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Research article

The medicinal wonders and formulation of bael (aegle marmelos): a comprehensive review

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ABSTRACT

Bael, belonging to the Rutaceae family, has long been held in high esteem because of its incredible medicinal properties and wide applications in therapy. With over 80% of the plant species forming angiosperms, they have huge medicinal values; bael remains one of the best examples of such species. Aegle marmelos, classified under the family Rutaceae, or bael tree, has been traditionally used in Ayurvedic medicine and has gained much attention regarding the various sets of bioactive compounds and phytochemicals endowed with a wide range of health benefits - anti-diabetic, anti-microbial, anti-cancerous, and wound healing. This ancient medicinal herb has emerged as the most widely applied in the world where various portions of the bael plant, such as fruit leaves, bark, and seeds are processed into numerous functional products including powders, toffees, candies, jams, and juices.

Keywords: Bael, Phytochemicals Medicinal Importance, Biological Description, botanical garden, Development of Functional Products, Aegle marmelos.

INTRODUCTION

In daily life, different herbal products help to provide essential nutrition. 80% of Plant species on earth belong to the Angiosperms species; WHO listed only 21000 Angiosperms plant species used for medicinal purposes [1, 2]. Found that plant species having healing or recovery factors provide a lot of health benefits [3].Globally, there has been a recent increase in attention to plant research, and more studies are demonstrating the potential health benefits of medicinal plants used in various traditional systems [4]. India has the largest market that produces medicinal herb [5].

Bael is an Indigenous plant in India. That is also known as Aegle marmelos. It is a Fruit tree that belongs to the family Rutaceae. For over a long period, A.marmelos has been used medicinally. They contain many bioactive components and many phytochemicals such as alkaloids, tannins, essential oil, resins, gums, coumarin, polysaccharides [6].

Bael is a nutrient-rich fruit. Parts of bael like Roots, Bark, Leaves, Fruits, Seeds, and Flowers are used in traditional medicine. Bael fruits are commonly used as a home remedy in India. It is good for the immune system. releaving constipation, and also good for the heart. Fruit is a dry land crop in nature & their tonics are used as a drink preparation called sharbat as a tonic [7]. In ancient times in India Ayurveda utilized beal as a medicine. Bael fruit contains numerous seeds; covered with fibrous hairs [8]. They have many health benefits like anti-diabetic, anti-microbial, anti-cancer, and proper wound healing properties[9]. Ayurveda medicine uses the fruits, leaves, stems, bark, and roots of trees- the most important and edible tree components—to treat a wide range of human ailments. Bael fruits are utilized during the season and are

ready for harvest and mature from mid-April to May.

It can continue to add economic value by producing various products like juice, candies, and others [4] [10].

It is regarded as extremely religious since it is widely used to worship gods, particularly Lord Siva. They have huge nutritional or medicinal properties: providing immunity and other health benefits [11].

Biological Description

Bael (Aegle marmelos) belongs to the following terms,

Table 1: Biological Description of Bale Plant

Terms	Biological Description
Kingdom	Plantae
Subkingdom	Tracheobionta
Super division	Spermatophyta
Division	Magnoliophyta
Class	Magnoliopsida
Subclass	Rosidae,
Family	Rutaceae,
Order	Sapindales

Genus Aegle Corr., Species marmelos (L.) Corrêa.

Bael is scientifically known as Aegle marmelos and is also known as Belou marmelos (L.) Lyons, Crateva marmelos L., Bilacus marmelos (L.) Kuntze, Crateva religiosa Ainslie, and Feronia pellucida Roth ·

Geography

Bael tree grow/present in India, Bangladesh, Thailand, Srilanka, Myanmar, Pakistan, Nepal, China, Egypt

Fruit

The Bael fruit was used to isolate furanocoumarin, alloimperatorin, imperatorin, and β- sitosterol. Bael fruit was extracted using acetone and methanol.

Were acetone extract unripe fruit and the methanol extract hardshell of bael fruit [12].

