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The Potential of Guava Leaf-Enriched Chocolate in Sugar-Free Anti-Diabetic Confectionery: A Review

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Abstract

People of all age groups enjoy chocolate however, it is often linked to health issues like obesity, hypertension, diabetes, and cardiovascular diseases. This study aimed to develop a medicinal chocolate suitable for diabetic individuals by incorporating herbal ingredients. Specifically, guava leaves (Psidium guajava), known for their rich vitamin and antioxidant content and their ability to help regulate blood sugar, were used. The chocolate formulation included guava leaf powder, coffee, and cocoa powder. The primary objective was to create and evaluate a sugar-free chocolate using guava leaf extract as a natural component. Guava leaves were selected due to their potential health benefits, especially in blood sugar control and their antioxidant properties. Stevia served as the sugar substitute, while cocoa powder and cocoa butter formed the base of the chocolate. Various concentrations of guava leaf extract were tested to achieve the best balance of functionality and taste. A trained sensory panel evaluated the chocolate based on its flavour, texture, and overall acceptability. Results indicated that the inclusion of guava leaf extract improved the chocolate's antioxidant capacity without negatively affecting its taste or texture. Moreover, the product demonstrated a reduced glycaemic response compared to conventional chocolate, suggesting it may be appropriate for individuals with diabetes. Shelf-life analysis confirmed the product's stability under standard storage conditions. In summary, the findings support the feasibility of using guava leaf extract in sugar-free chocolate as a health-friendly option for diabetic consumers. Nevertheless, additional studies are required to optimize the formulation and assess its commercial viability. This abstract offers a concise overview of the study's objectives, methodology, findings, and significance for readers interested in its outcomes.

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INTRODUCTION

In recent years, the global incidence of diabetes mellitus has been steadily increasing, leading to greater interest in alternative therapies and preventive strategies. One promising avenue involves the investigation of natural substances with antidiabetic potential, such as guava leaves [1]. Guava (*Psidium guajava L.),* a tropical fruit known for its medicinal benefits, is recognized for its ability to help regulate blood sugar levels [2]. The leaves of the guava plant contain bioactive compounds, like flavonoids, polyphenols, and tannins, which have

demonstrated antidiabetic effects in several studies. On the other hand, chocolate – while widely enjoyed – typically contains high sugar levels, which can be harmful to people with diabetes [3]. A possible solution is the development of sugar-free chocolate that replicates the taste of regular chocolate through alternative sweeteners and additives [4]. This research focuses on developing and accessing sugar-free chocolate infused with guava leaf extract [5]. The goal is to harness the health-promoting compounds of guava leaves to create a functional food that appeals to consumers while offering potential benefits for those managing or at risk of diabetes [6–7].

KEY OBJECTIVES OF THIS RESEARCH

1. To formulate a sugar-free chocolate incorporating guava leaf extract as a functional ingredient.
2. To analyze the sensory characteristics, such as taste, texture, and aroma of the developed antidiabetic chocolate.
3. To examine the potential antidiabetic activity of the product through in vitro methods and, if applicable, in vivo studies.
4. To evaluate the shelf-life and overall stability of the formulated chocolate under standard storage conditions.

This research could contribute to the development of innovative functional foods that offer both appealing flavors and health benefits, meeting the growing worldwide need for healthier eating choices [8].

- *Vitamins:* Guava leaves are rich in vitamins C and A. Vitamin C plays a crucial role in enhancing the immune system, while vitamin A helps preserve healthy skin and supports proper vision [9].
- *Minerals:* Important minerals, like potassium, are also carried by these leaves. Potassium helps regulate blood pressure and is excellent for your heart [10].
- *Antioxidants:* Guava leaves shield the body from dangerous substances known as free radicals [11].

Blood Sugar Level

Guava leaves may offer health benefits for individuals with diabetes or those at risk of developing the condition. They aid in preventing sudden increases in blood glucose levels following meals and help maintain steady glucose control, thereby promoting overall health (Figure 1) [12].

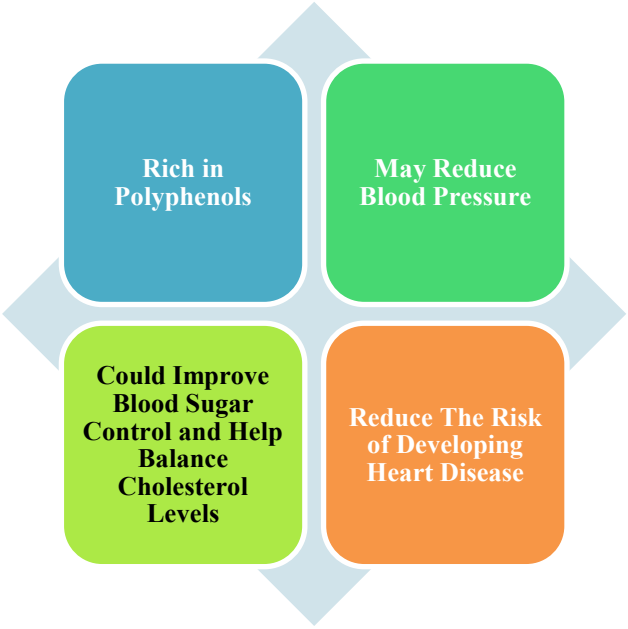

Figure 1. Health benefits.

