael Preserve	Preserved with syrup	New product development	Made with specific pulp-to-sugar-to-water ratio

	Dehydrated Bael	Made by dehydration	New product development	Treated with sulphur dioxide and heated	
<b>Bael Fruit Seed</b>	Seed Oil	Extracted with ultrasound	Studied for biofuel production	Used for biofuel, particularly hydrogen production	
	Seed Cake Oil	Made through pyrolysis	Studied for lower carbon monoxide emission	Resulted in lower carbon monoxide emissions	
	Oil	Extracted using microwaves	Studied using RSM modeling	Achieved 42.6% oil yield at specific conditions	
<b>Bael Peel and Pomace</b>	Used as cattle feed	Made by dehydration and grinding	Utilization of waste	Found to be digestible	

## 7. Medicinal Properties of Bael Fruit

### 7.1. Treating Diarrhea and Dysentery

Bael fruit, especially when it's half-ripe or unripe, can be used to treat chronic diarrhea. The best way to do this is by using dried bael fruit powder. You can also bake unripe bael fruits and mix them with jaggery to make them easier to consume[12]. The astringent (drying) properties of unripe bael fruit are key in treating chronic diarrhea and dysentery. The ethanolic extract of the fruit can effectively inhibit over 35 strains of diarrhea-causing bacteria, including *Vibrio cholera*, *Escherichia coli*, and *Shigella sp.* When people consume bael fruit powder, their stool gradually becomes solid, and any blood or mucus in their stool disappears[13]. Studies have shown that bael can strongly inhibit bacteria like *S. sonnei*, *Shigella boydii*, and *S. flexneri*, with moderate activity against *S. dysenteriae*. In vitro (lab-based) and in vivo (animal-based) studies have also demonstrated bael fruit's anti-diarrheal properties. For example, the chloroform extract of bael root was found to be as effective as the antibiotic ciprofloxacin in some studies. Bael fruit's unripe pulp, juice, water extract, dried pulp, and leaves have all shown anti-diarrheal activity, which is assessed using the minimum inhibitory concentration (MIC) method. Tannins in bael contribute to its astringent properties, making it a helpful remedy for diarrhea. Bael has been tested for mutagenicity and has been found to be non-mutagenic. Studies on animals have shown that bael extract is non-toxic when administered at certain doses. In experiments, no adverse effects were observed for up to 30 days at a maximum dose of 250 mg/kg of body weight. Bael has also demonstrated an anti-giardial effect through the decoction of unripe fruit. It has been studied for its ability to prevent the colonization of different organisms, reducing the entry of harmful bacteria. Additionally, bael decoction appears to affect bacterial metabolism, which may explain its effectiveness. It can inhibit the binding of toxins like *E. coli* heatlabile toxin (LT) and cholera toxin (CT) to cell receptors, reducing their impact. In experiments with albino rats, which serve as an experimental model for inflammatory bowel disease (IBD), unripe fruit extract was found to be effective in reducing intestinal inflammation. It inhibited inflammatory mediators such as interleukins (IL1, IL6, and IL8) and tumor necrosis factor (TNF)- $\alpha$ . The anti-diarrheal properties of unripe bael fruit extract were also found to slow down intestinal movements and secretion in albino rats[14,15].

### 7.2. Bael and Diabetes

Diabetes happens when your body lacks insulin, so you need to get insulin from outside. Bael can help by improving how your body takes in glucose from outside. Studies have shown that bael leaf extracts can lower blood sugar levels in diabetic rats. These extracts were tested by checking various markers in the rats' blood and tissues. Other studies on rats have found that bael fruit juice can help lower oxidative stress in diabetic animals. It does this by reducing certain harmful substances and increasing beneficial ones in the blood and liver. The amino acids and dietary fiber in bael can also help with sugar absorption. In some experiments, bael was even more effective than a common diabetes drug called glibenclamide. Researchers believe that coumarin, a compound in bael, might be the key to increasing insulin secretion from the pancreas. Bael can help manage diabetes in several ways, like reducing blood glucose levels and glycosylated hemoglobin while increasing liver glycogen in diabetic rats. It also affects the function of glucose transporters in the cells. Phenolic acids in bael, such as ferulic acid and chlorogenic acid, can inhibit enzymes that convert carbohydrates to glucose. This means that it can slow down the process of turning carbs into sugar. In experiments, different doses of bael seed extracts were given to normal rats, fasting rats, and rats with mild diabetes. These extracts significantly lowered total cholesterol and triglycerides while increasing high-density lipoprotein (HDL), which is good for your heart. Vitamin E in bael also shows anti-diabetic effects. Bael leaf extracts have been tested on diabetic rats and found to reduce blood glucose levels. Various compounds isolated from bael, like

anhydromarmeline and phenyl ethyl cinnamide, have shown promise as alpha-glucosidase inhibitors, which can help manage diabetes[1,10,16].