Physical Properties

Shape

Round, oval or oblong

Color

Grey-green until the fruit is fully ripe and Yellowish after fully riped

Test

Sweet, Mucilaginous

Odor

Aromatic

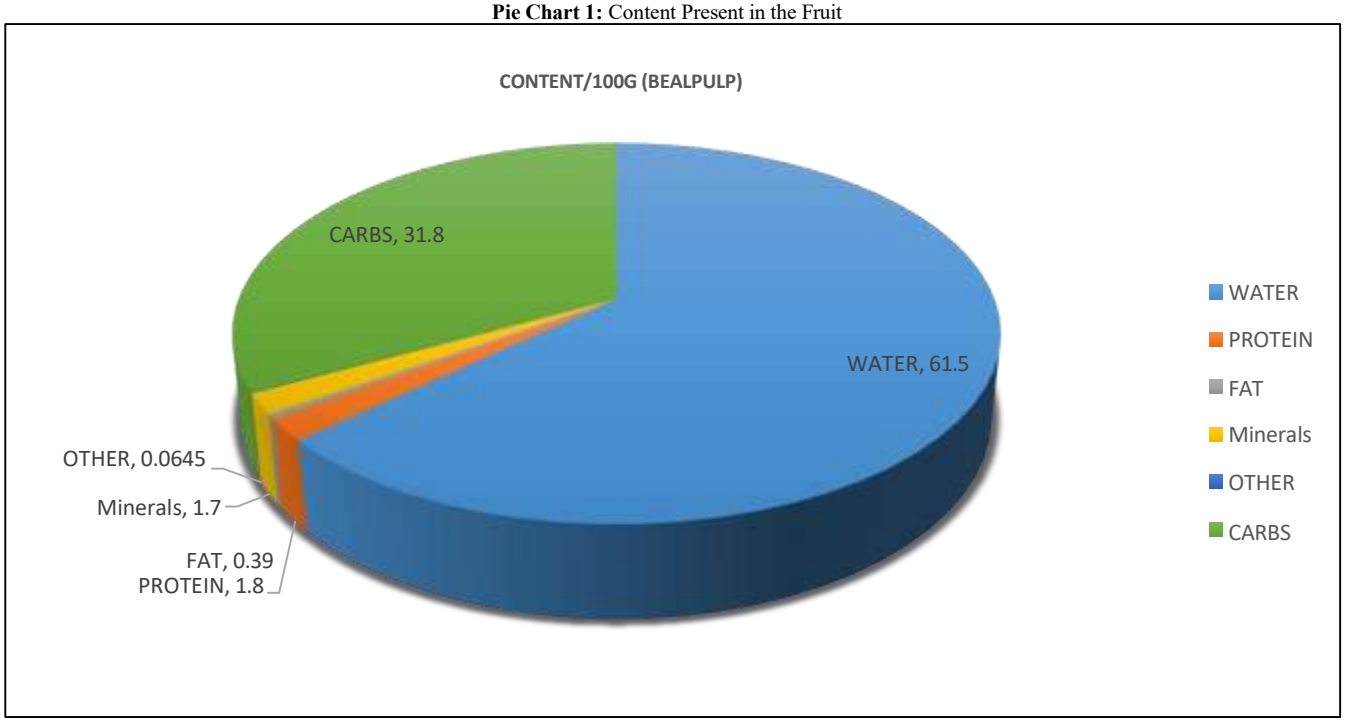
Figure 1: Unriped fruit

Figure 2: Riped fruit

Contents

In fruit/ 100g:- They contain 61.5g water, 1.8g protein, 0.39g fat,1.7g minerals, 31.8g carbohydrates, 55mg carotene, 0.31mg thiamine, 1.19mg riboflavin, 1.1mg niacin, 8mg /100g of edible portion vitamin C [13].

Pie Chart 1: Content Present in the Fruit



Phytochemicals Present in the Fruit

Table 2: Phytochemicals and their medicinal value of bael fruit

Bioactive Compound	Medicinal Value
Marmelosin	Anthelminthic, Antibacterial
Luvangetin	Antiulcer
Aurapten	Heartbeat Inhibitor, hypertension
Psoralen	Cytotoxic, Antispasmoic, Artemiside
Marmalade	Antiviral
Tannin	Antidiarrhea, Astringent
Riboflavin	Essential For Growth, Prevent Glossitis And Cheilosis
B-carotene	Glaucoma, Cataract

Application

It is used as an astringent, and antimicrobial, for stomach problems, relieving constipation, diarrhea, dysentery, gonorrhea, epilepsy, ulcers, antidiabetic, anticancer, and antioxient.

Their consumption lowers blood sugar and enhances the secretion of insulin.

Leaves

Beal leaves have nutritional value.

Figure 3: Bael Leaf (Trifoliate)

Physical Properties

Bael leaves have several distinct physical properties:

Shape

Trifoliate (means each leaf is composed of three leaflets); each leaflet is ovate with a tip is pointed and base are rounded.

Color

Young bael leaf is pale-green, and the mature leaf is dark green

Odor

Aromatic

Veins

Each leaf has 4-12 side veins pairs.

Chemical Composition

Beal leaves contain tannins, flavonoids and coumarins, Alkaloids, anthocyanins, cardiac glycosides, glycosides, steroids, terpenoids, tannins, lignins, carotenoids, ascorbic acid, phenols, polyphenols, phlorotannins, saponins, sterols, inulin, proteins, carbohydrates, amino acids, reducing sugars, nonreducing sugars, gallotannic acid, oxalates, fat, and oils.

Phytochemicals Present in Beal Leaves and Their Uses

Table 3: Medicinal value and phytochemicals of bael leaf

Bioactive Compound	Medicinal Value
Skimmianine	Hypothermic, Antimethamphetmine Antipyretic, Anticancer
Cuminaldehyde	Antibacterial
Lupeol	Antiinflammatory
Eugenol	Antioxidant, Antiulcer, Heptoprotective
Cineol	Antiulcer
Citronellal	Antiseptic
Marmesinin	Cardioprotective , Antioxidant
Cital	Antiseptic, Antiallergic
Aegelin	Antidyslipidemic, Cardioactive

Application

They are have medicinal properties such as an antidiabetic, Antidyslipidemic, Cardioactive, Antipyretic, Anticancer, Antiseptic, Antiulcer, and Antibacterial.

Flowers

They occur between April and May soon after new leaves.

Physical Properties

Shape

Bell-shaped, with petals that can be slightly curled.

Size

Flowers are small about 1.5-2 cm in diameter.

Color

Pale green and yellowish.

