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IP International Journal of Comprehensive and Advanced Pharmacology

Journal homepage: https://ijcap.in/

Original Research Article

A research on the formulation and evaluation of bael fruit herbal tea for the treatment of diabetes mellitus

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Abstract

Aim and Objective: To develop and evaluate bael-based herbal tea granules enriched with natural ingredients for diabetes management.
Introduction: Bael fruit, rich in antioxidants and bioactive compounds, may help control diabetes. Blending bael with herbs like turmeric, cinnamon, fenugreek, ginger, and orange peel enhances its therapeutic value.
Materials and Methods: Bael powder was prepared by sun drying and extraction, then mixed with selected herbs. Phytochemical analysis identified flavonoids, tannins, saponins, alkaloids, and terpenoids. The granules were tested for solubility, pH, density, ash value, and sensory properties.
Results: The herbal tea granules showed good quality, stability, and the presence of key phytochemicals with therapeutic potential.
Conclusion: Bael-based herbal tea shows promise as a natural supplement for diabetes management and health promotion.

Keywords: Bael fruit, Herbal tea, Flavonoids, Diabetes, Functional food

Received: 07-07-2025; **Accepted:** 03-11-2025; **Available Online**: 19-11-2025

1. Introduction

Tea is the world's most popular beverage, valued for its flavor, aroma, and cultural significance. Traditionally made from Camellia leaves, modern trends now favour herbal teas from other plants.[1] Herbal tea, once called tisane, is a medicinal beverage made from various plant parts like bark, flowers, herbs, seeds, and leaves, offering both flavor and health benefits.[1] Herbal teas are caffeine-free and soothing, made from herbs that promote relaxation and relieve ailments.[3] Diabetes mellitus is a major global health issue. While medications can help manage it, no cure currently exists for complete recovery.[4] In 2000, diabetes affected 2.8% of the global population, and this is projected to rise to 5.4% by 2025. Although treatments like insulin and oral antidiabetic drugs exist, they are expensive and less accessible in developing countries. Due to side effects of synthetic drugs, herbal remedies are increasingly preferred for managing diabetes.[5] Plant-based medicines are gaining importance as natural hypoglycemic agents. Over a thousand plant species are used traditionally to treat diabetes, rich in compounds like phenolics, flavonoids, and terpenoids that help lower blood sugar. Herbal remedies are favored for their effectiveness, affordability, and fewer side effects.[6]

A vital treatment for diabetes is Bael.[7] Bael has been used in Ayurvedic medicine for over 5000 years and is mentioned in ancient texts like the Yajur Veda, Ramayan, Charak Samhita, and Upvana Vinod.[8] Aegle marmelos, another name for Bael, is a member of Rutaceae family.[9] Bioactive compounds such alkaloids, tannins, flavonoids, saponins and terpenoids are abundant in the pulp of the Bael fruit.[10] Bael stimulates the pancreas and aids in the production of insulin, which regulates blood sugar levels and has antidiabetic effects.[7] Bael fruit holds nutritional, environmental, and commercial value. Every part of t

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https://doi.org/doi:10.18231/j.ijcaap.12212.1762145553

tree—stem, bark, root, leaves, fruit, and seeds—has medicinal uses, known for antidiarrheal, antidysenteric, antipyretic, and anti-inflammatory properties.[11]

The term diabetes mellitus is derived from the Latin word mellitus, which means sweet, and the Greek word diabetes, which means siphon, which means to pass through.[12] Diabetes mellitus (DM) is a chronic metabolic disorder characterized by persistently high blood glucose due to impaired insulin production, action, or both.[13]

1.1. Types of diabetes

1. **Type 1 DM (NIDDM):** It is an autoimmune disease; this type of diabetes generally occurs due to the destruction of beta cells in the pancreas where insulin is formed.[14] In type 1 diabetes, the body fails to produce insulin. Often developing before age 40, it is also called insulin-dependent or juvenile diabetes. Patients require lifelong insulin therapy, regular blood glucose monitoring, and a controlled diet.[15]

2. **Type 2 DM (NIDDM):** The body does not produce enough insulin for proper function, or the cells in the body do not react to insulin (insulin resistance). Approximately 90% of all cases of diabetes worldwide are type 2. Some people may be able to control their type 2 diabetes. However, type 2 diabetes is typically a progressive disease - it gradually gets worse - and the patient will probably end up having to take insulin, usually in tablet form. Overweight and obese people have a much higher risk of developing type 2 diabetes Compared to those with healthy body weight.[15]

