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AN IN-DEPTH REVIEW ON: FORMULATION AND EVALUATION OF PARTS OF AEGLE MARMELOS

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ABSTRACT

The Bael Tree (Aegle Marmelos), has a rich history in traditional medicine systems and is increasingly being explored for its medicinal and nutraceutical potential. The bael tree (Aegle marmelos) is a revered botanical treasure, renowned for its richness in phytochemicals, which provide countless medicinal and nutritional benefits. The phytochemical composition, including alkaloids, flavonoids, tannins and essential oils, is analyzed in detail, highlighting its important role in the diverse therapeutic potential of bael tree parts. This comprehensive review explores the various methods used for formulating and evaluating different parts of the bael tree, such as its leaves, fruits, and roots, for their medicinal and nutraceutical applications. These methods encompass the extraction of bael fruit juice, leaf extracts, root and bark formulations, as well as nutraceutical and cosmetic preparations. A deeper understanding of its chemical constituents of different parts, taxonomical classification, cultural significance, medicinal properties, and effective formulation and evaluation methods is crucial for harnessing its therapeutic benefits. This review provides an in-depth analysis of the medicinal and nutritional activities of the bael tree, including its antimicrobial, anti-inflammatory, antidiabetic, and antioxidant properties. As demand for medicinal plants and nutraceuticals continues to grow, this journal provides a comprehensive resource for researchers, scientists and healthcare professionals, providing insight about the promising world of Bael and Bael formulas.

KEYWORDS: Aegle marmelos, bael, medicinal plant, phytochemical, formulation and evaluation of bael tree.

1. INTRODUCTION

The Bael, *Aegle marmelos (Linn.)* Correa (*Family: Rutaceae*), is one of the most medicinally valuable tree species among the 250,000 species of land plants on Earth. Historical records indicate that Bael has been inhabited since 5000 BC. It is used medicinally and as food and it was already known to people when he wrote the famous Sanskrit epic Ramayana. Baer mentioned it in his famous book 'Charaka Samhita' which is a comprehensive compilation of all important Ayurvedic information and Bael identified it as a necessary element of Ayurvedic medicine.[1] Bael is a medium-sized slender aromatic tree in the western Himalayas, 6.0-7.5 meters high and 90-120 cm wide, growing up to 1200 meters above sea level.[2] This plant is native to northern India, but is widely cultivated in other parts of India as well as in Thailand, Bangladesh, Pakistan, Sri Lanka, and Burma.[3]

The bael tree is a sacred and highly revered plant in various traditional medical systems, including Ayurveda and Traditional Chinese Medicine. Other medical systems such as Siddha, Unani, and Ayurvedic systems provide information regarding the possible effects of Bael tree.[3]

It is a common plant found in various parts of India. This plant has several names, including bael, Bengal quince, golden apple, and crabapple. It is cultivated as a garden plant in temples, and the leaves of Aegle marmelos L. are used for prayers to Lord Shiva [Figure 2]. Its fruits are used both as food and in traditional medicine.[4]

Due to its diverse medicinal properties, it is of increasing interest in the fields of modern medicine and nutritional supplements. Various parts of this tree, including leaves, fruits, and roots, are traditionally used in herbal remedies and in the production of nutritional supplements. Bael fruit has excellent pharmacological activity and its fruit is effective against indigestion, diarrhea and dysentery. The fruit is also used as a nutritional supplement and has effects on intermittent fever, psychiatric disorders, hypoglycemic effect, antifungal effect, antibacterial, analgesic, anti-inflammatory, antipyretic, ant dyslipidemia, immunomodulatory effect, antifungal proliferative effect, wound treatment. Also used for Healing effect, anti-reproductive promoting effect, insecticidal effect, etc.[5] The bael plant and its plant products are used to heal and alleviate physical and mental ailments.[2]

Figure 1: Aegle Marmelos Tree.

Table 1: Taxonomical classification of Aegle Marmelos.[4]

Kingdom	Plantae
Subkingdom	**Tracheobionta**
Super division	**Spermatophyta**
Division	**Magnoliophyta**
Class	**Magnoliopsida**
Subclass	**Rosidae**
Order	**Sapindales**
Family	**Rutaceae**
Genus	**Aegle**
Species	**Aegle marmelos**

Table 2: Chemical constituents present in different parts of Aegle Marmelos.[6]

Plant Part	Chemical Constituents
Bark	Fagarine, Marmin.
Fruit	Marmelosin, Luvangetin, Aurapten, Psoralen, Marmelide, Tannin.
Seed	Essential oil: D-limonene, A-D-phellandrene, Cineol, Citronellal, Citral, P-cyrnene, Cumin aldehyde.
Leaf	Skimmianine, Aeglin, Rutin, Y-sitosterol, β-sitosterol, Flavone, Lupeol, Cineol, Citral, Glycoside, O-isopentenyl , Halfordiol, Marmeline, Citronellal, Cuminaldehyde phenylethyl cinnamamides, Eugenol, Marmesinin.

- **Cultural Significance of the Bael Tree**

The bael tree has great cultural significance in various countries in Asia, especially India, Nepal, and Sri Lanka. Its cultural significance is deeply rooted in religious, traditional and social practices, making it a revered symbol in these societies.

The Bael tree is considered sacred in Hinduism and is often referred to as “Bilva” or “Shiva Tree.” It is closely related to Lord Shiva, one of the main gods of Hinduism. The leaves of

the bael tree, known as 'Bilva leaves', are considered to be one of Lord Shiva's favorite offerings. It is used in various religious rituals, poojas (prayers) and rituals. The three leaves of the bael tree are believed to symbolize the Hindu holy trinity: Brahma, Vishnu, and Mahesh (Shiva). Bael leaves are used as a symbol of devotion and are offered to Lord Shiva as a sign of respect.[7]

In Buddhism, the bael tree also has cultural significance. The Buddha is believed to have attained enlightenment while meditating under a Bodhi tree, often identified as a type of Bael tree. Therefore, the bael tree is considered a symbol of enlightenment and spiritual awakening in the Buddhist tradition. Buddhists view bael trees with deep respect and may plant and protect these trees as a sign of respect.[8]

The presence of bael trees is often considered sacred, and they are commonly planted near temples, shrines, and in public spaces. These trees serve as gathering points for religious and cultural activities, and they are an integral part of various ceremonies and rituals. Bael fruits, leaves, and roots are used as offerings to deities in religious worship, making the tree an essential element of Hindu and Buddhist religious practices.