Boost Immune System

Guava leaves contain high levels of vitamin C and antioxidants, which contribute to strengthening the body's immune defenses. By reinforcing the body's natural defenses, they contribute to better protection against illnesses and infections [13].

Promoting a Healthy Heart

Guava leaves improve good cholesterol and decrease bad cholesterol, which helps protect the heart. This may lower the likelihood of developing heart disease and support overall cardiovascular well-being [14].

Cocoa Powder

Cocoa and its primary flavanols may help prevent or delay the onset of type 2 diabetes by influencing insulin secretion in pancreatic β-cells and affecting insulin-sensitive tissues. These compounds exhibit insulin-like properties and can regulate key proteins involved in the insulin signaling pathway. This not only enhances glucose uptake and reduces glucose production but also improves lipid metabolism. Furthermore, the anti-inflammatory properties of cocoa may help safeguard the body from several chronic conditions, such as cardiovascular disease, cancer, and diabetes. Rich in antioxidants, cocoa powder holds significant potential for promoting overall health [15].

HEALTH BENEFITS

Stevia rebaudiana is a small, perennial herb that usually reaches a height of 65 to 80 cm and features sessile leaves arranged opposite each other. Among the various species of the Stevia genus, S. *rebaudiana* is recognized as the sweetest due to its high concentration of natural sweetening compounds. Like other vegetable crops, it thrives in semi-humid subtropical climates and can even be cultivated in home gardens. Ideal soil conditions include a pH range of 6.5 to 7.5, with well-drained red or sandy loam soil, while saline soils should be avoided.

In recent years, cultivation of Stevia has expanded across several Indian states, including Rajasthan, Maharashtra, Kerala, and Odisha, driven by the rising demand for plant-based sweeteners. Wild Stevia leaves contain several diterpene glycosides, including approximately 0.3% dulcoside, 0.6% rebaudioside C, 3.8% rebaudioside A, and 9.1% stevioside, which contribute to their sweet taste [16].

The Stevia genus, belonging to the Asteraceae family, comprises at least 110 species, and possibly up to 300, according to researchers. These plants are native to parts of Central and South America, particularly the highland areas of Brazil, as well as regions in the southwestern United States. S. rebaudiana is also widely used in Japan as a sweetener in products like soft drinks, candies, and seafood. Additionally, the plant has a history of traditional use in countries, such as Brazil and Paraguay for managing diabetes and aiding weight control in obese individuals [17].

EVALUATION OF ANTIDIABETIC PROPERTIES

To investigate the antidiabetic potential of *Psidium guajava* (guava) leaves through a systematic review of existing literature and preliminary laboratory testing. This research aims to assess the effects of compounds found in guava leaves on blood glucose regulation using experimental models.

Sensory Evaluation

To perform sensory evaluations to assess the taste, texture, and overall consumer acceptability of the formulated sugar-free, antidiabetic chocolate.

Nutritional Analysis

To analyze the nutritional profile of the developed chocolate, with a specific focus on carbohydrate levels, dietary fiber content, and the presence of antioxidants potentially derived from guava leaf extracts [18–19].

Standard Diabetic Chocolates

Conduct a comparison between the nutritional content and sensory qualities of the formulated chocolate and those of commercially available diabetic chocolate products.

Stability Testing

To assess the shelf-life and physicochemical stability of the sugar-free antidiabetic chocolate when stored under varying environmental conditions [20].

DRUG PROFILE

Guava Leaves Powder

- *Syntheticname: Psidium guajava.*
- *Family:* Myrtaceae.
- *Biological Source: Psidium guajava* L., commonly known as guava, is a tropical plant native to the Americas (Figure 2) [21].

Figure 2. Guava leaves.

Cocoa Powder

- *Scientific name: Theobroma cocoa.*
- *Family:* Malvaceae.
- *Biological Source:* Cocoa, obtained from the Theobroma cacao tree, is extensively utilized in the food industry as a key ingredient in products, such as chocolate, jams, and jellies (Figure 3) [22].

Figure 3. Cocoa powder.