3. **Gestational diabetes mellitus (GDM):** Gestational diabetes affects about 7% of pregnancies and can cause complications like macrosomia, birth trauma, cesarean delivery, and newborn metabolic issues.[16] GDM affects approximately 15% of pregnancies worldwide, accounting for approximately 18 million births annually.[17]

1.2. Symptoms and causes

1. Enhance thirst and urination
2. Increased appetite
3. Tiredness
4. Blurred vision
5. Numbness in the feet or hands
6. Aching that cannot heal
7. Unusual weight loss
8. Reduced sensitivity of peripheral tissues to insulin.[7]

2. Materials and Methods

2.1. Materials

2.1.1 Bael fruit

Bael (Aegle marmelos Corr.) is an indigenous fruit of India belongs to family Rutaceae, and it is commonly known as Bengal quince, Bilva, Indian quince, Golden apple, Stone apple. Bael is native to India and found throughout Southeast Asia.[18] It is a slow-growing sharp tree and medium in size, about 12 to 15 meter in height with short trunk, thick, soft, flaking bark, and the lower ones drooping.[19] Harvesting period is mid-April-May.[7] Bael fruit is valued in Ayurveda for treating diarrhea and supporting heart and brain health. It has antiviral, antibacterial, and hypoglycemic properties, with a hard shell and sweet, aromatic pulp.[20]

1. ***Scientific Name:*** Aegle marmelos
2. ***Family:*** Rutaceae
3. ***Kingdom:*** Plantae
4. ***Subkingdom:*** Tracheobionta
5. ***Class:*** Magnoliopsida
6. ***Division:*** Magnoliophyta
7. ***Genus:*** Aegle
8. **Species:** Aegle marmelos
9. **Common Name:** Bael fruit, Golden apple, Stone apple, Bela, Bilva[21]
10. **Phytochemical components:** alkaloids, flavonoids, tannins, coumarins, terpenoids, saponins, tannins[22]
11. **Nutrients:** water, proteins, carbs, lipids, minerals, vitamin C, calcium, phosphorus[7]

2.1.1. Cinnamon powder

The word Cinnamon, derived from the Latin term for “sweet wood,” comes from the inner bark of evergreen trees in the Lauraceae family. Widely used in cooking and herbal medicine, it is native to South India, Sri Lanka, China, and Indonesia.[23] Cinnamon possesses antibacterial, antifungal, anti-inflammatory, analgesic, antioxidant, antithrombotic, antidiabetic properties, Cinnamon reduces dental plaque, and other functions.[24] Cinnamon, derived from tree bark, is a nutrient-rich spice widely used worldwide. Valued for its distinct flavor and aroma, it has long been used both as a food enhancer and an herbal remedy.[25]

1. ***Scientific Name:*** Cinnamomum zeylanicum
2. ***Family:*** Lauraceae
3. ***Kingdom:*** Plantae
4. ***Sub-kingdom:*** Viridiplantae[26]
5. ***Class:*** Magnoliopsida
6. ***Division:*** Tracheophyta
7. **Genus:** Cinnamomum
8. ***Species:*** Cinnamomum verum J. Presl
9. ***Common Name:*** Cinnamon bark, Kalmi-dalchini, Ceylon cinnamon[27]
10. Phytochemical components: cinnamaldehyde, flavonoids, phenolic compounds, tannins, saponins, and terpenoid[27]
11. Nutrients: It provides a valuable source of energy, carbohydrates, and vitamins, and Minerals[25]

2.1.2. Turmeric powder

Turmeric (Curcuma longa) is a rhizomatous plant from the ginger family, Zingiberaceae, valued for its culinary uses and medical significance.[28] Turmeric (Curcuma longa) naturally grows in South Asian forests, including India, Indonesia, and Indochina, and is also found in nearby Asian regions and some Pacific islands like Hawaii.[29] Turmeric has antidiabetic, antimicrobial, anticancer, antioxidant, and anti-inflammatory properties and helps manage heart diseases, indigestion, ulcers, and IBS.[30]

