

Original Research

Formulation and Evaluation of an Antioxidant Rich Food Product Using Nutrient Dense Bael Fruit Extract

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Abstract

Bael fruit (*Aegle marmelos*), native to the Indian subcontinent, is well known for its rich nutritional and medicinal value. It contains important bioactive compounds such as phenolics and flavonoids, which possess strong antioxidant properties. These antioxidants help in neutralizing free radicals and reducing oxidative stress, thereby contributing to better health. The aim of this study is to formulate and evaluate an antioxidant-rich food product using nutrient-dense bael fruit extract. Bael fruit was chosen for this study because it is a natural, underutilized fruit with high antioxidant potential and significant health benefits. Incorporating bael fruit extract into a food product can enhance its nutritional quality and functional value. The expected outcome of this study is the development of a nutritious food product with improved antioxidant properties and good acceptability. This study highlights the potential use of bael fruit as a natural ingredient for developing healthy, antioxidant-rich functional food products.

Keywords: Bael fruit , Antioxidants , Functional food , Phytochemicals

1. Introduction

Bael fruit, (botanical name: *Aegle marmelos*) also known as bael, Bengal quince, stone apple or golden apple is an important tropical fruit tree that is native to Indian subcontinent and widely cultivated throughout many regions of South and Southeast Asia. What it is, is a member of the Rutaceae family of plants which includes many familiar citrus fruits including oranges, lemons, and limes. Its high nutritional value, medicinal importance, ecological adaptability and cultural relevance has made it well-known to mankind for thousands of years. Geographic Distribution: Historical census studies suggest that the bael tree has been cultivated in India from ancient times and it is one of the most valuable indigenous fruit species of Indian origin. It grows widely in tropical and subtropical climatic conditions where temperature and rainfall favors the growth of plant. The bael tree has caught the attention of agricultural scientists, nutritionists and traditional medicine practitioners because of its impressive resilience and it can grow in a variety of environmental condition. And not only for the edible pulp, but also because of its medicinal properties which have been mentioned in traditional literature and scientific researches. {} Bael fruit is widely valued not just for its nutrition but also for its healing properties, making it an important functional food that supports overall health and well-being.(1).

The bael tree itself is a medium-sized deciduous tree, typically growing between 10 and 18 meters tall, though it can become even taller under ideal conditions. It has a sturdy trunk and a wide, spreading crown that creates a dense canopy. The bark is usually rough and ranges from gray to brown, often developing cracks as the tree matures. Its branches are slender and sometimes bear sharp thorns, which help protect the tree from animals. The bael tree is well known for its remarkable ability to survive in harsh environmental conditions. Unlike many fruit trees that need fertile soil and regular watering, it can grow in poor soils with very little water. It is highly tolerant of drought, extreme heat, and even saline or alkaline soils. This adaptability makes it especially suitable for dry and semi-arid regions where other fruit crops may fail. Due to its low maintenance needs and resilience, the bael tree is commonly planted in rural areas, along roadsides, in temple grounds, and on community lands, where it provides both ecological and economic benefits.(2).

The leaves of the bael tree are trifoliate, meaning each leaf consists of three leaflets attached to a single stalk (petiole). These leaflets are usually oval or lance-shaped, with smooth surfaces and

slightly pointed tips. When crushed, the leaves release a pleasant aroma due to the presence of volatile oils. These compounds enhance the plant's medicinal value and are believed to possess antimicrobial and therapeutic properties. During the flowering season, the bael tree produces clusters of small, greenish-white or pale yellow flowers. These mildly fragrant flowers attract pollinators such as bees and butterflies, which play a crucial role in pollination and fruit formation, ensuring the continuation of the species. The fruit of the bael tree is round to slightly oval and is covered with a hard, woody outer shell. This tough shell protects the inner pulp from physical damage and microbial contamination. Depending on the variety and growing conditions, the fruit typically ranges from about 5 to 20 centimeters in diameter. As it matures, the shell changes color from green to yellowish or light brown. Inside, the fruit contains a soft, aromatic pulp that varies from yellow to deep orange.