- **Medicinal Uses Of Different Parts Of Bael Tree**

All parts of Aegle marmelos are medicinally useful like leaves, fruit, flower, root bark etc.

Figure 2: Aegle Marmelos Leaves.

LEAVES

The leaves are used as a mild laxative, in inflammation of the mucous membranes with free secretions, and in asthma. A decoction of the leaves has an antipyretic effect, helps get rid of fever, has an expectorant effect, or facilitates the removal of mucus secretions from the bronchi. Leaf juice is administered for dropsy and abnormal fluid accumulation in the tissue

associated with constipation and jaundice. Warm compresses of the leaves are used for severe conjunctivitis with ophthalmitis and acute bronchitis, as well as inflammation of other parts of the body.[9]

FRUIT

The treatment of thyroid diseases in body parts is facilitated by fruit extracts. It is considered very helpful in curing vomiting during pregnancy when taken with boiled rice water. Pulp powder from unripe fruits is very useful in treating abscesses. The starch in immature fruit is converted to sugar by heating. The fruit extract is then mixed with hot water and anesi and strained. The extract found is useful in dysentery. Mixing the pulp with sugar and milk helps with urinary and reproductive problems.[3]

Figure 3: Aegle Marmelos Fruit.

FLOWER

Distilling the flowers yielded a drug used as a gastrointestinal tonic, medicine against dysentery, antidiabetic, diaphoretic, and local anesthetic. It is also used in epilepsy and as an expectorant.[9] Although recognized for use in traditional medicine, scientific research on bael flowers is limited and we recommend consulting a medical professional before use.

Figure 4: Aegle Marmelos Flower.

ROOT BARK

The root bark is used as a remedy for intermittent fevers, fish poisoning, fever and melancholy. Bark juice mixed with a little cumin in milk is prized as a remedy for semen deficiency. Alcohol root extract has a hypoglycemic effect. Also used for dog bites, stomach problems, heart problems, intermittent fever, formic acid, hypoglycemia, and rheumatism.[6]

Figure 5: Aegle Marmelos Bark.

2. Formulation and Evaluation of Different Parts of Bael Tree

2.1 Bael Leaves Formulations

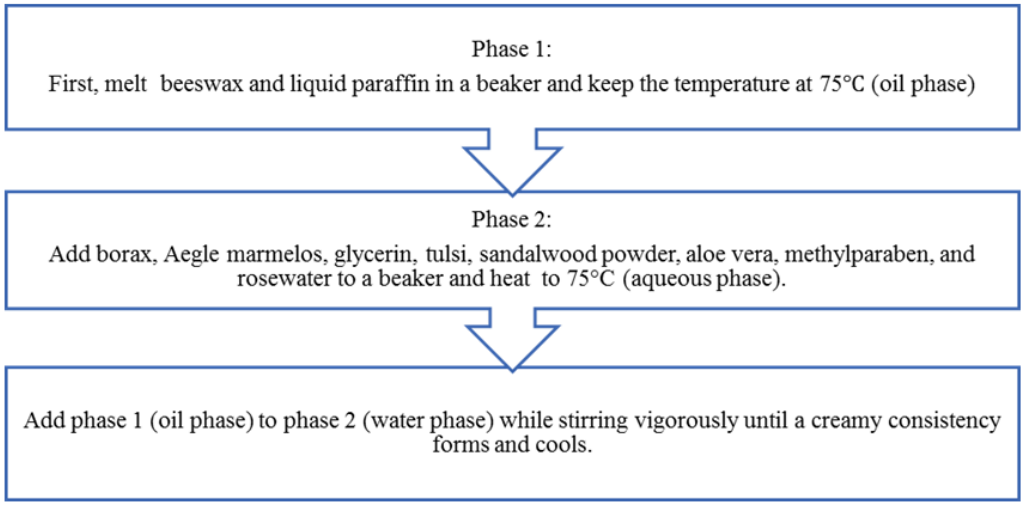
Bael leaves, derived from the Aegle marmelos tree, are renowned for their medicinal properties. Commonly used in traditional medicine, these leaves contain antioxidants and exhibit anti-inflammatory and antimicrobial effects. Infusions made from bael leaves are popular for promoting digestive health and overall well-being. However, it's advisable to seek guidance from healthcare professionals before incorporating such remedies into your routine.

2.1.1 Herbal Cold Cream By Using Leaves[10]

Table 3: Formulas.

Ingredients	Quantity
Beeswax	3gm
Borax	1gm
Liquid paraffin	4ml
Glycerin	3ml
Aegle Marmelos	2ml
Aloe Vera	0.10gm
Tulsi	1ml
Sandalwood powder	2.5gm
Methyl paraben	Q. S
Rose water	3ml
Water	Q. S

- **Method Of Preparation**



- **Evaluation of cold cream**

1. Physical properties

The physical properties of the formulated cream were observed in terms of color, odor, and appearance.

Table 4: Physical Properties.

Sr. No.	Properties	Result
1	Colour	Crimish Colour
2	Odour	Pleasant
3	Texture	Smooth

2. Washability

The washability test is carried out by applying a small amount of cream to the hands and washing with tap water.

3. PH Determination

Cold cream has a pH in the range of 5 and is known to be good for the skin.