1. **Scientific name**: Curcuma longa
2. **Family:** Zingiberaceae
3. **Kingdom:** Plantae
4. **Subkingdom:** Tracheobionta - Vascular flora
5. **Class:** Lilliopsida – monocots
6. **Division:** Magnoliophyta – flowering plants
7. **Genus:** Curcuma L. – turmeric
8. **Species:** Curcuma longa L
9. **Common Name:** haldi, Indian saffron, halad
10. **Phytochemical components:** alkaloids, terpenoids, flavonoids, steroids, saponins, tannins, phenols, glycosides
11. **Nutrients:** carbohydrates, proteins, dietary fiber, as well as vitamins and minerals

2.1.2. Ginger Powder

Ginger belongs to the same plant family as turmeric and cardamom. Southeast Asia is where ginger originated. It has long been prized for its culinary, medicinal, and aromatic qualities and is mentioned in ancient Chinese, Indian, and Middle Eastern periodicals. It exhibits characteristics such as radioprotective Antioxidant, Antiviral, Anticancer, Antidiabetic, Antihypertensive, Antimicrobial, and Antiallergic.

1. **Scientific name:** Zingiber Officinale
2. **Family:** Zingiberaceae
3. **Kingdom:** Plantae
4. **Subkingdom:** Tracheobionta
5. **Division:** Magnoliophyta
6. **Class:** Liliopsida-Monocotyledons
7. **Genus:** Zingiber P. Mill
8. **Species:** Zingiberofficinale Roscoe
9. **Common Name:** Gingerin, Rhizoma zingiberis, zingibere, Ginger Officinale
10. **Phytoconstituents:** Phenolic compounds, flavonoids, alkaloids, glycosides, saponins, steroids,
11. terpenoids, tannins
12. **Nutrients:** Proteins, carbohydrates, fats, vitamins, minerals.

2.1.3. Fenugreek powder

Fenugreek (Trigonella foenum-graecum L.) is a fragrant medicinal plant rich in phytochemicals, long used in Ayurvedic, Chinese, and Tibetan medicine. Grown widely across Asia and the Mediterranean, it's commonly used as a spice in Indian cuisine. It offers health benefits like anticancer, antioxidant, cholesterol-lowering, blood sugar–reducing, and antifungal effects.

1. **Scientific name:** Trigonella foenum-graecum L
2. **Family:** Fabaceae
3. **Kingdom:** Plantae
4. **Subkingdom:** Tracheobionta
5. **Class:** Magnoliophyta
6. **Division:** Magnoliophyta
7. **Genus:** Trigonella
8. **Species:** T fornum-graecum
9. **Synonyms:** Meti, methi, kasuri methi, fenugreek
10. **Phytoconstituents**: Flavonoids, volatile oils, alkaloids
11. **Nutrients**: Vitamin, minerals

2.1.4. Orange peel powder

Orange peels are often left-over during fruit processing, but research shows they're actually a rich source of beneficial bioactive compounds. Each year, a significant quantity of waste by-products from oranges, such as peels, is produced. India produces about 2.5 million tonnes of oranges each year, mainly in Punjab, Madhya Pradesh, Andhra Pradesh, Maharashtra, Rajasthan, Assam, and Karnataka. It is utilized for its ability to function as an antidiabetic, antimicrobial, and antifungal agent.

1. *Scientific name:* Citrus sinensis
2. *Family:* Rutaceae
3. *Kingdom:* Plantae
4. *Subkingdom:* Tracheobionta
5. *Class:* Magnoliophyta
6. *Division:* Magnoliophyte
7. *Genus:* Citrus*Species:* Citrus sinensis

8. *Synonyms:* Mosambi, Nembu, Musambi
9. *Phytoconstituents:* Flavonoids, steroids, terpenoids, alkanes, ethyl ester.
10. Nutrients: calcium, Magnesium, zinc, Phosphorus, Potassium, Vit B1, Vit B2, Vit B3, Vit B6

2.2. Preformulation test for bael fruit extract

2.2.1. Phytochemical screening test

A. Test for alkaloids

1. **Dragendorff's Test**: The extract was treated with Dragendroff's reagent (potassium bismuth iodide solution). An orange precipitate was formed, indicating the presence of alkaloids.
2. **Wagner's Test**: The extract was treated with Wagner's reagent (saturated picric acid solution). A reddish-brown precipitate was formed, indicating the presence of alkaloids.
3. **c. Mayer's Test**: The extract was treated with Mayer's reagent. A coloured precipitate was formed, indicating the presence of alkaloids.
4. **Hager's Test**: The extract was treated with Hager's reagent (iodine-potassium solution). A bright yellow precipitate was formed, indicating the presence of alkaloids.