### 7.3. Bael's Antimicrobial Properties

Bael has been found to be effective against a wide range of harmful organisms, including bacteria, viruses, and fungi. For example, bael has shown antiviral activity against coxsackieviruses and Ranikhet disease virus. In terms of bacteria, bael root extracts have been effective against diarrhea-causing bacteria like *Vibrio cholera*, *Escherichia coli*, and *Shigella* species. Methanolic extract of bael also affects *Salmonella typhi*.

Bael has been tested against various fungi, with its essential oils inhibiting the growth of eight different pathogens. It has also been found to prevent filariae. Bael powder can help prevent intestinal parasites like *Ascaris lumbricoides* and *Entamoeba histolytica*. Additionally, certain compounds from bael seeds and leaves have shown anti-parasitic properties. Bael's antimicrobial properties extend to tick and fluke larvae, making it useful in controlling these parasites. Studies have also reported that bael leaf extracts can inhibit the growth of dermatophytic fungi. In summary, bael exhibits antimicrobial activity against various pathogens, making it potentially valuable in treating infections caused by bacteria, viruses, fungi, and parasites[1,2].

### 7.4. Bael and Anti-Cancer Activity

Cancer is a serious disease, and bael shows promise in fighting it. Different compounds from bael, like butylated hydroxyanisole, butyl p-tolyl sulfide, and 6-methyl-4-chromanone, have been found to inhibit cancer cells. Bael extracts have shown cytotoxic effects on breast cancer cells (MDA-MB-231 and MCF-7) and have inhibited various tumor cell types, including leukemia, melanoma, and carcinoma cells[17]. In experiments with mice, bael extract extended the survival time of mice with Ehrlich ascites carcinoma, providing promising results. Carotenoids, phytochemicals, and polyphenols in bael may reduce cell mutations and DNA damage. Lupeol, found in bael, can inhibit the growth of cancer cells and arrest the cell cycle in certain phases. Bael extract has also been linked to improving the immune system, which can aid in fighting cancer. Studies have shown that bael extract can reduce genotoxic effects caused by chemotherapy drugs. Other compounds in bael, like dlimonene, eugenol, and citral, exhibit antineoplastic effects, which means they can help prevent the growth of tumors. Bael fruit extract has been tested on mice with skin papilloma, and it significantly reduced the incidence of papillomas and lowered tumor burden. In experiments with hepatocarcinoma, bael extract restored antioxidant enzyme levels, reduced tumor gene expression, and inhibited the progression of cancer. Certain compounds isolated from bael, like imperatoin, have also been studied for their anticancer effects. In summary, bael shows potential in fighting cancer by inhibiting tumor growth, reducing DNA damage, and improving the body's immune response[17].

### 7.5. Bael and its Ability to Prevent Ulcers

Ulcers in the stomach or intestines are common and can be caused by factors like oxidative stress or an infection called *Helicobacter pylori*[18]. Bael contains a compound called luvangetin, which has been shown to protect against ulcers caused by aspirin and a condition called pylorus ligation in rats. Another study used extracts from the pulp of bael fruit to treat rats with ulcers. The treatment reduced the thickness of the protective mucous layer in the stomach, but it also lowered oxidative stress and improved the activity of enzymes like catalase and superoxide dismutase. These effects suggest that bael's anti-ulcer action is linked to its antioxidant properties. In rats, gastric ulcers induced by lipopolysaccharide were treated with a methanolic extract of bael, resulting in a significant reduction in ulcers. This treatment also lowered the volume of gastric juice, pepsin concentration, and acidity in the stomach. In another study, rats were given a single high dose of aspirin to induce ulcers. Those that had been pretreated with bael fruit extract showed fewer ulcers and healthier stomach linings compared to the group that received aspirin alone. Bael fruit extract was also tested for its ability to protect against mucosal damage caused by ethanol. It showed gastro-protective effects in this scenario, but not against ulcers induced by indomethacin or hypothermic restraint stress. This suggests that bael's gastro-protective mechanism doesn't rely on the prostaglandin pathway. Bael has also been studied for its anti-ulcer effects in colitis, a condition where the colon becomes inflamed. In rats with colitis, bael extract reduced colonic inflammation, mucosal damage, and levels of harmful free radicals and myeloperoxidase. It showed similar anti-colitis activity to the medicine sulfasalazine. Additionally, a formulation containing bael leaf, *Glycyrrhiza glabra* rhizome, *Hemidesmus indicus* root, and *Cuminum cyminum* fruit parts exhibited anti-ulcer activity in rats. In summary, bael has demonstrated anti-ulcer properties in various studies, protecting against ulcers caused by different factors, and its antioxidant compounds likely play a role in this protection[18,19].