4. Viscosity- Viscosity is checked with a Brookfield viscometer.

5. Spreadability- Good spreadability indicates how well the blended cold cream spreads. The spray area was 24.4g. centimeters/second.

6. Irritancy test- Application of the formulated cold wash cream to the hands did not cause irritation, edema, or inflammation during the study. The cream is safe to use.

7. Microbial test

Take a small amount of cold cream and place it in foil. Next, observe it under a microscope. No microorganisms observed.

8. Homogeneity test

The uniformity of the formulated cream was evaluated based on visual appearance and feel.

2.1.2 Toothpaste Preparation By Using Leaves[11]

- **Material Used**

I collected various plant materials to make herbal toothpaste. Namely: Bael Leaf, Neem, Honey, Acacia, Calcium Carbonate, Sodium Lauryl Sulfate, Glycerin, HPMC (Hydroxypropyl Methyl Cellulose), Methylparaben, Sodium Saccharin, Titanium Dioxide, Propylparaben, Methanol from India.

Table 5: Ingredient's & Uses.

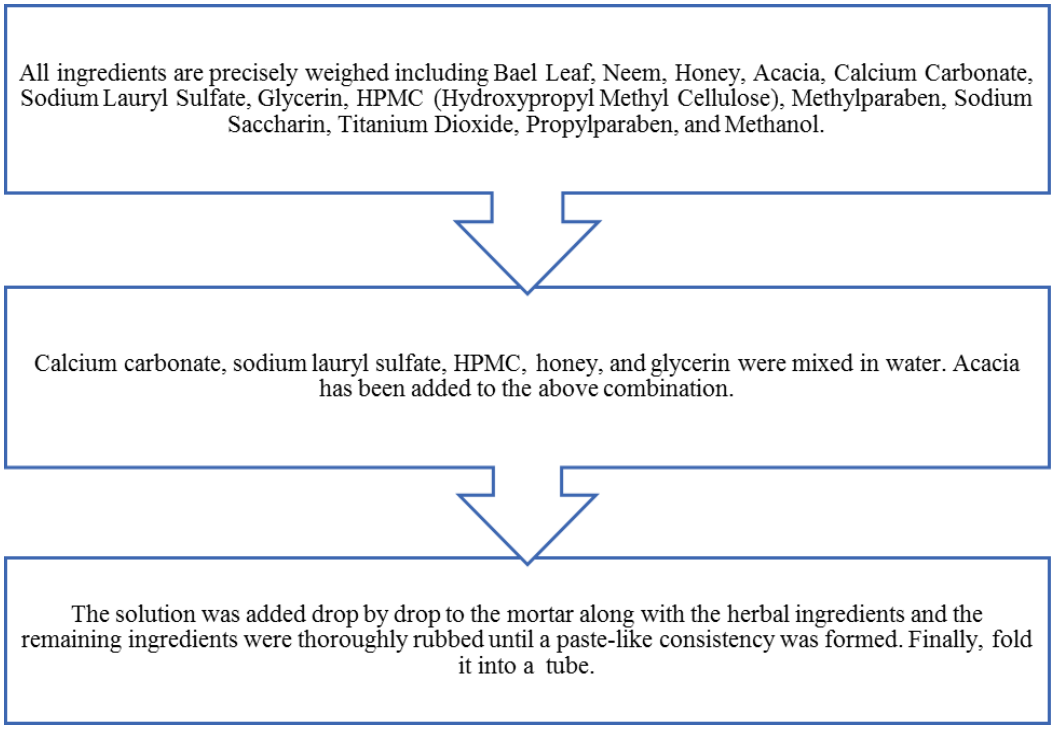
Sr. No.	Ingredient	Use Of Ingredient
1	Bael Leaves	Prevents formation of bacteria
2	Neem	Prevent cavities
3	Honey	Reduces swollen gums
4	Calcium Carbonate	Reduce dental caries
5	SLS(Sodium Lauryl Sulphate)	Foaming agent
6	Glycerin	Prevents dryness of mouth
7	HPMC(Hydroxypropyl Methylcellulose)	Thickening agent
8	Methyl Paraben	Preservative
9	Propyl Paraben	Prevent growth of microorganisms
10	Sodium saccharin	Masks the bitter taste
11	Titanium Dioxide	Whitening effect

Table 6: Formulas.

Ingredient	Quantity
Bael leaves	3gm
Neem	3gm
Honey	2gm
Acacia	3gm
Calcium carbonate	35gm
Sodium lauryl sulphate	1.50gm
Glycerin	25gm
HPMC	1gm
Methyl paraben	0.10gm
Sodium saccharin	0.30gm
Titanium dioxide	0.50gm
Propyl paraben	0.02gm

Methanol	1.50gm
Purified water	Q.s

- **Preparation Method**



- **Evaluation Test**

1. Physical Examination (colour, odour, taste, smoothness, and relative density)

The color of the toothpaste was visually evaluated. This product had an odor that could be confirmed by sniffing. The taste of the formulations was evaluated manually. The smoothness of the formulation was checked by rubbing the paste mixture with fingertips.

Table 7: Physical Examination.

Parameter	Observation
Color	Light Green
Odor	Characteristics
Taste	Sweet
Texture	Smooth

2. PH

Pour 10 grams of toothpaste from the container into a 50 mL beaker with 10 mL of freshly boiled and cooled (to 270 °C) water to obtain a 50% aqueous suspension. Stir thoroughly to ensure complete suspension. Measure the pH of the suspension in 5 min using a PH meter.

3. Homogeneity

The toothpaste should come out of the collapsible tube or other suitable container at 27°C under normal pressure. Additionally, most of the contents should gradually roll out from the flange of the container.

4. Sharp and edge abrasive particles

The contents were placed on a finger and scratched 15-20 cm on butter paper to check for the presence of sharp or abrasive particles. I must have repeated this process 10 times. No particles with sharp edges or abrasions were found.