B. Test for flavonoid's

1. Lead acetate test: Two ml of the test solution were mixed with a few drops of 10% lead acetate solution. A yellow precipitate was formed, confirming the presence of flavonoids.
2. Alkaline reagent test: One ml of the test solution was treated with 1N sodium hydroxide solution followed by a few drops of dilute acid. The formation of a yellow precipitate indicated the presence of flavonoids.
3. C. Test for Terpenoid's
4. Salkowski test: The extract war was treated with chloroform and sulfuric acid. The formation of red brown colour indicate presence of terpenoids.

D. Test for tannin's

1. *Ferric chloride test:* 2ml of test solution was treated with few drops of 10%ferric chloride solution. The formation of deep blue solution indicates the presence of tannins.
2. *Iodine solution test:* 2ml of test solution was treated with few drops of diluted iodine solution. Formation of red colour indicate the presence of tannins.

E. Test for Saponin's

Foam test: The extract was treated with water and Shaked vigorously. Formation of foam indicates the presence of saponins.

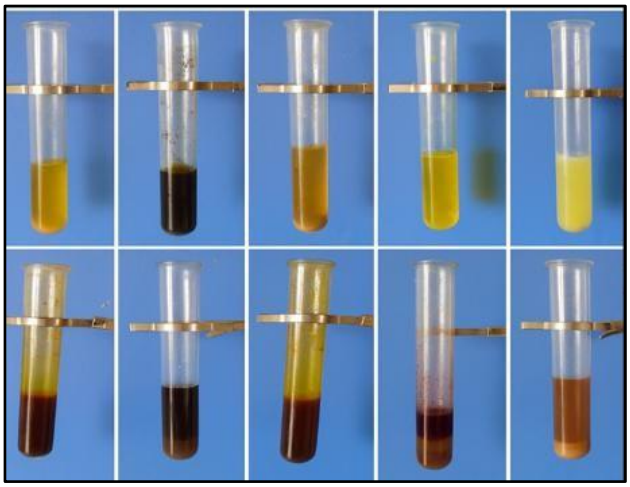

Figure 1: Phytochemical tests

2.3. Method of preparation

2.3.1. Collection of plant

For formulating herbal antidiabetic tea granules, Bael Fruit was collected from farms and surrounding area of satara (Maharashtra).

2.3.2. Preparation of powder (Fig 2)

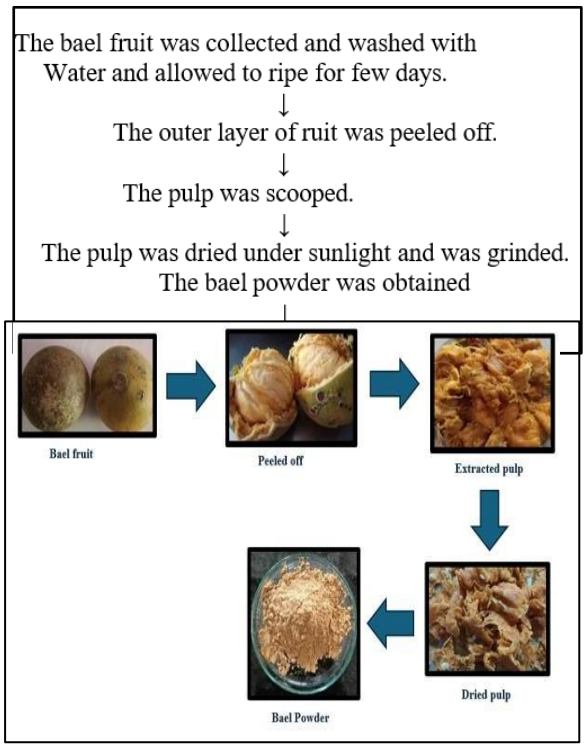

Figure 2: Preparation of bael powder

*Process of extraction***.** The obtained powder is then added into 100ml hot water for a specific time and then filtered, extract is obtained.