The pulp is filled with numerous small seeds embedded in a sticky, mucilaginous substance, giving the fruit its distinctive texture.(3). The pulp of the bael fruit is highly valued for its rich nutritional content and health-promoting properties. It contains a wide range of essential nutrients that support the proper functioning of the human body. One of the key nutrients present in bael fruit is vitamin C, which helps strengthen the immune system and protects the body against infections. It also plays an important role in collagen synthesis, which is essential for maintaining healthy skin, connective tissues, and blood vessels. Bael fruit is also a good source of vitamin A, which supports healthy vision and enhances immune function. In addition, it contains important B-complex vitamins such as riboflavin and niacin, which are crucial for energy metabolism and the proper functioning of the nervous system. These vitamins make bael fruit a valuable part of a balanced diet. Apart from vitamins, bael fruit is rich in essential minerals like calcium, phosphorus, potassium, and iron. Calcium and phosphorus are important for strong bones and teeth, while potassium helps regulate blood pressure and supports proper muscle and nerve function. Iron is essential for the formation of hemoglobin in red blood cells, which carries oxygen throughout the body. The combined presence of these nutrients enhances the overall nutritional value of bael fruit, making it highly beneficial for maintaining good health(4).

OBJECTIVES

To standardize the formulation of bael based food products to achieve optimum taste, texture, colour and consistency

To assess the sensory acceptability of the developed products using a trained or consumer panel.

To evaluate the shelf life stability of the bael incorporated products under different storage

conditions.

2. REVIEW OF LITERATURE

The literature pertaining to the thesis entitled “Formulation and Evaluation of an Antioxidant Rich Food Product Using Nutrient Dense Bael Fruit Extract” is discussed.

Bael fruit (*Aegle marmelos*), commonly known as wood apple, is a highly valued fruit native to the Indian subcontinent and has been widely used in traditional medicinal systems such as Ayurveda for centuries. The fruit is known for its remarkable nutritional and therapeutic properties. It contains essential nutrients such as carbohydrates, proteins, vitamins, and minerals that contribute to its health-promoting benefits. Due to its medicinal importance and nutritional richness, bael fruit has attracted significant attention in recent years for its potential use in the development of functional and health-promoting food products. [Sharma, P., et al., 2022]

3. METHODOLOGY

3.1 Selection of Functional Ingredients

Bael fruit (*Aegle marmelos*) was selected as the functional ingredient for the present study due to its high nutritional value and rich antioxidant properties. Fresh and mature bael fruits were selected, ensuring they were free from damage, spoilage, and contamination. The fruits were initially dried under sunlight and then further dried at room temperature to remove residual moisture. The completely dried bael fruit was then ground into a fine powder and used for product formulation.

3.1 Place of Collection

The bael fruits required for the study were collected from the local markets of sattu.

3.2 Other Ingredients

The other ingredients required for cake preparation such as wheat flour, sugar, vinegar, milk, baking powder, baking soda, vegetable oil, vanilla extract, and salt were purchased from the local markets of Kovilpatti. All ingredients used were of good quality and free from contamination to ensure the safety and acceptability of the final product.

3.3 Preparation of Bael Fruit Powder

The bael fruits were washed thoroughly under running water to remove dirt and impurities. The cleaned fruits were then cut and the pulp was separated. Dehydration is the process of removing moisture from the food material. In this study, sun drying was used as the primary method of

dehydration. The bael fruit pieces were spread evenly and dried under sunlight for two days.

After sun drying, the samples were kept at room temperature to ensure complete removal of residual moisture. Once fully dried, the bael fruit pieces were ground using a mixer grinder to obtain a fine powder. The powder was then sieved to ensure uniform particle size. The prepared bael fruit powder was stored in an airtight container and kept in a cool, dry place for further use and analysis.

3.4 Analysis of Phytochemicals Present in Bael Fruit Powder

The extract of bael fruit powder was prepared by dissolving 10 g of the sample in 100ml of 80% ethanol. The mixture was kept under a flame for 30 minutes. Then the mixture was filtered. The filtrate is considered as extract. This extract was used for further phytochemical analysis.