Figure 4: Bael Flower

Chemical Properties

Essential Oils

Bale flower is Rich in volatile oils that give it its aroma and may possess medicinal properties.

Flavonoid

Bale flower is Rich in flavonoids, which carry antioxidant activity.

Phenolic Compounds

Bale flower Contains phenolic acids used as a medicine for healthy benefits.

Vitamins

Is in that vitamin C and various B vitamins are abundant.

Minerals

It contains valuable calcium, magnesium, and potassium minerals.

Antioxidant

Compounds found in them that are active against oxidative stress [14].

Chemical Constituent

Alkaloids, flavonoids, anthraquinone glycosides, cardiac glycosides, catechins, coumarins, diterpenes, emodins, fixed oils, fats, furanoidsContain, leucoanthocyanins, steroids, sterols, triterpenoids, pseudo tannins, proteins, phenolics, carbohydrates, fatty acids, phlorotannins, quinones, reducing sugars, sugars and saponins [15].

Application

They show some Health Benefits such as being traditionally used for digestive health, and respiratory issues, and as an anti-inflammatory agent.

There is medicinal utilization in the Ayurvedic system of medicine for various ailments.

Seed

These are present in bael fruit pulp. In the presence of Arabinose, rhamnose, glucose, and galactose were found in the Ethanol Extract of Bael's Seed.

Figure 5: Bael Fruit Seeds

Physico-chemical Properties of Bael Seeds

Physical Properties

Shape

Oval or round.

Color

Brownish or tan, depending on maturity.

Size

Approximately 1-2 cm in diameter.

Texture

Hard outer shell, with a smooth surface.

Weight

Light, typically a few grams per seed.

Odor

Mild, with a slightly sweet aroma.

Taste

Bitter when raw; flavor improves when processed.

Chemical Properties

Composition

Seeds have beneficial content such as high in dietary fiber, proteins, & carbs.

Phytochemicals

Found that the Alkaloids, tannins, and flavonoids.

Fatty Acids

Oleic and linoleic acids are found in the seed.

Antioxidants

They are abundant in antioxidants they have therapeutic values

Solubility

They are insoluble in water and using organic solvents are extracted effectively...

pH Level

Slightly acidic to neutral.

Application

They have Nutritional value, such as they contain vitamins A, C, and various B vitamins.

They provide essential minerals like calcium, potassium, and magnesium.

Bark

Physical Properties

Color

Brown to grayish-brown.

Texture

Rough and fibrous outer layer with a hard inner bark.

Thickness

Can vary, usually thicker than the bark of many other trees.

Shape

Peels in strips or flakes.

Fragrance

Mild, earthy scent when crushed

Figure 6: Bark of Bael tree

Chemical Properties

Tannins

The presence of tannins in seeds provides them a property of astringency.

Flavonoids

Those having properties of anti-oxidants.

Alkaloids

Advantages relating to health.

Phenolic Compounds

These possess anticancer and antioxidant activities.

Saponins

Saponins may be health-promoting.

Phytochemicals

Application

They relieve peptic ulcers. They have antimicrobial,

antiulcer anti-inflammatory properties. According to certain research, it might support blood sugar regulation

Table 4: Therapeutic property and bioactive compound of bael bark

Bioactive compound	Medicinal value
Marmin	antiulcer
fagrine	Abortifacient

Medicinal Importance

Various parts of Bael (Aegle marmelos) provide so many health benefits. Traditionally they rea used for therapeutic purposes for their numerous medicinal importance or healing properties such as Anti-microbial, Anti-cancer, Anti-inflammatory, Anti-diabetic, Anti-pyretic, Analgesic, Anti- acne, Anti-lipidemic, Immuno-modulator, Anti-proliferative, Anti-fertility, Radio-protective, Anti-spermatogenic. They are also helpful in relieving constipation, Diarrhea, Dysentery, Peptic Ulcer, and Respiratory Infection. They are used to treat various ailments like Tuberculosis, skin- related disorders, and fungal infections, and they are used in wound healing, antiseptic, antiallergic, and also used as an antioxidant, Aegle marmelos control cholesterol and stomach- related problems.

We will briefly discuss the following,

Anti-cancer

Bael is a natural source in the treatment or prevention of cancer. Worldwide, one of the main causes of death is cancer. Researchers find the natural source of herbs that treat serious diseases (cancer). Synthetic chemical medicine has so many ADR; that are avoided by natural herbs. In the study they are conducted on the bael perform the hydroalcoholic extraction technique on the bael leaf, is the result of discovering the anti-cancer properties of the bael leaves. The presence of Skimmianine content in the leaf helps treat cancer [16].

Anti-microbial

Researchers conducted many in-vitro studies that inhibit microbes like bacteria, fungi, and viruses through the bael extract (such as bael fruit or leaves or other parts). Bael extract shows many antiviral, antifungal, anti-inflammatory, and antimicrobial actions that protect against broad-spectrum pathogenic organisms such as effective against e.coli, staphylococcus aureus, Pseudomonas aeruginosa, etc. ethanolic extract and methanolic extract of bael are effective against various pathogen [17].

Anti-diabetic

Traditionally ayurveda system are used bael to manage diabetic mallitus. Aqueous extract of bael has been used in the antidiabetic effects. They are used as a sugar reduction in the blood. They enhance the ability of the body to manage/stimulate the external glucose load. Compared to glycenamide, bael extract has superior results when administered at a dosage of 250 mg/kg of body weight has been proven study. In the Unani system of medicine, bael leaf extract has worked [18].