2.3.3. List of Ingredients (Table 1)

Table 1: list of ingredients

SR. NO.	Ingredient	Quantity	Role
1	Bael Fruit powder (Active Ingredient)	15g	Regulate blood sugar level
2	Cinnamon Powder	5g	Improve insulin sensitivity
3	Fenugreek powder	5g	Rich in fiber, Insulin mimitic property
4	Turmeric powder	5g	Antioxidant, insulin sensitivity
5	Ginger powder	5g	Anti-inflammatory
6	Orange peel powder	2.5g	Vit C, flavor
7	Guargum	2.5g	Binder
8	Maize starch	5g	Disintegrant
9	Glycerine	1g	Moisturizing agent
10	Water	q. s	Granulating agent
11	Mg sterate	2g	Lubricant
12	Liqurose	2g	Sweeter

2.3.4. Preparation of herbal tea granules (Fig 3)

Mix all the dry powders, extract and dry ingredients.
↓
Add moisturizer (glycerine), gradually incorporate granulating fluid while mixing to achieve the desired consistency.
↓
Add the disintegrating agent (maize starch) to ensure effective dissolution.
↓
Add lubricant to improve flow property.
↓
Pass the mixture through the sieve, allow granules to sun dry.
↓
The required herbal tea granules are obtained.

Figure 3: Herbal tea granules

2.4. Evaluation test

2.4.1. Totalash value

Accurately weigh approximately 2 grams of the powdered drug into a pre-weighed (tarred) silica crucible. Incinerate the sample at a temperature not exceeding 450 °C for 4 hours or until all carbon is completely removed. Allow the crucible to cool and then weigh it.

% Total Ash Value = Wt of total ash ÷ Wt of crude drug taken = 7.5

2.4.2. Water soluble ash value

The total ash was boiled with 25 ml of water, then filtered. The water-insoluble residue was collected on ashless filter paper, washed thoroughly with hot water, and transferred to a pre-weighed (tarred) crucible. This was then ignited at a temperature not exceeding 450 °C for 4 hours. After cooling in a desiccator, the residue was weighed.

Water soluble ash value = Wt of total ash- Wt of water insoluble ash ÷ Wt of crude drug taken *100 = 3.75

2.4.3. Bulk density (gm/ml) 2

Bulk volume in ml
Mass of granules in grams
Bulk density = Mass
Bulk Volume=0.7gm/ml^2

2.4.4. Tapped density (gm/ml) 2

Tapped volume in ml.
Mass of granules in gram
Tapped density = Mass÷Tapped volume=30gm/ml^2

2.4.5. Angle of repose

Height of pile in cm
Average radius of circle in cm
Angle of repose(ɵ)=tan-1(h/r)=26.5

2.4.6. PH determination test

Dissolve 1g of granules in 10 ml distilled water and measure PH using a calibrated PH meter.

The PH of herbal antidiabetic tea was found to be = 5.2

2.4.7. Solubility test (Fig 4)

Dissolve 1g of granules in 40 ml water.

2.5. Organoleptic test: (Table 2)

Organoleptic study is basic study to identify and evaluate the quality of the Product. Prepared herbal tea has reported the following parameters like colour, Odour and taste.

Table 2: Organoleptic test

Sr. No	Organoleptic character	Result
1	Colour	Yellowish brown
2	Odour	Aromatic
3	Taste	Sweet and spicy

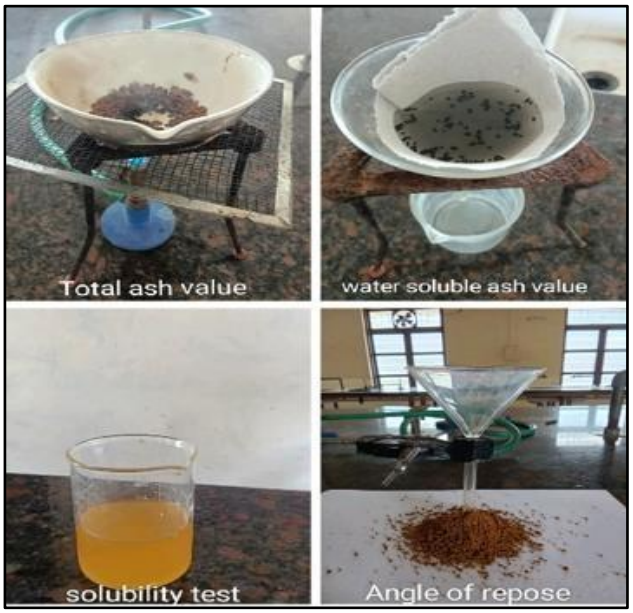

Figure 4: Evaluation tes

3. Results

3.1. Phytochemical screening test for bael fruit

3.1.1. Test for alkaloids

1. Dragendorff's Test: The appearance of an orange precipitate showed the presence of alkaloids.
2. Wagner's Test: A reddish-brown precipitate confirmed the presence of alkaloids.
3. Mayer's Test: Formation of a coloured precipitate indicated alkaloids in the extract.
4. Hager's Test: A bright yellow precipitate confirmed the presence of alkaloids.