### 7.6. Bael's Ability to Reduce Fever and Inflammation

When your body encounters foreign particles or harmful invaders like germs, it often responds with inflammation. This can lead to pain, swelling, redness, or warmth in the affected area. Bael has shown some promising properties when it comes to reducing inflammation. For example, it has been found to have analgesic (pain-relieving) effects in situations where inflammation occurs, like carrageenan-induced paw swelling and cotton-pellet granuloma. Certain compounds found in bael, such as lupeol, citral, and skimmianine, seem to act as anti-inflammatory agents by affecting signals related to histamine, a substance involved in the inflammatory process. In studies involving mice, bael leaf extract also demonstrated antipyretic (fever-reducing) and analgesic effects. This means it can help lower fever and reduce paw licking, which indicates pain relief. Bael leaf extract, when used in combination with nickel nanoparticles, showed even greater mosquito larvicidal activity compared to the leaf extract alone. This means it can help in controlling mosquito larvae more effectively. Compounds like  $\beta$ -caryophyllene and caryophyllene oxide found in bael extract have shown anti-inflammatory effects against certain types of cancer cells. They work by influencing genes involved in

cell death, preventing the growth of cancer cells. Bael flower extract has also been studied for its anti-inflammatory properties, with an optimal dose of 200 mg/kg found to be effective in Wistar rats. In experiments with albino rats, bael extract was found to have antipyretic effects, helping to reduce fever caused by Brewer's yeast. The ethanolic extract of bael has the ability to lower body temperature when given at doses of 200 and 400 mg/kg, suggesting its antipyretic properties. Bael fruit extract has demonstrated multiple actions, including anti-inflammatory effects, mast cell stabilization, and antioxidant properties. It also increases the activity of superoxide dismutase while decreasing malondialdehyde levels, which helps protect against cell degranulation. The bark of the bael tree root has shown strong anti-inflammatory effects, particularly when tested in a model involving carrageenan-induced paw swelling. Studies on young bael tree roots have revealed potent anti-inflammatory effects, including the inhibition of cyclooxygenase (COX-2) and the reduction of pro-inflammatory cytokines, which are molecules associated with inflammation. In vitro studies using bael leaf extract have also shown anti-inflammatory effects, particularly at a dose of 100 µg/mL. A compound called marmelosin extracted from bael fruit has been found to have anti-inflammatory properties by reducing nitric oxide (NO) levels and the presence of a pro-inflammatory cytokine called TNF- $\alpha$ . In another study, the methanolic extract of bael demonstrated analgesic effects both centrally (in the brain) and peripherally (outside the brain). It was found to be effective in reducing pain in different animal models, including acetic acid-induced writhing and tail-flick radiant heat models. Overall, bael shows promise as a natural remedy for reducing fever and inflammation and providing relief from pain.[20]

### 7.7. Protecting the Liver

Bael leaf extract has shown great promise in protecting the liver. It effectively combats liver damage caused by substances like doxorubicin. In diabetic rats, it helps restore normal liver function by reducing fibrosis, vein dilation, and other harmful changes. In another study, rats were given a bacterial suspension that caused liver damage. After treatment with bael leaf powder, their liver parameters improved significantly. Similarly, when rats and mice were exposed to liver-damaging agents like carbon tetrachloride (CCl<sub>4</sub>), bael extract helped reduce markers of liver damage and toxicity. Compounds like eugenol from bael leaves and rutin found in bael are believed to contribute to its liver-protective effects. Piperine, when combined with bael extract, has also shown effectiveness against liver problems caused by CCl<sub>4</sub>. Hydroalcoholic bael extract has been found to increase various enzymes and substances in the liver that are important for its health and function.[21,22]

### 7.8. Shielding Against Radiation

Radiation therapy is commonly used to treat cancer but can have side effects. Bael extract has shown promise in protecting against the harmful effects of radiation. In experiments with mice exposed to gamma radiation, bael extract, especially at a concentration of 20 mg/kg, increased their chances of survival. This radioprotective effect is believed to result from bael's ability to neutralize harmful molecules called free radicals and reduce lipid peroxidation, which can damage cells. Bael leaf extract has been found to be particularly effective in shielding against radiation compared to fruit extract. It can counteract the damage caused by radiation, such as DNA damage and the production of reactive oxygen species (ROS), which can harm cells. Bael has also demonstrated its ability to prevent DNA damage in bone marrow cells and human blood cells. When administered before radiation exposure, it reduces lipid peroxidation and helps maintain immune function. Radiation can weaken the immune system, but bael leaf extract has been shown to increase the count of certain immune cells in mice, suggesting an immunomodulatory effect. Furthermore, bael has been found to protect gastrointestinal cells from radiation damage. After exposure to radiation, administering bael leaf extract helps restore the levels of important blood components and immune cells.[1,23]