3.4.1 Test for Saponins (Foam Test)

A volume of 2 ml of the extract was mixed with 2 ml of distilled water and shaken thoroughly. Subsequently, 1 ml of olive oil was added. The formation of a stable foam indicates the presence of saponins.

3.4.2 Test for Flavonoids (Lead Acetate Test)

To 3 ml of the extract, a few drops of lead acetate solution were added. The formation of a yellow precipitate confirms the presence of flavonoids.

3.4.3 Test for Steroids

To 2 ml of the extract, chloroform was added, followed by the careful addition of 2 ml of concentrated sulphuric acid along the sides of the test tube. The appearance of a characteristic color change indicates the presence of steroids.

3.4.4 Test for Tannins (Ferric Chloride Test)

A volume of 1 ml of the extract was treated with 2 ml of 5% ferric chloride solution. The development of a dark blue or greenish-black coloration indicates the presence of tannins.

3.4.5 Test for Terpenoids

To 2 ml of the extract, a few drops of copper acetate solution were added. The formation of a deep bluish-green color confirms the presence of terpenoids.

3.4.6 Test for Phenolic Compounds

A volume of 2 ml of the extract was treated with 5% ferric chloride solution. The formation of a deep blue color indicates the presence of phenolic compounds.

3.4.7 Test for Glycosides

To 2 ml of the extract, glacial acetic acid and a few drops of ferric chloride were added. The

formation of a brown ring indicates the presence of glycoside

3.5 Development and Standardization of Bael Powder Incorporated Cake

The prepared bael fruit powder was incorporated into cake formulation at three different levels, namely 1 g, 2 g, and 3 g. The standard cake formulation was prepared using wheat flour (100 g), milk (20 ml), vanilla essence (2 ml), baking soda (1 g), baking powder (1 g), vegetable oil (30 ml), sugar (60 g) and vinegar (5 ml). These are clearly illustrated in the table 1.

Table: 1 Standardization of Bael Powder Incorporated Cake

Formulation of Bael Powder Incorporated Cake

INGREDIENTS	CONTROL	SAMPLE A	SAMPLE B	SAMPLE C
Bael powder	—	1 g	2 g	3 g
Wheat flour	100 g	100 g	100 g	100 g
Sugar	60 g	60 g	60 g	60 g
Milk	20 ml	20 ml	20 ml	20 ml
Vanilla essence	2 ml	2 ml	2 ml	2 ml
Baking soda	1 g	1 g	1 g	1 g
Baking powder	1 g	1 g	1 g	1 g
Vegetable oil	30 ml	30 ml	30 ml	30 ml
Vinegar	5 ml	5 ml	5 ml	5 ml

The bael powder was added to the cake mixture in the above-mentioned proportions, and the batter was mixed thoroughly to ensure uniform distribution. The prepared batter was then poured into a suitable container and baked using a microwave oven.

Sensory evaluation was carried out by a panel of 6 members to assess attributes such as taste, texture, color, flavor, and overall acceptability. Sensory evaluation is a scientific method that uses human senses to evaluate the quality and acceptability of food products.

Plate 1 Prepared bael fruit powder incorporated cake



3.6 Sensory Evaluation of Bael Powder Incorporated Cake

Sensory evaluation refers to the assessment of food quality using human senses such as taste, smell, vision, and touch. It is a useful method to evaluate the acceptability of newly developed food products.

The sensory attributes of the bael powder incorporated cake were evaluated by a panel of 6 judges. The cake samples prepared with different concentrations of bael powder (1 g, 2 g, and 3 g) were assessed. A hedonic scale was used to assign scores for parameters such as colour, flavour, texture, taste, and overall acceptability.

The average (mean) scores for all the sensory attributes were calculated to identify the most acceptable sample. This evaluation helped in determining the best formulation with desirable sensory qualities and higher consumer acceptability.

4. Results And Discussion

4.1. Analysis of Phytochemicals in Bael Fruit powder

Phytochemicals are naturally occurring chemical compounds present in plants, produced through primary and secondary metabolism. These compounds play an important role in plant defense and also provide several health benefits to humans.