3.1.2. Test for flavonoids

1. **Lead acetate test:** Formation of a yellow precipitate confirmed the presence of flavonoids.
2. **Alkalinereagent test:** Formation of yellow precipitate confirmed the presence of flavonoids.

3.1.3. Test for terpenoids

Salkowski test: Formation of red brown colour confirmed the presence of terpenoids.

3.1.4 Test for tannins

1. Ferric chloride Test: Formation of deep blue colour confirmed the presence of tannins.
2. Iodine solution test: Formation of red colour confirmed the presence of tannins.

3.1.5. Test for saponins

Foam test: Formation of foam confirmed the presence of saponins.

3.1.6. Evaluation test (Table 3)

Table 3: Evaluation test

Sr. No.	Parameter	Result
1	Total ash value	7.5%
2	Water soluble ash value	3.75%
3	Bulk density	0.7 gm/ml^2
4	Tapped density	30 gm/ml^2
5	Angle of repose	26.5
6	PH determination	5.2
7	Solubility	soluble

3.1.7. Organoleptic tests (Table 4)

Table 4: Organoleptic test

Sr. No	Organoleptic Characters	Results
1.	Colour	Yellowish brown
2.	Odour	Aromatic
3.	Taste	Sweet and spicy

4. Discussion

The development of herbal tea granules incorporating Bael fruit extract along with complementary medicinal herbs offers a promising natural approach for managing diabetes. The phytochemical screening of Bael fruit confirmed the presence of key bioactive constituents such as alkaloids, flavonoids, tannins, and terpenoids, which are well-documented for their hypoglycemic and antioxidant properties. These compounds are believed to stimulate pancreatic activity and improve insulin secretion, aligning with traditional uses of Bael in Ayurvedic medicine. The bael fruit pulp was dried and grinded and the powder was made, then the extract was formed. The combination of other herbs like cinnamon, fenugreek, turmeric, ginger, and orange peel adds to the therapeutic potential, as each has demonstrated antidiabetic, anti-inflammatory, and antioxidant effects in

various studies. The combination aimed at harnessing synergistic effects, potentially enhancing the overall efficacy of the herbal tea. The physical evaluation parameters, including total ash value, water-soluble ash, bulk density, tapped density, and angle of repose, indicated that the granules possessed suitable physicochemical properties for oral administration, ensuring proper flow, disintegration, and dissolution. The pH measurement of the herbal tea granules (pH 5.2) suggests that the formulation is mildly acidic, aligning well with the typical pH range suitable for consumption without causing gastrointestinal discomfort. Organoleptic properties yellowish-brown color, aromatic smell, and sweet-spicy taste enhance patient acceptability, which is crucial for adherence in herbal therapies. The sensory attributes, along with appropriate physical properties, make the formulation suitable for regular use. The solubility test demonstrated that the granules dissolve adequately in water, indicating good bioavailability of the active constituents. Additionally, the moisture content and other physical parameters suggest the formulation's stability and suitability for storage. The formulation of herbal tea granules containing Bael fruit extract and other medicinal herbs appears promising as a natural, cost-effective, and accessible approach for managing blood glucose levels in diabetic patients.

5. Conclusion

Herbal antidiabetic tea granules made from bael fruit (Aegle marmelos) present a natural and promising option for blood sugar regulation. They are abundant in bioactive substances like antioxidants, flavonoids, and phenolics, which possess hypoglycemic effects that may enhance glucose metabolism and aid in diabetes management. Traditional usage combined with scientific findings indicates that bael fruit could help alleviate diabetic symptoms and improve overall health. The various phytochemical tests prove the presence of alkaloids, flavonoids, tannins, terpenoid, saponins and evaluation test were performed to know about purity and quality of herbal tea granules. In summary, bael fruit-based herbal tea granules can be a beneficial complementary supplement for those looking to naturally support their diabetic health.

6. Source of Funding

None.

7. Conflict of Interest

None.

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Cite this article: Pisal SD, Jawal DT, Pawar RK. A research on the formulation and evaluation of bael fruit herbal tea for the treatment of diabetes mellitus. *IP Int J Compr Adv Pharmacol*. 2025;10(3):169-176.