### 7.9. Reducing Sperm Activity

Bael leaf extract has been found to affect sperm activity, decreasing their motility and interfering with the process of sperm production (spermatogenesis). In male rats, bael leaf extract, given at different doses, significantly reduces sperm count and alters sexual behavior. This extract also affects testicular steroidogenic enzymes and reduces the weight of sex organs. It can change the number of cells involved in the seminiferous epithelial cell cycle, particularly at stage VII. Similar antispermatogenic effects have been observed with bael bark extract at various doses. These changes in sperm function can lead to infertility. Ethanolic bark extract of bael can entirely inhibit sperm motility, leading to a decrease in sperm density, damage to the acrosome (a part of the sperm), and degeneration of the germinal epithelium. Bael extract is thought to achieve this by inhibiting calcium channels. In simpler terms, bael leaf and bark extracts can impact sperm function and fertility in male animals.[24,25]

### 7.10. Healing Wounds

The process of healing wounds involves different stages, including inflammation, cell growth, and the formation of collagen. When you get a wound, you might experience symptoms like redness, pain, and swelling, which are all part of the body's defense against injury. Researchers conducted experiments on rats to test the woundhealing ability of bael seed extract. They used a method where they made small cuts on the rats' skin and then applied bael seed ointment. By observing the wounds on various days, they found that the ointment effectively helped the wounds heal completely. In another study, they used a different method to create wounds in rats and treated them with bael extract ointment for ten days. They measured the wounds and discovered that bael extract improved wound healing compared to rats that didn't receive the treatment. The skin's ability to withstand stress also increased, showing that bael has wound-healing properties similar to a drug called nitrofurazone. Similar experiments were conducted on rats using both cuts and incisions. Bael pulp extract was applied, and the results showed that it had wound-healing properties. It reduced oxidative stress, inflammation, and free radicals, which are harmful molecules in the body. This helped support the healing process. Bael contains various natural compounds like flavonoids, alkaloids, essential oils, and sterols, which are believed to be responsible

for its ability to heal wounds. These compounds enhance the growth of new skin, reduce the size of wounds, and improve the strength of the healing tissue.[8,20,26]

### 7.11. Stress Relief

To test how bael affects stress, researchers conducted various tests on rats. They checked swimming endurance, motor function after swimming, and responses in situations like forced swimming and cold water swimming. In the forced swim test, bael helped rats stay active in stressful situations. It also increased their endurance when they had to swim. These effects may help reduce stress. Another study found that bael extract could counteract the damage caused by immobilization stress. It increased certain chemicals in the blood and reduced oxidative damage caused by stress. This suggests that bael might help the body cope with stress.[27]

### 7.12. Fighting Malaria

Researchers tested bael root extract to see if it could fight against malaria parasites. They used a method to see how much the extract could inhibit the growth of these parasites in the lab.

The leaf and immature bark extract of bael also showed promise in fighting malaria parasites.[28]

### 7.13. Easing Arthritis

Bael has shown potential in reducing arthritis symptoms in rats. Some compounds in bael, like steroids, saponins, and alkaloids, may help reduce swelling and pain in arthritic rats. These compounds might also reduce the production of prostaglandins, which are involved in causing arthritis.[6]

### 7.14. Protecting the Kidneys

Bael leaf extract has been found to protect the kidneys in Wistar rats. It reduced the harmful effects of a substance called gentamicin, which can damage the kidneys. Bael extract decreased markers of kidney damage and increased antioxidant levels, which helped protect the kidneys.[29,30]

### 7.15. Worm-Killing Abilities

Bael extract was tested for its ability to kill earthworms. Researchers found that even at low concentrations, the extract affected the movement of earthworms, making them unable to function properly.[31]

### 7.16. Relieving Asthma

Bael leaf decoction has been used to reduce mucus in the respiratory system during colds and asthma. It was also found to relax the muscles in the airways, making it easier to breathe. Some compounds in bael, like aegeline, may help prevent the release of histamine from mast cells, which can trigger allergic reactions and asthma symptoms.[32,33,34]

### 7.17. Balancing Thyroid Activity

Scopoletin, a compound found in bael leaves, has been studied for its effects on hyperthyroidism. It was able to reduce thyroid hormone levels in animals. This suggests that bael might help regulate thyroid activity.[35]

### 7.18. Lowering Eye Pressure

Bael fruit extract was tested in rabbits to see if it could lower intraocular pressure (IOP), which can be a problem in conditions like glaucoma. The extract was effective in reducing IOP.[36]

### 7.19. Insect-Killing Abilities

Bael extract has shown the ability to kill larvae of disease-carrying mosquitoes like the Japanese encephalitis vector and malaria vector. It can also deter mosquitoes from laying eggs and repel them.[37]

### 7.20. Safety Tests

Studies on bael have found it to be safe for consumption. Even when given in relatively high doses to animals over extended periods, it didn't show toxic effects. Tests also found that bael didn't cause mutations in bacteria and didn't lead to harmful changes in the organs of animals. Pregnant rats also didn't show any problems when given bael extract.

