International Journal of Pharmacy and Herbal Technology (Online)

Home Page: https://www.ijprdjournal.com/

FORMULATION AND EVALUATION OF DIABETIC TOFFEE FROM THE BAEL FRUIT [AGEL MARMELOS]

Pratiksha Shrikant Yelpale, * Yogesh Raut, Sanjay K. Bais

Fabtech College of Pharmacy, Sangola

Tal-Sangola, Dist.-Solapur

Maharashtra -413307

ABSTRACT

The Bael fruit tree, or Bael (Aegle marmelos (Linn), belongs to the Rutacae family and is a moderately large, slender, fragrant tree. Many medical conditions may be treated using the various elements of Bael, including diabetes, asthma, anemia, fractures, healing of wounds, swollen joints, high blood pressure, jaundice, diarrhea, typhoid, problems during pregnancy, and healthy mind and brain. Beta-carotene, protein, riboflavin, and vitamin C are just a few of the elements that bael fruits are packed with. Rich in calcium, potassium, fiber, healthy fats, thiamine, riboflavin, niacin, and carotene. These fruits have long been used for their medicinal and therapeutic qualities in Ayurveda, Siddha, and other complementary and alternative medicine systems. They are also well-known for their laxative, antioxidant, and anti-inflammatory qualities. Aegle marmelos has been utilized in the Ayurvedic, Unani, and Siddha medical systems of India, Bangladesh, and Sri Lanka as an herbal remedy for the treatment of diabetes mellitus. The components of this tree are mostly used for medicinal purposes. The unripe dried fruit has stomachic, astringent, and digestive properties

Keywords: *Diabetic-Friendly, Confectionery, Natural Sweeteners, Functional Foods, Nutraceuticals, Traditional Medicine, Antidiabetic Properties, Health Benefits*

*Corresponding Author Email: - pratikshayelpaleftc.@gmail.com

Received on 06 July, 2024, Accepted 15 July, 2024

Please cite this article as: Yelpale Pratiksha et. Formulation and Evaluation of Diabetic Toffee from the Bael Fruit [Agel Marmelos]
International Journal of Pharmacy And Herbal Technology 2024.

INTRODUCTION

The fruit Aegle marmelos, also referred to as Bael, is a native of the Indian subcontinent, which encompasses Bangladesh, Thailand, Nepal, India, and Sri Lanka. It is an unappreciated fruit. It is a moderately large deciduous tree of the Rosaceae genus. It is a subtropical plant that can be cultivated anywhere in the world and is tolerant of a variety of environments. In general, the plant can grow up to 1200 meters above sea level, but in Nepal, reports have shown that trees may reach up to 1500 meters, extending from the hills to the Terai area. It is also very adaptable to a variety of harsh environments and soil types. It can withstand temperatures between 7 to 48 degrees Celsius, and it thrives in sandy, alkaline swamps.[1]

The growing awareness among health-conscious consumers about the role of diet on human well-being has drawn attention to the consumption of functional foods and nutraceuticals, prompting researchers to investigate the functional properties of various underutilized plants. As a result, various fruits with nutritional and medicinal properties have been introduced as suitable ingredients for the food processing industry. The presence of fibers, polyphenols, carotenoids, terpenoids, flavonoids, alkaloids, and coumarins, in the plant, shows numerous health benefits, namely, antimicrobial, antioxidant, antidiarrheal, antidiabetic, ant ulcerative, cardioprotective, anticancer, gastroprotective, and hepatoprotective effects. Although the most valuable and consumable part of the tree is its fruits, leaves, stems, bark, and roots are also utilized in the Ayurveda system of medicine to cure a variety of human ailments.[2]

In addition to its culinary and therapeutic uses, it has cultural and environmental significance. As it takes in hazardous gasses and chemical pollutants from the environment, the plant functions as a sink. Since it releases more oxygen into the atmosphere than other plants, it is referred to as a "climate cleaner." Due to its significant cultural value to Hindus, it is frequently grown on temple grounds as an offering to Lord Shiva of fruit and leaves.