5. Formability

The foaming power (flammability) of herbal toothpaste was determined by mixing 2 g of toothpaste and 5 ml of water in a graduated cylinder and shaking 10 times. The total volume of foam was calculated.

6. Determination of moisture and volatile matter

To determine moisture and volatile content, 5 g of herbal toothpaste was placed in a porcelain dish with a diameter of 6–8 cm and a depth of 2–4 cm. It was dried in an oven at 105℃.

7. Determination of spread ability

The diffusivity strategy is selected based on the sliding and drawing properties of the paste. To avoid slipping, 1–2 g of herbal toothpaste was weighed and placed between two stacked glass slides (10 × 10 cm). The slide was then moved in the opposite direction. Measure the amount of toothpaste spread after 3 minutes (cm). Run the experiment again and average the three measurements.

Table 8: Evaluation Tests.

Spread ability (cm)	4.4cm
Abrasiveness	Good abrasive
Stability	Good
Foaming Power	54

Parameter	**Observation**
pH determination	7.50
Homogeneity	Good

2.1.3 Microemulsion By Using Leaves[12]

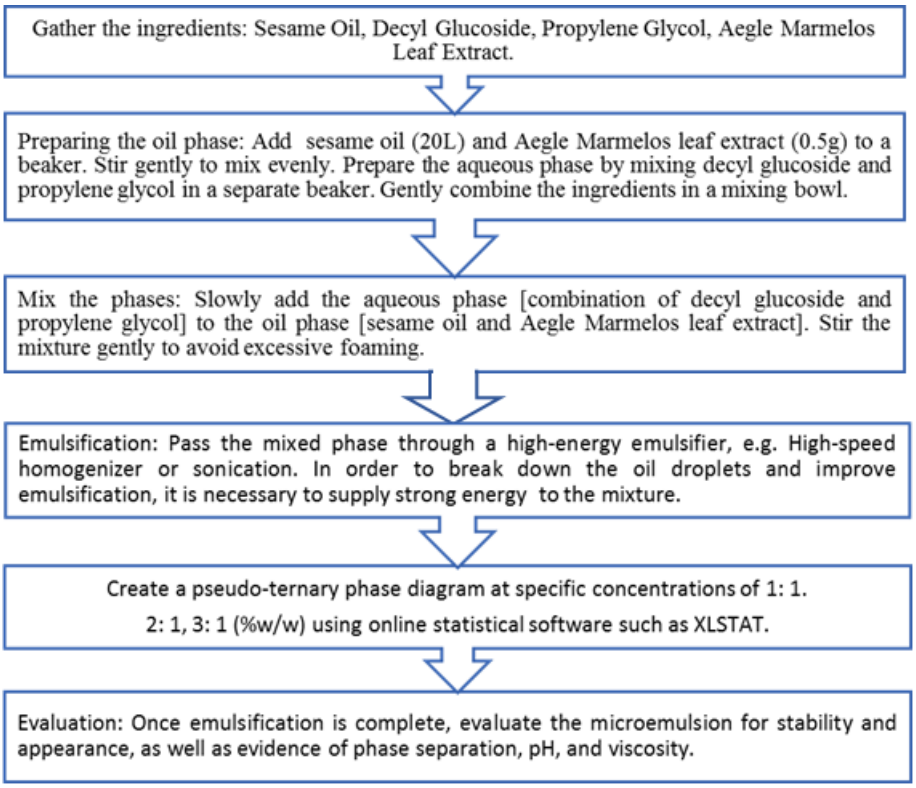
- **Materials Used**

- Aegle marmelos leaves
- Sesame oil
- Decyl glucoside
- Propylene glycol
- Methanol

- **Method to extract Aegle marmelos (Bael) leaf extraction**

Fresh leaves (300 g) were picked and dried in the shade for an entire day on a winter morning [25 °C]. Dry leaves (100 g) were ground into powder using a motor and pestle. Cold extract 10 g of Aegle Marmelos powder with water [5 ml]. The total weight of the obtained components was 7 ml, and the dried extract was placed in a hot air oven [170 °C for 30 min]. A total of 8g of all components was recovered. The dried extract was dehydrated for 2 days and then stored in an airtight container.

- **Formulation of Microemulsion**



- **Characterization**

1. PH determination

The pH of the microemulsions was measured at 25 °C using a pH meter (digital pH meter). The obtained value is 6.42 ± 0.04.

2. Percentage transmittance

The clarity of the microemulsions was determined by measuring the percent transmittance at 650 nm using a UV-visible spectrophotometer 3000+ T60 with distilled water as a blank.

3. Centrifugation test

This sample was centrifuged at 3000 rpm for 60 minutes and tested to determine whether the system was monophasic or biphasic.

4. Viscosity measurement

The rheological behavior of the formulations was evaluated using a Brookfield viscometer at room temperature.

5. Staining test/dye solubility test

A water-soluble dye, 10 µl of methylene blue solution, was added to the emulsion. When the continuous phase is water (O/W emulsion), the dye is uniformly dissolved throughout the system. When the continuous phase is oil (W/O emulsion), the dye remains as clusters on the surface of the system.

2.2 Bael Fruit Formulations

Bael fruit formulations typically involve extracting its bioactive compounds for medicinal use. Common methods include preparing powders, capsules, or infusions, providing convenient ways to harness the fruit's therapeutic properties. These formulations are then subject to rigorous evaluation, including phytochemical analysis and biological activity testing, to ensure their efficacy and safety.