Stevia Powder

- *Scientific Name: Stevia rebaudiana.*
- *Family:* Asteraceae.
- *Biological Source:* Stevia is a natural sugar alternative that is approximately 50 to 300 times sweeter than regular sugar. *Stevia rebaudiana* is a plant native to Brazil's southern Amazon rainforest (Figure 4) [23].

Figure 4. Leaves of Stevia.

- *Materials:* Guava leaves powder, Cocoa powder, coffee, Stevia sugar and Distilled water.
- *Tools:* Conical flask, chocolate mold, Petri dish, conical flask, mortar and pestle, measuring cylinder, and beaker.
- *Instruments:* Refrigerator, water bath, sieves, grinder [24].

METHODS

Preparation for Chocolate

- Gather Guava leaves and rinse them with water to get rid of any dirt.
- Dried it naturally for 4–5 days.
- Use a grinder to reduce the size to powder.
- Pass Guava powder through sieves.
- Take cocoa powder and guava leaves powder then add other Ingredients and mix well.
- Then poured the melted chocolate in a mold and freeze it at 5° temperature.
- After freeze chocolate is ready (Table 1) (Figures 5–8) [25, 26].

Table 1. Formulation table: Composition of antidiabetic chocolate product.

S. N.	Ingredients	Quantity Gives	Quantity Taken	Use
1.	Guava Leaves powder	100 gm	10 gm	Antidiabetic
2.	Cocoa powder	1000 gm	100 gm	Antidiabetic
3.	Stevia	250 gm	25 gm	Sweetening Agent
4.	Coffee	10 gm	1 gm	Flavoring Agent
5.	Butter	50 gm	5 gm	Shine

Figure 5.

Figure 6.

Figure 7.

Figure 8.

EVALUATION TEST

- *Color:* Assess the color through visual inspection.
- *Texture:* Assess the chocolate's texture by examining its softness and brittleness.
- *Mouthfeel:* Place the chocolate in the mouth and assess its texture.
- *Taste:* Evaluate the flavor of the chocolate (Table 2).
- *Blooming Test:* The chocolate was heated to 40°C for 30 minutes, then cooled to 20°C. After holding at 20°C for 8 hours, the sample was examined to determine if fat bloom had developed.
- *Physical Stability:* A sample of chocolate was stored in a closed container at 28°C for a month to assess its physical stability. A month later, the chocolate test sample was examined for both drug degradation and physical appearance [27].
- *Melting Point:* The chocolate will melt due to its residual heat. When reheating chocolate in the microwave, don't rely just on appearance. Using an instant-read thermometer to check the temperature of chocolate while it melts and gently stirs it are the only ways to determine whether it is completely melted. Stir the chocolate that is melting with a rubber spatula.
- *PH:* The pH of the formulation was measured using a digital pH meter (Figure 9) [28, 29].

Figure 9. Digital pH meter.

- *Carbohydrate Test (Fehling's Test):* Equal amounts of Fehling's solutions A and B were combined with the test sample and heated. The formation of a brick-red precipitate signifies the presence of carbohydrates.

- *Protein Test:* The chocolate formulation was mixed with 4% sodium hydroxide solution and a few drops of 1% copper sulfate solution. A violet coloration indicates the presence of proteins.
- *Amino Acid Test:* The test solution was heated, followed by the addition of 5% Ninhydrin solution. After boiling for 10 minutes, the appearance of a purple or blue color indicates the presence of amino acids (Figure 10) [16].

Figure 10. Evaluation test.

Table 2. Observation table.

S. N.	Test	Result
1.	Color	Dark brown color
2.	Texture	Bitter with chalky texture
3.	Taste	Sweet
4.	Mouth feel	Soft
5.	Blooming	Occurred
6.	Melting point	87°F
7.	pH	6.5
8.	Stability	Stable

CONCLUSIONS

According to the results of the study, guava leaf powder extract's natural active ingredients show better inhibition of diabetes activity than antidiabetic chocolate that is sold commercially. The formulations that demonstrated adequate sweetening qualities, pH levels, and stability profiles were evaluated as the optimized batch. To create high-quality sugar-free chocolate, the best ingredients must be used ones that can fully substitute sugar without compromising the product's rheological, physical, or sensory qualities. Sugar has numerous functional qualities that make it helpful as a bulking agent, texture adjuster, Mouth feel modulator, taste enhancer, and preservative in addition to being added to chocolate to increase sweetness. High-intensity sweeteners, like saccharin, acesulfame K, sucralose, stevioside, thaumatin, and sugar alcohols, along with bulking agents like polydextrose, maltodextrin, and inulin, have the potential to successfully replace sucrose in chocolate products while maintaining the same desirable quality in terms of appearance, texture, taste, and flavor as their sugar-sweetened counterparts.

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