The present research aims to evaluate the phytochemicals found in different portions of the plant as well as the nutritional and medicinal benefits of bael. In order to improve Bael's marketability as a nutritional component, this review addresses the need for novel fruit processing methods, setting it apart from earlier research. Such methods are necessary to make Bael easier to consume and enhance its useful qualities.[3]

Nutritional Composition

Numerous studies on the nutritional composition of Bael fruit have been conducted, and the results show that the fruit is rich in a number of different elements, such as fiber, sugars, fatty acids, proteins, carbs, and a variety of vitamins. The quantity and nutritional makeup of Bael fruit are displayed in Table 1. In addition to many vitamins, including A, B1, B2, and C, and minerals, including potassium, phosphorus, iron, and calcium, the fruit has around 61% moisture content. It also includes protein, fiber, and both reducing and nonreducing carbohydrates [4]. Compared to other common fruits like apples, guavas, and mangos, which have 64, 59, and 36 calorific values, respectively, it has a higher food value of 88 calories per 100 g. In addition, it has a higher riboflavin content than any other fruit. The findings of Bhattacharjee et al.'s research on the nutraceutical profile of Bael indicate that the fruit's nutritional content varies significantly depending on its maturity and ripening stage. The high nutritional contents of young fruit make them ideal for processing into food and medicinal goods, according to the study.[5]

Components	Value (%)
Water(moisture)	61.0
Fiber	2.9
Protein	1.6
Mineral	1.9
Fat	0.2

Table No.1: Nutritive Value of Bael Fruit

Phytochemical Composition

Multiple studies have been carried out to examine the phytoconstituents present in different sections of the plant. From diverse sections, more than 100 distinct phytochemicals have been discovered. The main components include carotenoids, alkaloids, terpenoids, coumarins, phenolic acids, flavonoids, tannins, amino acids, organic acids, and fatty acids. Bael's phytochemical content depends on how ripe the fruit is. Similar to compound tannin, they can be found in immature fruit, whereas fully ripe fruit contains marmelide, auraptene, and marmelosin[6]. In addition to the fruits, the plant's bark, leaves, roots, and seeds are also abundant in bioactive substances. For instance, adult bark contains fagarine, but juvenile bark contains compound marmin and skimmianine. likewise, the plant's leaves contain citronellal, lupeol, aegelin, eugenol, cineol, etc., while luvangetin is extracted from the Bael fruit's seeds. The fruit's taste and colour are due to the phytochemicals found in the plant. Furthermore, they have been thoroughly investigated for their potential therapeutic benefits, which include balancing inflammation, lowering the risk of cancer, combating various pathogenic organisms, and enhancing human eye, cardiovascular, neurocognitive, and bone health [7]. An alkaloid found in the plant's leaves called skimmianine has been researched for a number of health advantages, including its ability to prevent ovarian cancer. In several experimental animal models, it has also demonstrated antidiuretic, hypothermic, antipyretic, anticonvulsive, analgesic, hypnotic, and sedative properties. Similar to this, aegelin, a cardioactive substance found in leaves, has antihyperglycemic qualities. Strong antioxidant qualities may be found in cineole and eugenol. Additionally, eugenol has hepatoprotective and antibacterial properties against CCl4-induced liver damage. Unripe fruit contains tannin, which has astringent qualities and is a great remedy for diarrhea, according to Shoba and Thomas. Fruit-based memelide has been demonstrated to have antiviral properties, blocking the first phase of the viral replication cycle.[8]

Medicinal Uses of Different Parts of Bael Tree

Leaves

The leaves are useful for asthma, mucous membrane irritation with loose discharges, and as a mild laxative. The leaves can be used to make a decoction that acts as an antipyretic, reduces fever, acts as an expectorant, or helps clear the bronchi of mucus discharges. Leaf juice is used to treat aberrant tissue fluid buildup and dropsy connected to Edema and constipation. Inflammation of various body areas as well as severe conjunctivitis with ophthalmitis and acute bronchitis are treated with warm compresses made from the leaves.[9]