### 7.21. Arthritis Relief

In a study using rats with collagen-induced arthritis, it was found that bael has the ability to reduce arthritis symptoms. The study observed changes in X-rays and tissue samples that showed improvement. Another study also found that bael can help with arthritis. This is because bael contains substances like steroids, saponins, and alkaloids that can reduce joint swelling and lower the arthritis



index in arthritic rats. Bael works by inhibiting enzymes called cyclooxygenases, which in turn reduces the production of prostaglandins, a key factor in arthritis [12].

## 7.22. Kidney Protection

Bael leaf extract has been shown to protect the kidneys in experiments using Wistar rats. When rats were given gentamicin, a substance that can harm the kidneys, their blood tests showed increased levels of creatinine and blood urea nitrogen, which are signs of kidney damage. Bael extract was able to lower these elevated levels, demonstrating its ability to protect the kidneys. Another study confirmed that bael leaf extract can also protect against kidney damage caused by cisplatin [29,30]

## 7.23. Worm-Killing Activity

Bael has shown effectiveness in killing worms using a model involving Indian earthworms. Different concentrations of dried bael fruit extract were given to these earthworms, and even at a low concentration of 1 mg/mL, it had an impact on the paralysis and death time of the worms compared to a control group.

## 7.24. Asthma Relief

Bael leaf decoction has been found to be effective in reducing mucus in colds and asthma. In experiments with guinea pig ileum and tracheal chains, it was observed that bael had an antagonistic effect on contractions caused by histamine, a substance that triggers asthma symptoms [32]. Aegeline, a compound found in bael leaves, helps prevent the release of histamine from mast cells, which is a key factor in asthma [34]. Other studies suggest that skimmianine, found in bael roots, also plays a role in blocking histamine release from rat mast cells [32].

## 7.25. Thyroid Regulation

Scopoletin, a compound found in bael leaves, has been studied for its ability to regulate hyperthyroidism. When administered to animals treated with thyroxine, scopoletin at a concentration of 1 mg/kg for 7 days reduced thyroid hormone levels in the blood. This effect was similar to the antithyroid drug propylthiouracil. Another study found that leaf extracts from *Aegle marmelos*, *Bacopa monnieri*, and *Aloe vera* also have anti-thyroid activity [35].

## 7.26. Lowering Eye Pressure

Bael fruit extract has been found to lower intraocular pressure (IOP) in rabbits. A 1% dosage of bael fruit extract reduced IOP by 22.81%, which is comparable to the effect of the drug timolol. Additionally, chloroform extract from bael leaves at doses of 150 and 300 mg/kg bodyweight helped prevent cataracts by increasing certain enzymes and inhibiting others in the eye lens, ultimately reducing stress on the lens.

## 7.27. Insect Control

Bael extract has shown insecticidal properties against larvae of disease-carrying mosquitoes like the Japanese encephalitis vector, malaria vector *Anopheles subpictus*, and *Culex tritaeniorhynchus*. Bael leaf extract has also been effective in preventing mosquito egg laying and repelling mosquitoes. At certain concentrations, it can inhibit egg laying by over 90%, and at lower concentrations, it still deters egg laying. Bael extract is also effective in controlling adult mosquito emergence to some extent. It has also shown potential as a repellent, egg killer, and egg-laying deterrent against *Culex tritaeniorhynchus* and *Andrographis paniculata* [92]. Methanolic and acetone extracts of bael have been particularly effective against these mosquitoes. Bael leaf extract has also been moderately effective against larvae of *Aedes aegypti* and *Anopheles stephensi* mosquitoes.

## 7.28. Safety Studies

Studies on the safety of bael consumption have found no adverse effects. Even when administered at a dosage of 250 mg/kg bodyweight for 30 days in animals, there were no reported toxic effects. Pathological examinations also showed no histopathological changes in animals consuming bael over the long term. In laboratory tests, bael did not show mutagenic properties. Additionally, intraperitoneal administration of 50 mg/kg bodyweight of bael extract did not cause any histopathological changes in the liver, kidneys, heart, testes, or brain [10]. When tested with various extracts, including aqueous, methanolic, and ethanolic extracts of bael, no adverse effects were observed in rats even after intraperitoneal administration of 50 mg/kg bodyweight for 14 days [10]. Other experiments have also confirmed the non-toxic nature of bael leaf extract, even when given to male and female Wistar rats in different dosages for 14 days. An experiment using bael essential oil in Wistar rats found that it did not cause any abnormalities in triglyceride levels or urea content, indicating its non-toxic nature. Finally, bael extract did not lead to any abnormalities in pregnant rats [38].