Anti-ulcer

An ulcer is a common problem of GIT caused by infection of helicobacter pylori or by using an NSAID (non-steroidal anti-inflammatory) drug. The study is conducted by Lavarasan et al. to assess the effectiveness of Báel against peptic ulcers. Bael fruits relieve ulcer disease: it has taken in the form of a beverage. And also leaves can be infused to treat ulcers effectively. The leaves are submerged in water for the whole night. In the morning, this leaf water or strained water is consumed; after a few weeks of this therapy, the pain and suffering are reduced. Luvangetin presence in the fruit; Eugenol, cineol presence in the leaves; and marmin found in the barks are shown the antiulcer medicinal activit [19].

Wound Healing Activity

The study is conducted on Wistar albino rats. In this study, the excision and incision wound models in Wistar albino rats were used to test the effects of topical and intraperitoneal administration of methanolic extract of A.marmelos ointment and injection, respectively. In the result, significant responses were seen in both of the tested wound types when the methanolic extract of A.marmelos was injected or applied topically. A.marmelos are valuable activity in wound healing [20].

Anti-viral

Unexpected health issues caused by viral infection. Study is conducted worldwide on natural herbs and their phytochemicals have rich sources of nutrients and their medicinal properties show antiviral activity against various viral infections. Marmelide, a bioactive compound found in bael fruits has been most effective against viral infection; they are rich in antiviral activity. Seselin is a bioactive compound effective against SAR-CoV-2(Severe acute respiratory syndrome coronavirus-2) [21].

Cardioprotective Activity

The researcher discovered that beasts are prevented from cardiovascular disease. They protect from arrhythmia, stroke, hypertension, myocardial infarction, and atherosclerosis— inhibition of lipid peroxidation by the marmesinin bioactive phytochemicals, which are found in the

bael leaves. The study is conducted on Wistar albino rats having myocardial injury. Dosage administration at 200mg/kg of bael extract has an effective result on Wistar albino rats' myocardial injury. Beal is used as a cardiac depressant [22].

Anti-oxidant

Mar Melos shows antioxidant properties. In the bael antioxidant properties due to the presence of phytochemicals such as flavonoid, alkaloid, sterols, tannins, glycoside, β-carotene, and ascorbic acid. It was discovered that marmelosin exhibited higher antioxidant properties than regular gallic acid. Several investigations have been carried out utilizing various techniques, such as the 2, 2-diphenyl-1-picrylhydrazyl (DPPH) assay for radical scavenging, and another radical scavenging assay. Antioxidant properties of bael prevent oxidative stress brought on by metabolic activities. Unriped bael fruits have more antioxidant properties than ripe fruit. In an investigation to ascertain the potential for antioxidants of methanolic extracts of various Bael plant components. Eugenol and marmesinin are bioactive components present in the bael leaves that they content antioxidant properties [23].

Constipation

Bael fruit are good result during the constipation problems. The intestinal tract is cleansed and toned by it. Consuming bael fruit for 8-12 weeks they remove all the stored, old feces from the digestive system. It should be taken in the form of bael beverage such as sharbat they provide better results [24].

Anti-inflammatory

Mar Melos shows an Anti-inflammatory activity. Extration of A.marmelos leaves that contain a lupol and skimmianine bioactive compound that is effective against inflammatory action. While inflammation serves as a natural defense against infections and autoimmune reactions, it may also be a contributing factor in several other health conditions. They induce histamine to show anti-inflammatory activity [25].

Diarrhea and Dysentery

Mar Melos fruit helps relieve Diarrhea. Specifically, unripe fruit or half-ripe fruit helps to treat chronic Diarrhea. Bael fruits are taken in the form of powered with jaggery for better results. In the sub-acute and chronic dysentery condition, powdered drugs are suggested to relieve dysentery [26].

Antidote in Snake Bite

Roots, leaves, and/or bark of A. marmelos are helpful in the snake bite as an antidote.

Development of Functional Products of A. Marmelos

Worldwide, Bael are most consumable component of the plant. They have medicinal, nutritional, and therapeutic value. Bael fruits have excellent flavor and taste; they also have nutritive content. It is not popular as a table fruit because of its hard shell, gluey texture, and numerous they are difficult to eat. Some possessing require the easy consumption. This processing added value to their nutrition. They also enhance flavor and taste. It should extend their shelf life. Post-harvesting losses are also reduced. The addition of nutritional content enhances the benefits. The product is available on the market as powder, beverages, ready-to-serve, pulp, preserve, candy, toffee, fruit extract, bael seed, jam, juice, beal (fruit or leaves) tea, probiotic chocolate, jelly, microemulsion, dehydrated bael, slab, squash are all prepared or processes and researcher and scientist are worked on processed product [27].