2.2.1 Peel Off Face Mask By Using Fruits[13]

- **Materials Used**

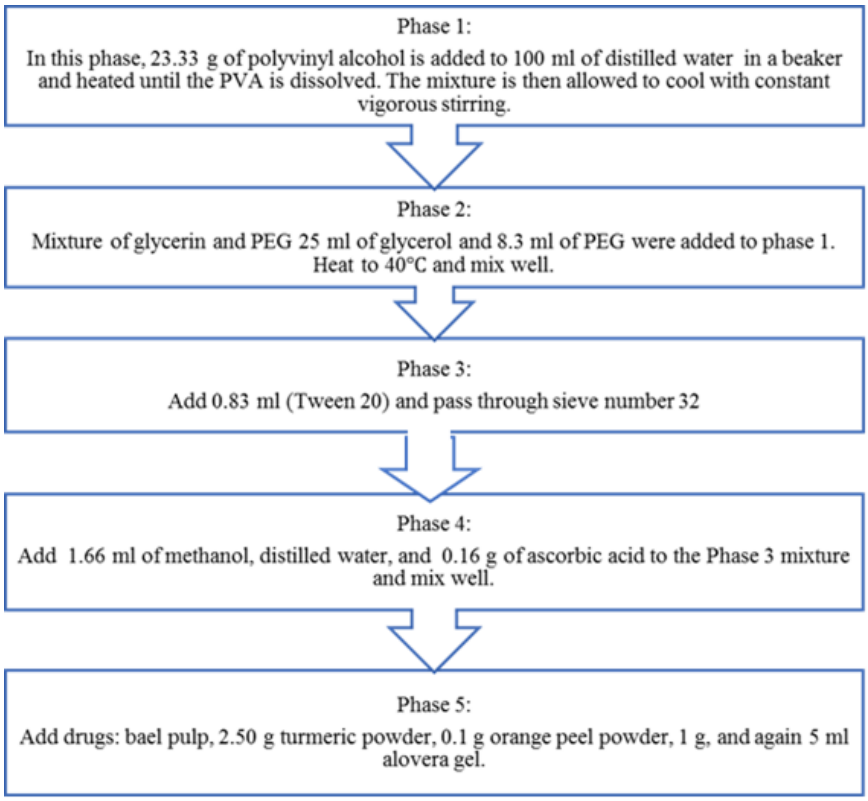
- Bael fruit powder
- orange peel
- Aloe Vera

- Turmeric powder
- Polyvinyl alcohol (PVA)
- Glycerin
- Polyethylene glycol (PEG)
- Polysorbate(tween twenty)
- Methanol
- Ascorbic acid

Table 9: Formulas.

Ingredients	Quantity
Bael fruit powder	2.50 gm
Ascorbic acid	0.16 gm
Methanol.	1.66 ml
Distilled water	100 ml
Aloe Vera	5 ml
Orange peel powder	1 gm
Polyethylene glycol	8.3 ml
Turmeric.	0.1 gm
Polyvinyl alcohol	23.33 gm
Glycerin	25 ml
Polysorbate.	0.8 ml

- **Preparation Of Peel Face Mask**



- **Evaluation Parameters**

1. **Physical Evaluation of Peel off mask** – Physical factors such as color, odor, and hardness were thoroughly tested by applying them to human skin.
2. **Homogeneity** - Homogeneity testing is used to confirm particle uniformity and uniform particle distribution on a drug product. The appearance and presence of agglomerates was visually inspected by applying the formulation to glass or transparent material.
3. **pH** - The pH value of the topical exfoliation mask was measured using pH paper.
4. **Drying time** - Drying time test was performed with one mask placed on the backhand. A timer was used to measure the time it took for the preparation to dry.
5. **Irritation test** - The irritation test is performed by applying the prepared peel-off gel mask to the skin of the hands. Place the mask on the back of your hand for 15 minutes and observe any irritation reactions such as swelling, itching, or skin redness.
6. **Spreadability test** - A total of 1 g of the stripping preparation was placed between two glass slides and a 100 g weight was placed on the glass slide for 2 minutes to compress the sample to a uniform thickness and reduce its diameter was measured.
7. **Washability test** - After application of the formulation to the skin, the ease and degree of wash-off with water was manually assessed. Physical stability testing of the formulation - Stability testing was performed at room and cold temperatures. Physical appearance was documented by visual inspection at each temperature.

Table 10: Result Of Peel Of Face Mask.

Sr.no.	Test	Result
1.	Color	Pale yellow
2.	Consistency	Smooth and sticky
3.	State	Semisolid
4.	pH	5
5.	Washabilty	Washable
6.	Irritancy test	no irritation effect shown
7.	Spreadibility Test	smooth and light to spread
8.	Peel of test	Peel removal from skin easily without breaking
9.	Homogeneity	Homogeneous
10.	Peeling time min	thick layer 10+_1
11.	Peeling time min	thin layer 6+_1