## 8. Other Uses of Bael

The seeds of the bael fruit, when they're not ripe, have a gum that can be used as glue for making jewelry or for waterproofing walls when mixed with lime plaster or cement. The yellow dye obtained from tannin in bael can be used to color silk fabrics. The Dutch in Ceylon have used something called "Mermelle oil" from bael. Bael can also be used to prevent scum formation and in making carts. People use it to craft tool and knife handles, smallscale turnery, pestles, and combs. It can even be used as an insecticide against the brown planthopper [39]. Methanolic bael extract has been found to fight parasites like *Haemaphysalis bispinosa*. The shells of bael fruit can be turned into activated carbon, which can be used to remove toxic Chromium (VI) from water. Bael can also help remove lead (II) when it's mixed with other metals from used batteries [40]

## 9. Conclusion

Bael has shown a lot of promise for treating various health issues, and it's worth looking into further. When we study the chemicals found in bael fruit, we discover a wide range of beneficial compounds like alkaloids, coumarins, essential oils, phenols, and flavonoids, which can work like magic to treat different diseases. Clinical trials have shown that bael is safe to use with no harmful side effects. Plus, growing the bael plant is easy and doesn't require special care, making it economically practical for farmers to cultivate. While we know a lot about the bioactive compounds in bael, we still have a lot to learn about how they work at the molecular level. Besides drinking fresh bael juice, we should explore making other products from bael and consider exporting them. Although traditional medicine has long used bael, it's time to dig deeper into how its compounds work and share its health benefits with the world."

## 10. References

1. P.C. Sharma, V. Bhatia, N. Bansal, A. Sharma A review on bael tree Indian J. Nat. Prod. Resour., 6 (2007), pp. 171-178 View in Scopus Google Scholar
2. S. Brijesh, P. Daswani, P. Tetali, N. Antia, T. Birdi Studies on the antidiarrhoeal activity of *Aegle marmelos* unripe fruit: validating its traditional usage BMC Compl. Alternative Med., 9 (2009), p. 47, 10.1186/1472-6882-9-47 View PDF\_ This article is free to access. View in ScopusGoogle Scholar
3. T.K. Lim Edible Medicinal and Non Medicinal Plants Springer Netherlands (2015), 10.1007/978-94-017-9511-1 View article Google Scholar
4. K. Bhar, S. Mondal, P. Suresh An eye-catching review of *aegle marmelos* L. (golden apple) Phcog. J., 11 (2019), pp. 207-224, 10.5530/pj.2019.11.34 View article\_ View in ScopusGoogle Scholar
5. A.R. Patel, D. Garach, M. Chakraborty, J. Kamath *Aegle marmelos* (Linn.): a therapeutic boon for human health Int. J. Res. Ayurveda Pharm. (2012), pp. 159-163 View in ScopusGoogle Scholar
6. N.P. Atul, V.D. Nilesh, A.R. Akkatai, S.K. Kamalakar A review ON *aegle marmelos*: a potential medicinal tree Int. Res. J. Pharm., 3 (2012), pp. 86-91 Google Scholar
7. Mani, A. Singh, N. Jain, S. Misra Flowering, fruiting and physio-chemical characteristics of bael (*aegle marmelos* correa.) grown in northern districts of West Bengal Curr. J. Appl. Sci. Technol., 23 (2017), pp. 1-8, 10.9734/cjast/2017/36310 View article\_ Google Scholar
8. M.K. Gautam, V. Purohit, M. Agarwal, A. Singh, R.K. Goel In vivo healing potential of *aegle marmelos* in excision, incision, and dead space wound modelsSci. World J., 2014 (2014), 10.1155/2014/740107View article\_ Google Scholar
9. C. Prakash Kala Ethnobotany and Ethnoconservation of *Aegle Marmelos* L.) *Correa* (2006) Google Scholar
10. R.L. Bhardwaj, U. Nandal Nutritional and therapeutic potential of bael (*Aegle marmelos* Corr.) fruit juice: a review Nutr. Food Sci., 45 (2015), pp. 895-919, 10.1108/NFS-05-2015-0058 View article\_ View in ScopusGoogle Scholar
11. J.K.R. Radhika Samarasekera, B.P.S. Khambay, K.P. Hemalal A new insecticidal protolimonoid from *Aegle marmelos* Nat. Prod. Res., 18 (2004), pp. 117-122, 10.1080/1478641031000149858 View article\_ View in Scopus Google Scholar
12. R.N. Chopra, I.C. Chopra Indigenous Drugs of India (third ed.), Academic Publishers (2006) Google Scholar