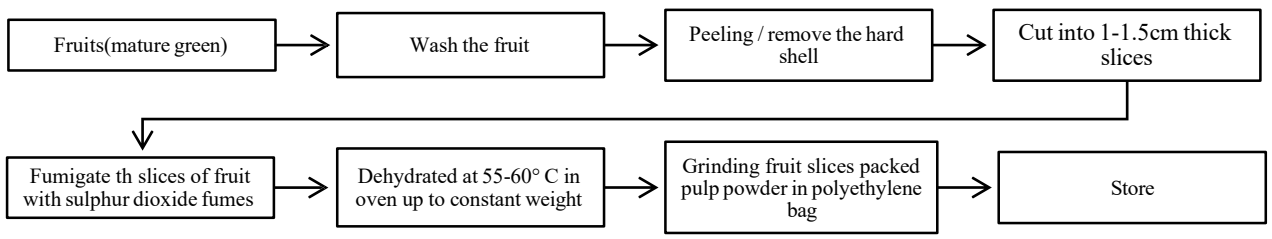
Bael products are developed by different processes carried on different parts of plants.

Bael Powder

Bael fruit powder is prepared by different techniques. They are stored for a long period and also maintain their medicinal value. The powder is prepared from dehydrated unripe or unripe fruit. The bael fruit powder is prepared by following techniques [27].

Method A:(8)

Flow Chart 1: Preparation of Bael Powder



Method B

Take a fully mature, riped, yellowish, and without any defect Bael fruit. Rigid shells of fruit are broken and pulp is separated from it. And transfer pulp into a stainless steel container. They are divided into three sample categories. Sample-1 in this group pulp contains gum and seed. In a similar spirit, sample 2 only contains gum and does not contain seeds. Sample 3, on the other hand, has pulp that is free of gum and seeds. The sample was subsequently dried at 60 ± 5 degrees Celsius in a hot air oven. Shortly thereafter, the dried samples were meticulously mixed and sieved through a 1 mm mesh opening (sieve no. 18). To aid in future research, the powder was kept at room temperature, 25 ± 5 °C, and hermetically sealed in a glass container [28].

Method C

Fruit powder can be made by simply grinding dried fruit, which is a form of dried fruit that has been ground into a fine powder. You can use method either freeze-dried or dehydrated fruit for fruit powder processing. Generally, the freeze-dried method produces a finer powder than the dehydrated fruit method. It is a pure, concentrated fruit pulp with a long shelf life and maintains its medicinal value. The content of iron, potassium, psoralen, marmelosin, and tannic acid in a powder made from dehydrated unripe fruits was noticeably higher. However, the powder made from dried, ripe fruits had much higher levels of antioxidants, zinc, copper, and polyphenols. Additionally, Rmna and colleagues examined how fruit's physicochemical and antioxidant qualities were lost during processing, observing a decrease in β-carotene and total phenolic content in vacuum-dried samples relative to solar- and hot-air oven-dried samples. Therefore, for better fruit powder qualities, the study suggests vacuum drying over solar and hot air oven drying [29].

Bael Toffee

Melted butter and syrup combined with flavorings and colors to create brittle confections called toffee. In general, fruit toffees are higher in nutrients than regular toffees. Bael fruit pulp has both nutritional and therapeutic qualities, it will make even better toffees [30].

Method A

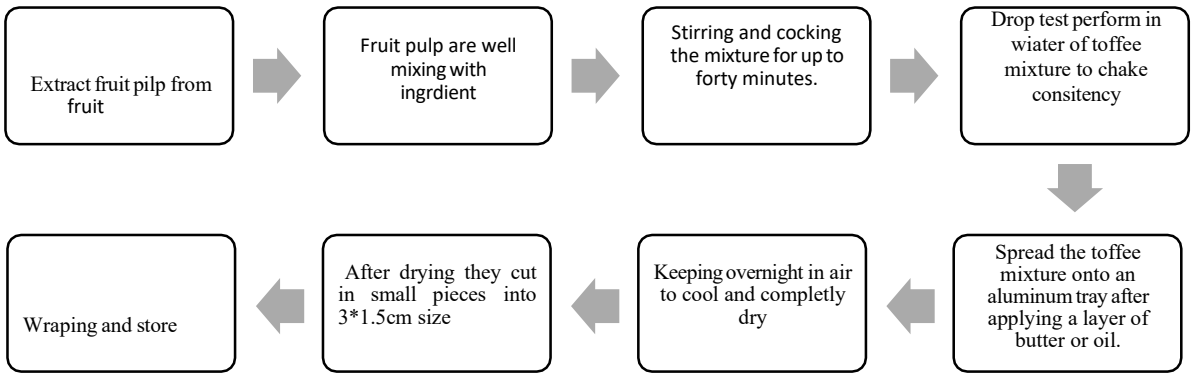
Cardamom and cinnamon are among the herbs they use to prepare the bale fruit toffee. To achieve the required flavor and nutritional value, the fruit pulp was combined with sugar, butter, milk powder, corn flour, citric acid, and different amounts of cardamom and cinnamon to make the toffee. It was discovered that the 0.5g prepared toffee was the best

Method B

A successful preparation of Bael fruit toffee was created by combining 100 parts extracted pulp with 40 parts cane sugar, 4.5 parts glucose, 10 parts skim milk powder, and 6 parts hydrogenated fat [31].

Bael Toffee has also prepared the following flow chart:2;

Flow Chart No. 2: Preparation of Bael Toffee



Method C

Step 1

The pulp of the fruit is extracted by water treatment and baked for around 20 minutes while various amounts (100%, 150%, and 200%) of sugar are added.

Step 2

The pulp is cooked for twenty minutes and then the ghee is added to a thick-bottomed pan.