2.2.2 Anti-Acne Cream By Using Fruits[14]

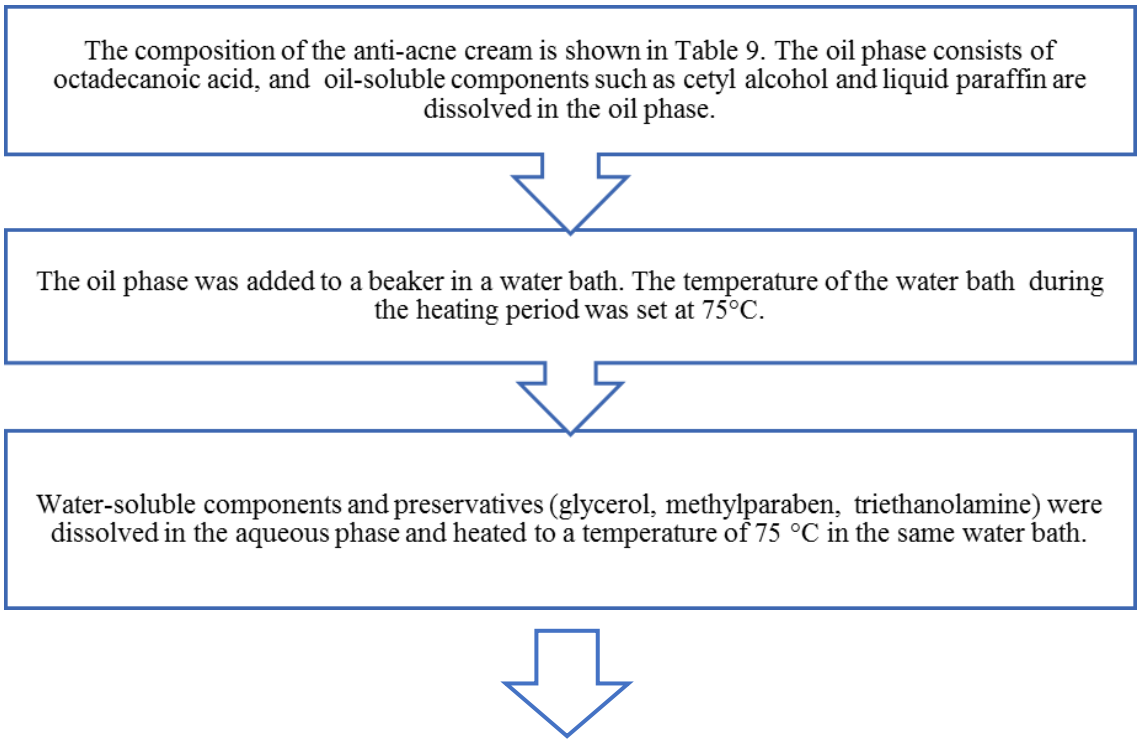
- **Extraction Method of Fruit using Maceration Process**

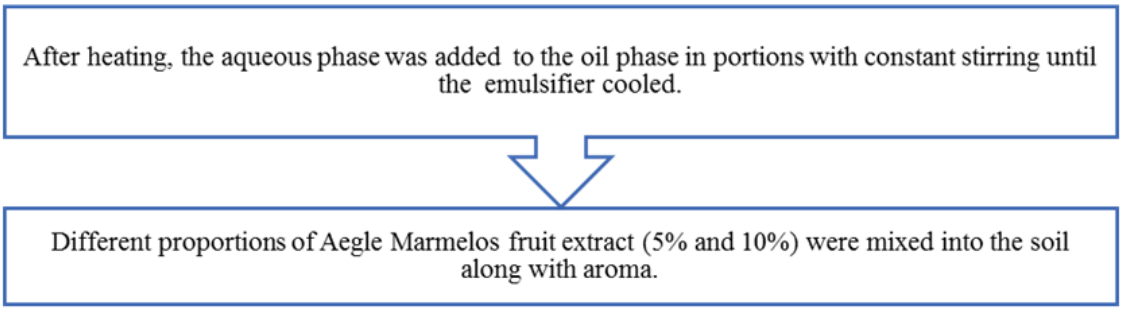
The collected fruits were thoroughly washed with H2O to remove impurities. The fruits were cut into small pieces and dried in the shade for a week. The dried product was coarsely ground using a mechanical mixer. Powdered fruit of Aegle quince with a total weight of 200 g was extracted by maceration method using 2.5 L of 70% ethanol as the solvent for about 1 week with occasional shaking. The ethanolic extract of Aegle marmelos fruit was filtered and concentrated to dryness using a rotary evaporator under reduced pressure and controlled temperature. The extract was stored in a refrigerator at 4 °C in a very tightly closed container until further use.

Table 11: Formulation table of the anti-acne cream containing Aegle Marmelos Extract.

Ingredient	Category	Quantity 20%
Aegle Marmelos Fruit Extract	Antibacterial Antioxidant	2
Stearic acid	Emulsifier	4
Cetyl alcohol	Stabilizer	1.6
Liquid paraffin	Lubricant	1.6
Glycerin	Humectant	2
Triethanolamine	-	Neutralizer
Distilled water	Vehicle	6.65
Methylparaben	Preservative	0.15

- **Preparation Of Anti-Acne Cream**





- **Evaluation Of Anti-Acne Cream**

1. **PH:** The pH meter was calibrated with a commercially available solution. Approximately 0.5 g of cream was weighed, dissolved in 50 ml of water, and the pH value was measured.
2. **Homogeneity:** The homogeneity of the formulation was checked visually and tactilely.
3. **Appearance:** The appearance of the cream was evaluated based on its color, pearlescence, and roughness, and checked by grade on the smoothness, slipperiness, and amount of residue remaining after applying a large amount of cream.
4. **After feel:** We checked the smoothness, lubricity, and amount of residue after applying a large amount of cream.
5. **Type of smear:** I checked the type of film or streaks that form on the skin after applying the cream.
6. **Washability:** The applied cream was washed with water and the ease with which the applied cream came off was examined.
7. **Stability study:** Stability studies were carried out by storing the anti-acne cream at three different temperatures, namely 8°C, 27°C and 40°C for 2 months.

Table 12: Evaluation Parameters.

Sr.no	Parameters	Observation
1	Color	White
2	Odor	Pleasant
3	Consistency	Good
4	Washability	Easily washable
5	Spreadability	Good
6	pH	7.4±0.8
7	After feel	Emollient and slipperiness
8	Type of Smear	Non-greasy

2.2.3 Value Added Products from Bael Fruit[15]

- **Materials and Methods**

Ripe bael fruits are selected and procured from the fields of farmers at ARS, Hegari Farm in Bellary and Hurikele village in Kudrigi taluk of Bellary district.

- **Development Of Value Added Products**

A variety of value-added products such as juices, jams and toffees have been developed with standardized combinations of ingredients and evaluated by a group of semi-trained judges from ARS and KVK, Hagari, Bellary) on a nine-point hedonic scale. Sensory evaluation was performed using a scale.

The most accepted products were used for consumer evaluation. They targeted a diverse group of consumers, and he recorded likes, dislikes, or neutral opinions on the products.

- **Value added products from bael**

Bael juice

Bael pulp is extracted with water and mixed with various ingredients such as sugar, sugar + lime, jaggery, jaggery + lime, and the flavoring ingredient cardamom powder.