13. K.P. Sampath, M. Umadevi, D. Bhowmik, D.M. Singh, A.S. Dutta Recent trends in medicinal uses and health benefits of Indian traditional herbs *Aegle marmelos* Pharma Innov., 1 (2012), pp. 57-65 Google Scholar
14. S. Rahman, R. Parvin Therapeutic potential of *Aegle marmelos* (L.)-An overview Asian Pacific J. Trop. Dis., 4 (2014), pp. 71-77, 10.1016/S2222-1808(14)60318-2 View PDFView articleView in ScopusGoogle Scholar
15. R. Rakulini, S. Kalaichelvi, S. Prasad A review of anti – diarrheal activity of *aegle marmelos* Orig. Res. Artic. Rakulini Kalaichelvi., 7 (2019), pp. 1-10, 10.9734/JOCAMR/2019/v7i230095 View article Google Scholar
16. N. Kamalakkannan, P.S.M. Prince Hypoglycaemic effect of water extracts of *Aegle marmelos* fruits in streptozotocin diabetic rats J. Ethnopharmacol., 87 (2003), pp. 207-210, 10.1016/S0378-8741(03)00148-X View PDFView articleView in ScopusGoogle Scholar
17. E. Lambertini, R. Piva, M.T.H. Khan, I. Lampronti, N. Bianchi, M. Borgatti, R. Gambari Effects of extracts from Bangladeshi medicinal plants on in vitro proliferation of human breast cancer cell lines and expression of estrogen receptor alpha gene Int. J. Oncol., 24 (2004), pp. 419-423, 10.3892/ijo.24.2.419 View article View in ScopusGoogle Scholar
18. K. Biswas, U. Bandyopadhyay, I. Chattopadhyay, A. Varadaraj, E. Ali, R.K. Banerjee A novel antioxidant and antiapoptotic role of omeprazole to block gastric ulcer through scavenging of hydroxyl radical J. Biol. Chem., 278 (2003), pp. 10993-11001, 10.1074/jbc.M210328200 View PDFView articleView in ScopusGoogle Scholar
19. R.K. Goel, R.N. Maiti, M. Manickam, A.B. Ray Antiulcer activity of naturally occurring pyrano- coumarin and isocoumarins and their effect on prostanoid synthesis using human colonic mucosa Indian J. Exp. Biol., 35 (1997), pp. 1080-1083 View in ScopusGoogle Scholar
20. Shirwaikar, R. Shenoy, A.L. Udupa, S.L. Udupa, S. Shetty Wound healing property of ethanolic extract of leaves of *Hyptis suaveolens* with supportive role of antioxidant enzymes Indian J. Exp. Biol., 41 (2003), pp. 238-241 View in ScopusGoogle Scholar
21. S. Panda, A. Kar Periplogenin-3-O- -d-glucopyranosyl -(1→6)- -d-glucopyranosyl- -(1→4) -d-cymaropyranoside, isolated from *aegle marmelos* protects doxorubicin induced cardiovascular problems and hepatotoxicity in rats Cardiovasc. Ther., 27 (2009), pp. 108-116, 10.1111/j.1755-5922.2009.00078.x View PDF This article is free to access. View in ScopusGoogle Scholar
22. R.P. Singh, S. Banerjee, A.R. Rao Effect of *aegle marmelos* on biotransformation enzyme systems and protection against free-radicalmediated damage in mice J. Pharm. Pharmacol., 52 (2000), pp. 991-1000, 10.1211/0022357001774714 View PDF This article is free to access. View in ScopusGoogle Scholar
23. G.C. Jagetia, P. Venkatesh, M.S. Baliga *Aegle marmelos* (L.) Correa inhibits the proliferation of transplanted Ehrlich ascites carcinoma in mice Biol. Pharm. Bull., 28 (2005), pp. 58-64, 10.1248/bpb.28.58 View article View in ScopusGoogle Scholar
24. P. Suriyamoorthy, M.R. Fathima Mary, H. Subrhamanian, D. Kanagasapabathy Anti hyperlipidemic effect of aqueous extract of *Aegle marmelos* and *Camellia sinensis* in oil fed hyperlipidemic rats Int. J. Pharm. Pharmaceut. Sci., 6 (2014), pp. 338-341 View in ScopusGoogle Scholar
25. Waghmare, M. Kanyalkar, M. Joshi, S. Srivastava In-vitro metabolic inhibition and antifertility effect facilitated by membrane alteration: search for novel antifertility agent using nifedipine analogues Eur. J. Med. Chem., 46 (2011), pp. 3581-3589, 10.1016/j.ejmech.2011.05.022 View PDFView articleView in ScopusGoogle Scholar
26. K. Ilango, V. Chitra Wound healing and anti-oxidant activities of the fruit pulp of *Limonia acidissima* linn (Rutaceae) in rats Trop. J. Pharmaceut. Res., 9 (2010), pp. 223-230, 10.4314/tjpr.v9i3.56281 View article View in ScopusGoogle Scholar
27. S. Meera, C.G. Nagarjuna Antistress and immunomodulatory activity of aqueous extract of *Momordica charantia* Pharmacogn Mag., 5 (2009), pp. 69-73 View in ScopusGoogle Scholar
28. R.E. Desjardins, C.J. Canfield, J.D. Haynes, J.D. Chulay Quantitative assessment of antimalarial activity in vitro by a semiautomated microdilution technique Antimicrob. Agents Chemother., 16 (1979), pp. 710-718, 10.1128/AAC.16.6.710 View PDF This article is free to access. View in ScopusGoogle Scholar
29. P. Chatterjee, B. Chakraborty, S. Nandy Review on activity study by Adv J Pharm Life Sci Res, 2 (2014), pp. 24-40 View article CrossRefGoogle Scholar