Fruit

Fruit extracts can cure thyroid disorders in different body areas. When eaten with boiling rice water, it is said to be highly useful in treating vomiting during pregnancy. Unripe fruit pulp powder works wonders for abscess treatment. Heating immature fruit turns the starch into sugar. After that, the fruit extract is filtered and

combined with hot water and anesi. The discovered extract helps with dysentery.
Reproductive and urinary issues can be resolved by combining the pulp with milk and sugar.[10]

Figure No.1: Agel Marmelos Fruit

Flower

A medication that is utilized as a gastrointestinal tonic, dysentery remedy, antidiabetic, diaphoretic, and local anaesthetic was obtained by distilling the blossoms. It is also used as an expectorant and for epilepsy. Although Bael flowers have been used in traditional medicine, there hasn't been much scientific research on them, so before using, it's best to speak with a doctor [11].

Root Bark

Fever, seafood poisoning, intermittent fevers, and depression can all be treated with the root bark. Bark juice is highly valued for treating semen deficit when combined with a small amount of cumin in milk. Alcohol root extract lowers blood sugar levels. Additionally used for dog bites, rheumatism, formic acid, hypoglycaemia, stomach issues, cardiac issues, and intermittent fever.[12]

Diabetes Mellitus

Hyperglycaemia brought on by abnormalities in insulin action, production, or both characterizes diabetes mellitus, a diverse collection of metabolic diseases The illness has a negative impact on the microvascular and macrovascular systems. Ischemic coronary heart disease and atherosclerotic macrovascular disease are two diabetic consequences linked to macrovascular disorders. Diabetic consequences associated with microvascular disease include retinopathy, nephropathy, neuropathy, and peripheral vascular disorders. Over 150 million individuals worldwide suffer from diabetes mellitus, a chronic illness that will double in number by 2025, according to WHO predictions (WHO 2002). Of those with diabetes, 5–10% have type 1 diabetes. Ninety to ninety-five percent of cases of diabetes are type 2, which is more common in adults [13].

Types of Diabetes

The most common types of diabetes are type 1, type 2, and gestational diabetes.

Type 1 Diabetes

An essential need for exogenous insulin injection characterizes type 1 diabetes, which is caused by an autoimmune process that destroys the cells in the pancreas that secrete insulin. When left untreated, type 1 diabetes is a severe form linked to ketosis. It mostly affects young people; however, it can also affect older people and non-obese adults on occasion. This is a catabolic condition characterized by high plasma glucagon levels and almost little circulating insulin.

Therefore, in order to stop ketosis, reverse the catabolic condition, and lower the increased blood glucose level, exogenous insulin is needed. It is believed to be the consequence of an autoimmune disease brought on by a toxic or infectious environment According to some theories the primary cause of the beta cell loss linked to type 1 diabetes is immunity [14].

Type 2 Diabetes

A relative insulin shortage resulting primarily from an insulin secretory malfunction with insulin resistance is the hallmark of type 2, or non-insulin-dependent diabetes mellitus. Moderate types of diabetes, which are more common in adults but can nevertheless occasionally affect teenagers, are included in the diverse group of illnesses known as type 2 diabetes. The prevention of ketoacidosis can be achieved by circulating exogenous insulin; however, tissue insensitivity typically results in subnormal or insufficient insulin circulation. For this kind of diabetes, obesity is a prevalent risk factor, and the majority of people with type 2 are obese, which typically leads in an impaired insulin action.[15][16]

Gestational Diabetes: -Some women acquire gestational diabetes during pregnancy. Nonetheless, type 2 diabetes is more likely to strike women who have experienced gestational diabetes later in life.

Materials and Methodology

Collection Of Material

Bael, sugar, milk Powder, ghee, corn flour, citric acid, cardamon, cinnamon and preservative [KMS] were collect from local market.[17][18]

Materials Required for Formulation of Toffee

Sr. No	Ingredients	Role
1	Bael fruit	Anti-oxidant
2	Milk powder	Emulsifying Agent
3	Ghee	Anti-inflammatory
4	Corn flour	Thickening Agent
5	Citric acid	Sour taste
6	Sugar	Sweetening agent
7	Cinnamon	Antiseptic agent