Bael jam: Bael pulp is extracted with water and with the addition of various sugar combinations (75%, 100%, 150%) he boils for 20 minutes. Add lime juice to fix the pectin. After cooking for 20 minutes, the consistency of the jam is checked (softball stage).

Bael toffee

Extract bael pulp with water, add different combinations of sugar (100%, 150D44, 200%) and boil for 20 minutes. After 20 minutes, pour the ghee into a thick-bottomed saucepan in which you have added the heated pulp, corn flour, milk powder and citric acid dissolved in water. After addition, boil the mixture for 20 minutes and check the consistency (softball stage).
All products were sensory evaluated by comparing to a control recipe.

2.3 Bael Root Formulations

Decoctions and tinctures: Bael root is used to prepare decoctions and tinctures and has traditionally been used for its digestive and antibacterial properties.

Root-based dietary supplements: Bael root extract is incorporated into dietary supplements to improve gut health and support the immune system.

Bael Root Teas: Bael Root Tea is consumed as a traditional treatment for indigestion and general health.

2.4 Herbal Ointment Prepared From Crude Extracts Of Aegle Marmelos[16]

Materials and Methods

- **Collection of Plant material**

Leaves, ripe fruits, unripe fruits and stems of Aegle marmelos were collected from Pune region, Maharashtra in July 2012. The samples were washed with distilled water to remove any attached dust particles. The leaves and bark were then dried in the shade for 3 weeks, and the fruits were freeze-dried. Dried plant samples were ground to a fine powder using a mechanical mill and passed through a 40-micron sieve. Samples were stored in airtight containers.

- **Preparation of plant extracts**

Extracts are mixtures of secondary plant substances from any plant obtained by extracting specific parts of the plant. Crude extracts of different parts of Aegle marmelos were prepared using different solvents such as ethanol (70%), methanol (80%), and distilled water. The different methods used for extraction are:

1. **Solvent extraction:** Plant material was dissolved in 70% ethanol and 80% methanol (1: 10); 1 g of sample must be dissolved in 10 ml of solvent. The mixture was stored in the dark at room temperature for 3 days in a sterile cup wrapped in aluminum foil to prevent evaporation and sunlight. After 3 days, the mixture was filtered through Whatman filter paper No.1 and kept in a 40°C water bath until all solvent was completely evaporated from the mixture.

2. **Solvent extraction using Soxhlet apparatus:** Plant powder (10 g) was extracted sequentially with 250 ml of ethanol (70%) and methanol (80%) at 75°C and 63°C, respectively, in a Soxhlet apparatus. Extracted about 10 to 12 hours. The extract was filtered through Whatman filter paper No.1. The extract was concentrated by keeping it in a 40°C water bath until all the solvent was completely evaporated from the mixture.

Water extraction: Powdered plant material was mixed with distilled water (1:×5) and magnetically stirred overnight at room temperature in a separate container. The residue was

removed by filtration through Whatman No.1 filter paper, and the aqueous extract was lyophilized and stored in an airtight container.

All extracts were stored at -20°C in sterile containers until used for testing. At the time of testing, extracts were reconstituted in dimethyl sulfoxide (DMSO).

- **Ointment Preparation**

Table 13: Formulation of ointment.

Emulsifying wax (6 gm)	
Ingredient	**Quantity**
Cetosteryl alcohol	5.4 gm
Sodium lauryl sulphate	0.6 gm

Aegle Marmelos Ointment	
Sample	**Quantity**
1. Unripe fruit ethanol extract	-
2. Ripe fruit methanol extract using Soxhlet apparatus	-
3. Unripe fruit ethanol extract using Soxhlet apparatus	-
4. Unripe fruit methanol extracts using Soxhlet apparatus	0.4 gm
5. Mixture of all four extracts Emulsifying ointment	20 gm
6. Distilled water	6 ml

- **Preparation Of Ointment**

The base ingredients listed in Table 14 were weighed and dissolved in a beaker at 70 °C using a heating mantle. The ingredients were gently stirred while maintaining the temperature at 70°C for 5 minutes. This was cooled with constant stirring. Sufficient amount of extract was added and stirred well until a homogeneous mass was formed.

Table 14: Evaluation of ointment.

Formulations	**Color**	**Odor**	**pH**	**Inhibition Zone (mm)**
Ethanol extract from unripe fruit	Yellowish	Characteristic	6.27	-
Ethanol extract from unripe fruit using Soxhlet	Cream	Characteristic	6.13	12
Methanol extract from ripe fruit using Soxhlet	White	Characteristic	6.21	-

Methanol extract from unripe fruit using Soxhlet	Off-white	Characteristic	6.47	12.5
Mixture of all four extracts	Creamish White	Characteristic	6.35	-
Standard (Mupirocin)	White	Characteristic	6.12	15

Emulsifying Ointment (20 gm)	
Ingredient	**Quantity**
Emulsifying wax	6 gm
Soft paraffin	10 gm
Liquid paraffin	4 ml
Emulsifying Ointment (20 gm)	
Ingredient	**Quantity**
Emulsifying wax	6 gm
Soft paraffin	10 gm
Liquid paraffin	4 ml

- **Evaluation of ointment**

Preliminary evaluation of the formulation was performed as follows.

1. **Color and Odor:** The prepared ointment was visually inspected for color and odor.
2. **PH:** The pH values of different formulations were determined using a digital pH meter. One gram of ointment was dissolved in 100 ml of distilled water and stored for 2 hours. The pH value of each formulation was measured after 2 hours.
3. **Antibacterial activity of ointment:** The antibacterial activity of ointment was evaluated using well diffusion pour plate method. The ointment was dissolved in DMSO (200 mg/ml) and added to agar wells; mupirocin was also added to the wells as a standard. The plates were incubated at 37 °C for 24 h and checked for antibacterial activity.
4. **Stability Studies:** Stability studies were carried out on the prepared formulations at 37 °C for 2 months.