30. R. Ahmad, M. Mujeeb, A. Ahmad, F. nwar Ameliorative effect of Aegle marmelos leaves extract against cisplatin-induced nephrotoxicity and oxidative stress Bangladesh J. Pharmacol., 11 (2016), pp. 101-109, 10.3329/bjp.v11i1.24004 View article View in ScopusGoogle Scholar
31. Waghmare, M. Kanyalkar, M. Joshi, S. Srivastava In-vitro metabolic inhibition and antifertility effect facilitated by membrane alteration: search for novel antifertility agent using nifedipine analogues Eur. J. Med. Chem., 46 (2011), pp. 3581-3589, 10.1016/j.ejmech.2011.05.022 View PDFView articleView in ScopusGoogle Scholar
32. V. Arul, S. Miyazaki, R. Dhananjayan Mechanisms of the contractile effect of the alcoholic extract of Aegle marmelos Corr. on isolated Guinea pig ileum and tracheal chain Phytomedicine, 11 (2004), pp. 679-683, 10.1016/j.phymed.2002.12.001 View PDFView articleView in ScopusGoogle Scholar
33. S. Laphookhieo, C. Phungpanya, C. Tantapakul, S. Techa, S. Tha-In, W. Narmdorkmai Chemical constituents from Aegle marmelos J. Braz. Chem. Soc., 22 (2011), pp. 176-178, 10.1590/s0103-50532011000100024 View article View in ScopusGoogle Scholar
34. M. Sankari, V. Chitra, P. Silambujanaki, D. Raju Anticonvulsant activity of ethanolic extract of Aegle marmelos (leaves) in mice Int. J. PharmTech Res., 2 (2010), pp. 640-643 View in Scopus Google Scholar
35. J. Behera, B. Mohanty, Y. Ramani, B. Rath, S. Pradhan Effect of aqueous extract of Aegle marmelos unripe fruit on inflammatory bowel disease Indian J. Pharmacol., 44 (2012), pp. 614-618, 10.4103/0253-7613.100389 View article View in Scopus Google Scholar
36. R. Agarwal, S.K. Gupta, S. Srivastava, R. Saxena, S.S. Agrawal Intraocular pressure-lowering activity of topical application of Aegle marmelos fruit extract in experimental animal models Ophthalmic Res., 42 (2009), pp. 112-116, 10.1159/000226216 View PDFView article Google Scholar
37. G. Elango, A. Bagavan, C. Kamaraj, A. Abdul Zahir, A. Abdul Rahuman Oviposition-deterrent, ovicidal, and repellent activities of indigenous plant extracts against Anopheles subpictus Grassi (Diptera: Culicidae) Parasitol. Res., 105 (2009), pp. 1567-1576, 10.1007/s00436-009-1593-8 View article View in ScopusGoogle Scholar
38. G.C. Jagetia, P. Venkatesh, M.S. Baliga Evaluation of the radioprotective effect of Aegle marmelos (L.) Correa in cultured human peripheral blood lymphocytes exposed to different doses of  $\gamma$ -radiation: a micronucleus study Mutagenesis, 18 (2003), pp. 387-393, 10.1093/mutage/geg011 View article View in ScopusGoogle Scholar
39. S. Afreen, K. Premakumar, Y. Inthujaa Preparation of ready-to-serve (RTS) beverage from carrot with sour-orange juices Int. J. Innov. Res. Sci. Eng. Technol., 5 (2016), pp. 1992-1998, 10.15680/IJIRSET.2016.0502148 View article
40. S. Chakravarty, A. Mohanty, T.N. Sudha, A.K. Upadhyay, J. Konar, J.K. Sircar, A. Madhukar, K.K. Gupta Removal of Pb(II) ions from aqueous solution by adsorption using bael leaves (Aegle marmelos) J. Hazard Mater., 173 (2010), pp. 502-509, 10.1016/j.jhazmat.2009.08.113 View PDFView articleView in ScopusGoogle Scholar