Step 3

Next, it is mixed with dissolved citric acid, milk powder, and corn flour in water. The mixture is baked around 20 minutes and the consistency.

Step 4

The consistency of the mixture is checked after cooking it for 20 minutes. The concept of mixing all these components and creating a product that embodies the benefits of each one results in a functional food that has a synergistic effect.

Bael Tea

Bael tea is prepared with aloe vera. The dried bael fruit was roasted at 120 degrees Celsius for five minutes in the oven. When the water was boiling, the fruits were crushed into small pieces. Boil the mixture around 10 minutes. Before filtering the bael tea, the cheesecloth and strainer were sanitized. After the filtering process, ½-by-½-inch pieces of aloe vera and sugar were added to the tea. Next, a 300 ml glass bottle that had been sterilized was hot-filled with 270 ml of bael tea, leaving 7% headspace for in-bottle sterilization. By using a water bath to cool them to room temperature, the samples were sterilized for 15 minutes at 121°C. After that, the samples were kept for additional observation at room temperature and 4°C.

Bael Jam

Method A

Jam is a fruit product that has been concentrated and has a naturally occurring fruit flavor with a heavier body. Fruit's high sugar content helps to preserve it, while pectin gives it a nice set.

Step 1: For the preparation of *jam* ripe firm fruit is taken and washed it

Step 2: After that remove pulp (seed and core)

Step 3: Then pulp and juice are boiled together with a suitable amount of sugar until the mixture becomes thick enough to keep the fruit tissues in place.

Step 4: Then add citric acid

Step 5: Determining the endpoint through either a sheet test or additional cooking to 105°C OR 68-70%TSS.

Step 6: At last, they are filled into sterilized bottles cooled, and stored at ambient temperature.

Method B

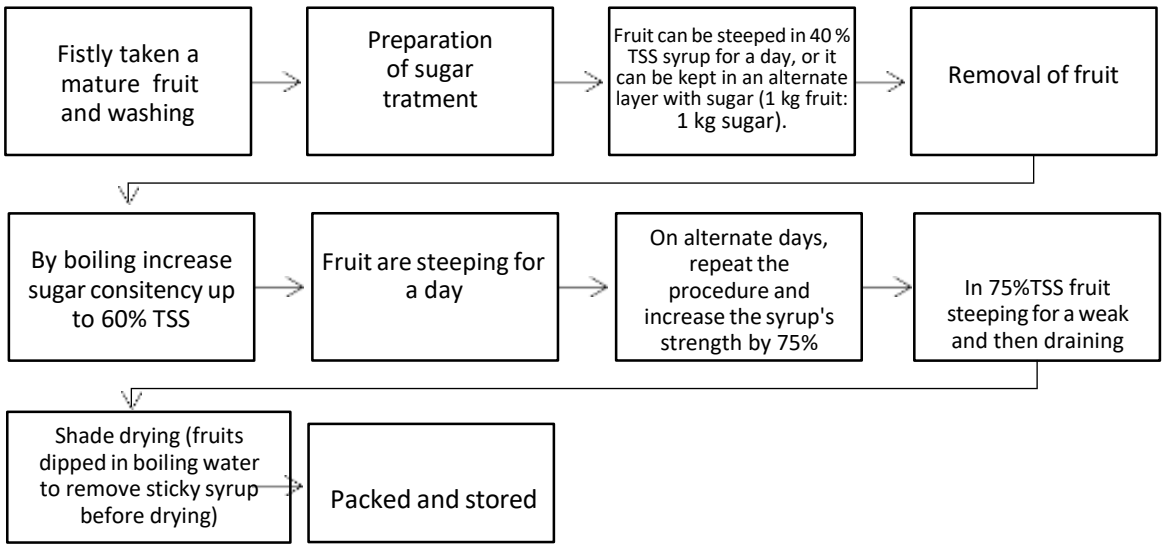
Bael fruit pulp is extracted by using water treatment and then adding sugar in different combinations and cooked for 20 minutes. Pectin is set by adding lime juice. After baking check the jam consistency [32].

Bael Candy

Method A

For bael candy, the fruit slices are first drained, syrup-free, and then baked for 8 to 10 hours at 55 to 60 degrees Celsius. The process of making bael candies

Flow Chart No. 3: Preparation of Bael Candy



Slab

Method A

Fruit slabs are another useful technique for increasing the acceptability and usability of fruit. The pulp was combined with sugar, citric acid, and potassium metabisulfite to prepare it. Acidity and pulp TSS are kept at 0.5% and 35%, respectively. For 15–26 hours, the prepared slab was dried at 55–60°C to maintain its moisture content. The finished product is wrapped in polyethylene and butter paper to act as a moisture barrier after it has dried.

Method B

Setp 1: It is prepared using ripe fruits.

Setp 2: Ripe fruits should be cleaned and their hard shells removed before gathering the pulp.

Setp 3: For every kg of fruit pulp, use 200–300 ml of water, stir thoroughly, and bring the mixture to 80°C.

Setp 4: Fruit pulp free of fibers and seeds can be obtained by passing heated material through a stainless steel sieve.

Setp 5: To make this pulp treated, add sugar, citric acid, and potassium meta-bisulphite (KMS) until the pulp has 35% total soluble solids, 0.5% total acidity, and 0.07% kms.