Table 2 : Analysis of Phytochemicals in Bael Fruit

Analysis of Phytochemicals in Bael Fruit

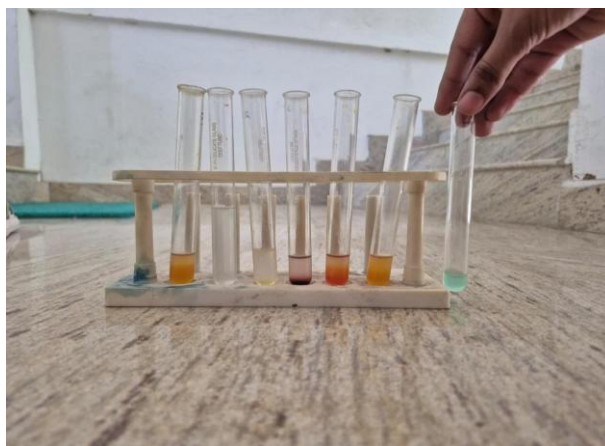
Phytoconstituents	Result
Phenols	+
Saponins	+
Tannins	+
Glycosides	+
Flavonoids	+
Terpenoids	+
Steroids	+

The results of the present study indicate that bael fruit powder contains several important phytochemicals such as saponins, glycosides, flavonoids, terpenoids, steroids, phenol and tannin.

The presence of flavonoids suggests antioxidant activity, which helps in reducing oxidative stress and protecting the body from harmful free radicals. Saponins and terpenoids are known for their antimicrobial and anti-inflammatory properties, contributing to the therapeutic value of the fruit. Glycosides and steroids also play a role in supporting various physiological functions. While Phenols and tannins are known for their astringent and anti-oxidant properties.

The findings of this study are partially consistent with previous research, which reported the presence of multiple phytochemicals in bael fruit. The picture1 shows the phytochemical analysis carried out for bael fruit powder.

PICTURE 1: Phytochemical analysis of bael powder



4.2. Sensory Evaluation of Bael Incorporated Product

The developed bael-based food product was evaluated for its sensory characteristics such as appearance, colour, flavour, taste, texture, and overall acceptability. The sensory evaluation was

TABLE 3: Sensory evaluation of bael powder incorporated cake

PARAMETERS	CONTROL	SAMPLE A	SAMPLE B	SAMPLE C
COLOUR AND APPEARANCE	4.7 ± 0.40	4.4 ± 0.45	3.6 ± 0.50	2.8 ± 0.55
TASTE	4.8 ± 0.35	4.5 ± 0.42	3.7 ± 0.48	2.7 ± 0.60
TEXTURE	4.6 ± 0.38	4.2 ± 0.50	3.5 ± 0.52	2.6 ± 0.58
FLAVOUR	4.9 ± 0.30	4.6 ± 0.40	3.8 ± 0.45	2.9 ± 0.50
OVERALL ACCEPTABILITY	4.8 ± 0.42	4.3 ± 0.46	3.6 ± 0.49	2.7 ± 0.57

conducted using a panel of judges, and the results indicated that the bael-incorporated product was acceptable. Among the different formulations, the selected sample showed better overall acceptability in terms of taste and texture. The incorporation of bael extract improved both the nutritional value of the product. Thus, the study confirms that bael fruit can be successfully used in the development of antioxidant-rich, value-added food products with good consumer acceptance.

Table 3 shows the mean score of colour, flavour, texture, taste, and overall acceptability of the Bael powder incorporated cake in the proportion of 1g, 2g and 3g.