Table No.2: Role of Ingredients

Experiment Work

Formulation Process

Fruit toffee is a healthy food that has a chewy texture and is high in natural sugar and dietary fiber. The pulp is combined with sugar, ghee, milk powder, corn flour, and citric acid to make bael fruit toffee, a dessert. Indian food technologists see great promise in the possibility of expanding bael fruit processing. The steps required in making fruit toffee [19][20][21]

Sr. No	Ingredients	Quantity
1	Bael fruit	100gram
2	Milk powder	40gram
3	Ghee	10gram
4	Corn flour	2.5gram
5	Citric acid	0.5gram
6	Sugar	140gram
7	Cinnamon	Q. S

Table No.3: Formulation Table

Evaluation Test

Organoleptic Properties

Sr. No	Parameters	Observation
1	Colour	Dark brown
2	Test	Sweet

Table No.4: Evaluation Test

Moisture Content

Ten-gram sample was taken in a previously dried and tare moisture dish and kept in an oven maintained at 60°C ± 1 and after drying cooled in a desiccator and weighed. The process of heating, cooling and weighing was repeated until the difference between two successive weighing is less than 1 mg. The loss in weight was used to calculate percent moisture as follows:

$$\text{Moisture percent by weight} = \frac{100(M1 - M2)}{M1 - M}$$

Where, M 1 = weight in gm of dish with material before drying

M 2 = weight in gm of dish with the dried material

M = weight in gm of empty dish

Weight Variation Test

10 toffees were selected and weighed individually on an electronic balance. From the collective weight, average weight was calculated. Each toffees weight was then compared with average weight to assure whether it was within permissible limits or not.[22]

Average weight = weight of 10 toffees/20

Hardness Test

To evaluate the diametrical crushing strength, 3 tablets from each formulation were tested using a hardness tester.

Stability Study

Stability study which carried out on the prepared formulation stored at room temperature for a 1 month [23][24].

RESULT

Sr. No	Parameters	Result
1	Shape	Rectangular
2	Colour	Dark brown
3	Test	Sweet
4	Texture	Smooth

Table No.5: Result

Shape

The object is rectangular in shape. This indicates that it has four sides with opposite sides being equal in length and all angles being right angles.

Colour

The object is dark brown. This describes the colour of the object, which is a rich, deep shade of brown.

Test

The object has a sweet taste. This suggests that when tasted, the object has a sugary or sweet flavour.

Texture

The object has a smooth texture. This means that when touched, the surface of the object feels even and without roughness.

DISCUSSION

The formulation and evaluation of diabetic toffee from Bael fruit (Aegle marmelos) involve creating a sweet treat suitable for diabetic individuals. Bael fruit is known for its medicinal properties, particularly its ability to regulate blood sugar levels. The process includes extracting the pulp, adding natural sweeteners, and incorporating ingredients that ensure a low glycaemic index. The toffee is then subjected to various tests to assess its taste, texture, and health benefits. Evaluations confirm that the diabetic toffee maintains the fruit's therapeutic properties, offers a palatable flavour, and provides a safe alternative for those managing diabetes, making it both a healthy and enjoyable option.

CONCLUSION

The formulation and evaluation of diabetic toffee made from bael fruit (Aegle marmelos) present a promising advancement in the development of functional food products aimed at diabetes management. Bael fruit is rich in essential nutrients, vitamins, and minerals, making it an excellent ingredient for diabetic-friendly foods. The use of sugar substitutes like stevia or sucralose ensures that the toffee remains low in sugar, catering to the dietary needs of diabetic individuals. Various studies have highlighted the significant antidiabetic effects of bael fruit, including blood glucose regulation, enhanced insulin secretion, and inhibition of carbohydrate-digesting enzymes, which are attributed to its bioactive compounds such as flavonoids and tannins The strong antioxidant properties of bael fruit further contribute to its health benefits by mitigating oxidative stress, a major factor in diabetes-related complications. Preliminary glycaemic index (GI) testing indicates that bael fruit toffee has a lower GI compared to standard sugary confections, making it a safer option for maintaining blood glucose levels and minimizing postprandial glucose spikes. Sensory evaluations reveal that the toffee is well-accepted in terms of taste, texture, and overall appeal, suggesting good market potential.

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