Setp 6: Boil the treated pulp and distribute it onto butter-smeared aluminum trays.

Setp 7: Dry for 15–16 hours at 55–600C until the moisture content is 14.5%.

Setp 8: Slaves of dried pulp are cut in aluminum trays, then wrapped in butter paper, and packed in polyethylene bags

Setp 9: Before drying the pulp to a moisture content of 14.5%, it was discovered that adding up to 10% of sugar to the extracted pulp was optimal.

Bael Preserv

Method A

The Bael preserve is formulated using the slow syrup method. This method was discovered to enhance the color, test, and overall appearance. This method is more suitable than other method [33].

Method B

For the preserve, a total of five treatments and three replications were conducted.

Unripe bael fruit was taken for preparation of preservation.

Split the bael shell, then cut the pulp into 3 cm by 2 cm by 1.5 cm slices.

After rinsing the slices with water and scoring them with a fork, they are treated with 2% alum for two to three hours to remove any astringency.

Next, they are blanched in boiling water for a duration of 12 to 15 minutes to achieve a soft texture.

The slices were steeped for 24 hours in a sugar syrup that usually contains 2 grams of citric acid per liter at 40°Brix.

After draining the pieces, the syrup's strength was increased to 60°brix, and the slices were stored for 24 hours.

Subsequently, the syrup's strength increased by 50°brix to 80°brix.

For one week, slices were steeped at varying concentrations.

Finally, fill in bottles with fresh sugar syrup of previous concentration [34].

Method C

Bael Juice

Bael juice is prepared by extracting fruit pulp by using water and adding different ingredients such as sugar, a mixture of sugar and lime, jaggery, a mixture of jaggery and lime, and also add flavoring content of cardamom powder.

Bael Ready-to-serve:

Method A

Formulation of bale ready-to-serve (RTS) drink that measures the TSS (%) and acidity (%) in bale pulp extract.

The bael ready-to-serve (RTS) is prepared by following steps;

Step 1: Use ripe fruit for the preparation

Step 2: Fruit is rinsed in the water

Step 3: After washing the shell is broken and remove pulp with seed and fibers

Step 4: Add 1liter water in 1kg pulp as 1:1 ratio

Step 5: Kneading and heating for one minute at 70 °c

Step 6: Analysis of TSS (%) and acidity (%) in bael pulp extract

Step 7: Sugar syrup is prepared as per the treatment

Step 8: Cooling and constricting sugar syrup

Step 9: Sugar syrup is well mixed with fruit pulp

Step 10: The RTS beverage was fully homogenized.

Step 11: Filled with sterile, 200 ml glass bottles, allowing a headspace of two to three centimeters.

Step 12: The bottles were pasteurized in boiling water for 30 minutes, and then sealed with sterile crown corks.

Step 13: cool, label, and storage

Method B

Step 1: Use ripe fruit for the preparation.

Step 2: Drinkable water is used to wash fruit.

Step 3: Then the fruit are broken and the pup are extracted with seed and fibers,

Step 4: Adding water 1:1 ratio in pulp,

Step 5: Add citric acid to adjust pH to 4.3,

Step 6: Pulp is heated at 75°c

Step 7: The materials are pass through a stainless steal sieve and the remaing portion (seed and fiber) are separated,

Step 8: The pulp is mixed with.06% KMS,

Step 9: Kept for later use at -20°C in deep freeze [35].

Bael Leaf Extract

On a winter morning [25ºc], 300g of fresh leaves were harvested and allowed to dry in the shade all day.

100 grams of dried leaves were ground into a powder using a motor and pestle.

10 grams of Aegel marmelos powder were cold extracted with 5 milliliters of water.

The obtained component weighs 7 milliliters in total.

A hot air oven set to 170 degrees Celsius for 30 minutes was used to dry the extract.

Eight grams of the entire component were gathered.

After two days of dehydration, the dried extract was placed in an airtight container for storage [36].

Synonyms of Bael Fruit

Different Synonyms of *Agele Maremlos* In Different Language Are Mentioned In Below **(Table no. 5)**

Table 5: Different Synonyms of Bael Fruit [37].