Figure :1 Sensory evaluation of bael powder incorporated cake

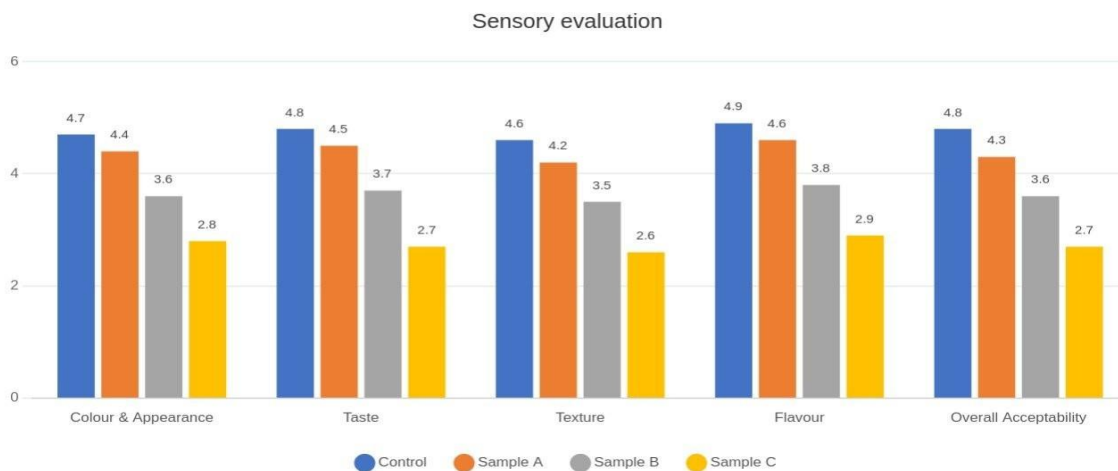


Table 3 and Figure 1 show the mean scores of the selected bael incorporated product. The evaluation of organoleptic attributes such as colour, taste, texture, flavour, and overall acceptability of the bael incorporated product revealed that Sample A showed better acceptability compared to the other variations. Sample A recorded a higher mean score (around 4.3 ± 0.46), indicating good sensory quality, whereas Sample B showed moderate acceptability and Sample C showed low acceptability.

4. Summary And Conclusion

The present study titled “Formulation and Evaluation of an Antioxidant-Rich Food Product Using Nutrient-Dense Bael (*Aegle marmelos*) Fruit Extract” was carried out to develop a value-added food product and evaluate its nutritional and sensory qualities.

- Bael fruit was selected for the study due to its rich nutritional composition, antioxidant activity and medicinal importance.
- Phytochemical analysis was performed to identify the presence of bioactive compounds in bael fruit extract.
- The results showed the presence of saponins, glycosides, flavonoids, terpenoids, steroids, phenols,

and tannins.

➤ These phytochemicals are responsible for antioxidant, antimicrobial, and anti-inflammatory activities.

➤ A value-added bakery product, bael cake, was developed by incorporating bael powder in different quantities.

➤ Three formulations were prepared for comparison:

Sample A (1 g bael powder)

• Sample B (2 g bael powder)

• Sample C (3 g bael powder)

➤ The developed products were subjected to sensory evaluation using parameters such as appearance, colour, flavour, taste, texture, and overall acceptability.

➤ The evaluation was carried out by a panel of judges to assess consumer acceptability.

➤ Sample A (1 g) showed the highest acceptability, with desirable taste, soft texture, and pleasant flavour.

➤ Sample B (2 g) showed moderate acceptability but had slight changes in flavour and texture.

➤ Sample C (3 g) showed low acceptability due to stronger flavour and less desirable texture.

➤ The increase in bael powder concentration affected the organoleptic properties of the cake.

➤ The study indicates that optimum level of incorporation is important to maintain product quality.

➤ Value addition of bael fruit helps in increasing its utilization and consumer acceptance.

➤ The developed product can be considered as a healthy alternative to conventional bakery products.

CONCLUSION

Bael fruit is a nutritionally rich and medicinally important fruit that can be effectively utilized in the development of value-added food products. Present study confirms that bael fruit contains beneficial phytochemicals that contribute to its antioxidant and therapeutic properties. The preparation of bael cake demonstrates that bael powder can be incorporated into bakery products. Among the different formulations, Sample A (1 g) showed the highest acceptability in terms of taste, texture, and overall quality, while higher concentrations (2 g and 3 g) reduced consumer

acceptance. Thus, it can be concluded that optimum incorporation of bael powder is essential to maintain both nutritional benefits and sensory quality. Bael-based products have good potential as functional foods that can contribute to improved health and nutrition.

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