3. Medicinal Properties Of Bael Tree

- **Hypoglycemic/ Antidiabetic activity**

Leaf extracts are used in Ayurveda as a treatment for diabetes. It improves the body's ability to utilize external glucose loads by stimulating glucose uptake, similar to insulin. Bael extract significantly lowers blood urea and cholesterol levels in diabetic laboratory animals. This extract also showed significant reduction in the levels of lipid peroxidation, conjugated dienes and hydroperoxides, and increased levels of superoxide dismutase, catalase, glutathione peroxidase and glutathione in serum and liver in diabetic experiments. Reduces

oxidative stress in animals. The leaf juice is also used as an anti-diabetic drug in the Unani system of medicine.[17]

- **Diarrhea and Dysentery**

Unripe or semi-ripe fruits are the most effective treatment for chronic diarrhea and dysentery without fever. Use dried fruits or their powder for best results. The still-green fruit is sliced and dried in the sun. Dried fruit slices are crushed and stored in airtight bottles. The unripe fruit can also be roasted and eaten with jaggery or brown sugar. If large amounts of stool, blood, or mucus are not excreted, and there is an obvious feeling of defecation, fruits are likely to have little effect on acute dysentery. This powder medicine is especially recommended for subacute or chronic dysentery. After using fruit powder for these diseases, the blood gradually disappears and the stool becomes more of a solid form of feces.[17] Even after long-term use, the mucus disappears. It is also a valuable treatment for chronic red bowel diseases characterized by alternating diarrhea and constipation.[18,19] Its use against amoebic dysentery has also been reported.[20]

- **Constipation**

Ripe fruits are considered the best laxative. Cleanses and strengthens the intestines. Regular use for 2-3 months will also help remove old stool accumulated in the intestines. For best results, it should be taken in the form of sharbat prepared from the pulp of ripe fruits. Crack the shell, remove the seeds, scoop out the contents with a spoon, and sieve. To make it more tastier, you can add milk and sugar. The pulp of ripe fruits can also be taken with a spoon without adding milk or sugar. Approximately 60g of edible fruit for one adult is the appropriate amount.[17]

- **Respiratory infections**

A medicinal oil made from the leaves relieves recurrent colds and respiratory infections. Mix the juice extracted from the leaves with an equal amount of sesame oil, heat well, add a few grains of black pepper and half a teaspoon of black cumin to the hot oil, remove from heat and reserve as needed. Before your head bath, massage 1 teaspoon of this oil into your scalp. Regular use strengthens resistance to colds and coughs. In southern India, leaf juice is commonly administered to relieve wheezing coughs and respiratory spasms. Mix the leaf juice with warm water and a little pepper and give it as a drink.[17]

- **Peptic ulcer**

Leaf infusion is an effective treatment for stomach ulcers. Soak the leaves in water overnight. Strain this water and drink it as your morning drink. After several weeks of this treatment, the pain and discomfort will be reduced. Consumed in the form of a drink, this fruit also has excellent healing properties due to its mucus, which forms a coating on the lining of the stomach and helps heal ulcers.[21,22]

- **Anticancer Activity[1]**

Cancer is a difficult disease, and researchers are studying the potential anti-cancer properties of herbs like bael. Research on bael has shown significant anti-cancer properties through a variety of tests and has identified compounds with bioactive properties. Bael extract can modulate biological processes such as reactive oxygen species, immunity, and inflammation. Advanced imaging techniques have confirmed its anti-inflammatory and anti-angiogenic properties.

In cancer treatments such as chemotherapy and radiation therapy, it is difficult to determine the effective dose that will minimize damage to healthy cells. Rephrase Bael, especially its fruit extract, is expected to protect against genetic damage caused by chemotherapy drugs such as doxorubicin. It also appears to act as a radioprotector in mice exposed to gamma rays. Plant-based protectants containing bael are less toxic and are thought to boost immunity, potentially improving the effectiveness of cancer treatments. Despite the promising results, further research is needed to determine the optimal dosage and administration method for using bael in combination with cancer treatment.

- **Antipyretic and Analgesic activities**

Bael extract exhibits antipyretic, anti-inflammatory, and analgesic effects as it has been shown to significantly inhibit carrageenan-induced paw edema, cotton pellet granuloma, and paw itch in mice and rats.[23] It is also used as an antipyretic agent for nocturnal and intermittent fevers.[17]

SUMMARY

This comprehensive and meticulous review extensively examines the formulation and evaluation processes of diverse constituents derived from Aegle marmelos, commonly known as the Bael tree. The review serves as a comprehensive guide, delving into the multifaceted

aspects of extracting bioactive compounds from various parts of this plant, including leaves, fruits, roots, and extracts.

The review elucidates an array of extraction methods utilized to isolate bioactive components from different parts of Aegle Marmelos. Various techniques, such as solvent extraction, maceration, chromatography, and their variations, are meticulously discussed. Furthermore, the review explores the formulation strategies deployed to translate these extracts into pharmaceutical formulations or functional products.

An in-depth analysis of the chemical constituents present in Aegle marmelos components is presented. The review meticulously outlines the composition of bioactive compounds, including alkaloids, flavonoids, phenolic compounds, essential oils, and other phytochemicals. Moreover, it critically examines the pharmacological properties and therapeutic potentials of these compounds, elucidating their antioxidant, antimicrobial, anti-inflammatory, antidiabetic, and other pertinent biological activities.

CONCLUSION

In conclusion, the bael tree's medicinal and nutraceutical potential is vast and promising. A deeper understanding of its chemical constituents of different parts, taxonomical classification, cultural significance, medicinal properties, and effective formulation and evaluation methods is crucial for harnessing its therapeutic benefits. The development of bael-based products has the potential to provide natural and sustainable healthcare solutions in an era when the demand for traditional remedies and herbal supplements is on the rise.

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