Language	Synonyms
Hindi	Bel, Bela, Bel Patra, Villi, Shivadume, Shriphal
English	Bael fruit tree, bael tree, ball tree, Bela tree, Bengal quince, elephant apple, golden apple, holy fruit, Indian bael, Indian quince, marked, quince-apple of India, stone apple, wood apple
Marathi	Bela, Kaveeth
Sanskrit	Bilva, Bilvam, Bilva-phalam, Mahura, Shivaphala, Shivadruma, Sriphal, Pootivat, Shaelpatra, Lakshmiputra, Shivestha
Gujarati	Bel, Bilivaohal, Billi
Urdu	Bel, Bael
Bengali,	Bael, Bela, Shriphal
Kannada	Bilpatra, Malura, Kumbala
Konkani	Gorakamli
Malayalam	Baela koovalam, Kuvalam, Maaredy, Vilvam
Panjabi	Beel, Bil
Sindhi	Katori
Oriya	Belo, Baela
Telegu	Bilva, Bilvamu, Bilva-pandu, Maradu-pandu, Malu-remu-chettu
Tamil	Bilva, Bilubam, Kuuviram, Villuvam, Vilvam, Vilvama, Vilva-maram, Vilva-pazham
Arabic	Safarjale-hindi, Shul
Burmese	Ohshit, Opesheet
Chinese	Mu ju, Yin du gou qi, Ying pi ju
Dutch	Slijmappelboom
French	Bel indien, Cognassier du Bengal, Coing de l'Inde, Oranger de Malabar
German	Belbaum, Bengalische quitte, Indische quitte, Schleimapfelbaum
Indonesian	Maja batuh, maja
Laotian(Sino Tibetan)	Toum
Italian	Cotogno del Bengala, Cotogno d'India
Vietnamese	Bau nau, Tráimam
Assamese	Bel
Japanese	Berunoki, Igure marumerozu
Malay	Bel, Bila, Bilak, Maja, Maja batuh, Maja pahit
Javanese	Modjo
Thai	Mapin, Matum
Nepali	Belapatra, Belpatra
Khmer	Phneou, poi
Persian	Bah hindi, Safarjal-e-hindi, Shull
Portuguese	Marmeleiro-da-índia
Turkish	Hind ava agh
Tagalog	Bael
Sinhalese	Beli
Spanish	Bela, Milva
Scientific	Aegle marmelos Corrêa, Belou marmelos (L.) Lyons, Bilacus marmelos (L.) Kuntze, Crateva marmelos L., Crateva religiosa Ainslie, and Feronia pellucida Roth

Conclusion

Many herbal products form the backbone in daily life with 80% of the species found on earth classified under the angiosperms species, with a larger part of them being medicinally valued. Bael fruit from the Rutaceae family, scientifically known as Aegle marmelos, has been used due to its rich bioactive component and source of phytochemicals for many health benefits such as assisting with boosting immunity and heart health. This ancient herbal medicine contains vital parts of the bael plant, ranging from roots, bark, leaves, fruits, seeds, and flowers. Traditionally used in Ayurveda, bael has medicinal properties and health benefits including anti-diabetic, anti-microbial, anti-cancer, and wound healing properties. From home remedies found in India to religious significance because it relates to Lord Shiva, bael stands out for its value in therapy. The bael tree's appeal is to be applied across countries like India, Bangladesh, Thailand, Sri Lanka, and others, which extensively study the fruit, leaves, bark, and seeds to be processed into a range of functional products such as powders, toffees, candies, jams, juices, enhancing shelf life and extended benefits, safe and natural remedies for various diseases such as cancer, diabetes, ulcers, wound

healing, cardiovascular health, and others.

The effectiveness, side effects, and adverse drug reactions (ADR) of the bael (Aegle marmelos), which is used in Ayurvedic medicine, comparing its practices with Allopathic medicine is used in various diseases treatment; comparison in detail below ***(Table no.6)*** in percentage with an example of adr;

In the case of chronic illnesses, Bael has proven to be a safer and natural option as compared to most of the allopathic medications for long-term treatment.

Table 6: Comparison of Bael (Aegle marmelos) vs Allopathy Medicine of their effectiveness and side effects

Disease/ Condition	Type of Treatment	Effectiveness (%)	ADRs (%)	Type of ADR
Type 2 Diabetes	Aegle marmelos	65–75%	5–10%	Rare hypoglycemia
	Allopathy medicine	75–90%	15–25%	Weight gain, hypoglycemia, gastrointestinal disturbances
Asthma	Aegle marmelos	60–75%	5–10%	Respiratory discomfort (mild)
	Allopathy medicine	80–90%	10–15%	Tachycardia, tremors, nervousness
Digestive Disorders	Aegle marmelos	70–80%	5–10%	Mild stomach cramps
	Allopathy medicine	80–95%	10–20%	Constipation, diarrhea
Skin Conditions (Eczema, Psoriasis)	Aegle marmelos	60–75%	5–10%	Mild skin irritation
	Allopathy medicine	70–85%	15–20%	Skin thinning (steroids), irritation
Arthritis (Osteo & Rheumatoid)	Aegle marmelos	70–80%	5–10%	Mild stomach upset
	Allopathy medicine	70–85%	15–30%	Stomach ulcers, kidney issues, joint pain
Hypertension	Aegle marmelos	60–70%	5–10%	Mild dizziness
	Allopathy medicine	80–85%	15–20%	Dizziness, fatigue, electrolyte imbalance
Cancer (Adjunct Therapy)	Aegle marmelos	50–65%	10–15%	Fatigue, mild nausea
	Allopathy medicine	80–95%	30–50%	Hair loss, nausea, immune suppression, fatigue
Cardioprotective Activity	Aegle marmelos	70–80%	5–10%	Mild dizziness or hypotension
	Allopathy medicine	85–90%	10–20%	Dizziness, low blood pressure, fatigue
Wound Healing Activity	Aegle marmelos	75–85%	0–5%	Rare allergic skin reactions
	Allopathy medicine	80–95%	15–25%	Infection, delayed wound healing (from synthetic treatments)
Antiviral Activity	Aegle marmelos	60–75%	5–10%	Mild gastrointestinal discomfort
	Allopathy medicine	5–95% (for specific viral infections)	20–30%	nausea, headache, fatigue
Antiulcer Activity	Aegle marmelos	70–80%	5–10%	Mild stomach cramps or discomfort
	Allopathy medicine	80–95%	15–25%	Diarrhea, constipation, headache (from proton pump inhibitors

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