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Research Article

Anti-Diabetic Chocolate: Formulation And Evaluation of Antidiabetic Chocolate from Herbal Extract of Fenugreek, Guava and Jamun

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ABSTRACT

The chocolate is product which love every age person to eat but due to health issues like obesity, high blood pressure, coronary artery disease, diabetes etc, doctor restrict patient to take chocolate. So, objective of present research was to formulate the medicated chocolate keeping note of health issue to prevent the Diabetes and make patient convenient to eat chocolate. The aim of the present study was to formulate medicated chocolate containing herbal ingredients aimed at preventing diabetes and providing diabetic patients with a convenient chocolate option. Fenugreek is rich in antioxidants and vitamins that aid in lowering blood sugar levels. The formulation of herbal chocolates included Fenugreek Seed powder, guava leaf powder, jamun seed powder, dark chocolate, sucralose, coffee, cocoa butter, cardamom powder, and lemon oil. The prepared chocolate formulations evaluated for parameters such as hardness, pH, general appearance, colour, texture, chemical composition, weight variation and bloom Test.

INTRODUCTION

Diabetes is a chronic disease which caused by a metabolic disorder characterized by fast increase of blood sugar level (high blood glucose). There are different types of diabetes that are Type 1, Type 2 and Gestational Diabetes. Type 1 diabetes is an autoimmune disease, Type 2 diabetes occurs when body becomes resistant to insulin, and sugar builds up in blood and Gestational diabetes is high blood sugar during pregnancy. Insulin-blocking

hormones produced by the placenta cause this type of diabetes. Guava leaves (*Psidium Guajava*) belongs to family Myrtaceae chemical contain carotenoids, polyphenols. Vit. C. linoleic acid. It is used for inflammation, diabetes, hypertension, pain relief, fever, diarrhea, ulcer rheumatism. Dark chocolate is powerful source of antioxidants which contain 70% or high cocoa, helps balance blood glucose, improve blood flow and blood pressure, reduce heart disease, improve brain function. It also reduce risk of diabetes for long term.

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Fenugreek seeds and leaves are composed of macronutrients, vitamins, minerals and are rich in bioactive compounds like alkaloids (trigonelline), flavonoids (quercetin, luteolin), saponins and steroidal saponins. Additionally, fenugreek seeds are palatable and nutritionally dense, containing carbohydrates, proteins, lipids and volatile oils, making them useful for digestive health and as a source of plant-based nutrition. It is used for Improves glucose uptake, Improves insulin sensitivity, Lowers cholesterol, Fenugreek also has antibacterial, antifungal, anti-inflammatory, and galactagogic properties. Jamun Seeds *Syzygium cumini* belong to the family Myrtaceae. Chemical contains jambosine, glycoside jamboline, alkaloids, Gallic acid, Mallic acid. Jamun is considered a highly effective fruit for fighting against diabetes. Jamun has many other health benefits, including anti-inflammatory, antioxidant, and anti-diarrheal properties. Guava leaves, Dark chocolate and Mulberry fruits are more effectively use as antidiabetic so chocolate is formulated which diabetic patient can convenient and happy to eat. This comprehensive study delves into the intricate process of creating a chocolate blend infused with the therapeutic properties of Fenugreek Seeds, guava leaves and Jamun Seeds along with the complementary flavours and functionalities of dark chocolate, sucralose, coffee, cocoa butter, cardamom, and Lemon [1]. The aim of the present study was to formulate medicated chocolate containing herbal ingredients aimed at preventing diabetes and providing diabetic patients with a convenient chocolate option. The consumption of chocolate is enjoyed by people of all ages, yet health concerns such as high blood pressure, diabetes, and coronary artery disease persist. The improvement of health-promoting properties of chocolate is a nowadays trend in the food industry. Plant-based foods, such as mung bean, fenugreek seed are well-acknowledged to have functional properties which are beneficial for

health. Fenugreek is a widely grown dietary herb in Asia, and its seeds are traditionally used for several diseases, including diabetes. The seeds and leaves possess a variety of compounds that play an important role in regulating their hypoglycemic effect. In recent years, there has been growing interest in developing food products that offer potential health benefits, particularly for individuals managing chronic conditions like diabetes. One such innovative endeavor is the formulation and evaluation of antidiabetic herbal chocolate. This study aims to create a chocolate blend infused with the therapeutic properties of Fenugreek Seeds, guava leaves and Jamun Seeds along with complementary flavours functionalities of dark chocolate, sucralose, coffee, cocoa butter, cardamom, and Lemon [2].



Fig no. 1. Herbal drugs

1.1 Overview of Diabetes

Diabetes is a chronic disease that occurs either when the pancreas does not produce enough insulin or when the body cannot effectively use the insulin it produces. Insulin is a hormone that regulates blood glucose. Hyperglycaemia, also called raised blood glucose or raised blood sugar, is a common effect of uncontrolled diabetes and over time leads to serious damage to many of the body's systems, especially the nerves and blood vessels.

Diabetes is a disease that occurs when your blood glucose, also called blood sugar, is too high. Glucose is your body's main source of energy. Your body can make glucose, but glucose also comes from the food you eat[5]. Insulin is a hormone made by the pancreas that helps glucose get into your cells to be used for energy. If you have diabetes, your body doesn't make enough or any insulin, or doesn't use insulin properly. Glucose then stays in your blood and doesn't reach your cells. Diabetes raises the risk for damage to the eyes, kidneys, nerves, and heart. Diabetes is also linked to some types of cancer. Taking steps to prevent or manage diabetes may lower your risk of developing diabetes health problems[3].

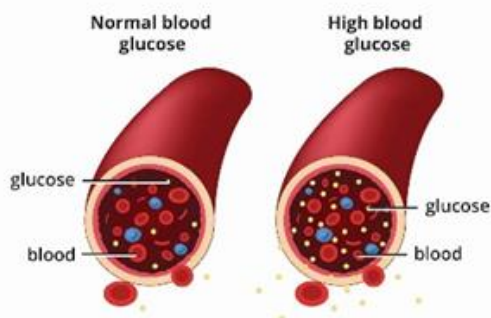


Fig no. 2. Glucose level

1.2 Types of Diabetes

1. Type 1 Diabetes: This results from the immune system mistakenly attacking and destroying insulin-producing beta cells in the pancreas. As a result, the body produces little to no insulin, leading to elevated blood sugar levels. Type 1 diabetes typically develops in children and young adults, requiring lifelong insulin therapy for management.
2. Type 2 Diabetes: This is the most common form of diabetes, accounting for the majority of cases. It occurs when the body becomes resistant to insulin or gradually loses the ability to produce enough insulin to maintain

normal blood sugar levels. Type 2 diabetes is often associated with lifestyle factors such as obesity, physical inactivity, and poor dietary habits. It can develop at any age, but it is more common in adults[1].

3. Gestational Diabetes: This type of diabetes occurs during pregnancy when the body cannot produce enough insulin to meet the increased demand. Gestational diabetes increases the risk of complications during pregnancy and childbirth, and women who develop it are at higher risk of developing type 2 diabetes later in life.
4. Prediabetes: People with prediabetes have blood glucose levels that are higher than normal but not high enough to be diagnosed with type 2 diabetes. If you have prediabetes, you have a higher risk of developing type 2 diabetes in the future. You also have a higher risk for heart disease than people with normal glucose levels.
5. Other Specific Types: There are other less common forms of diabetes, including genetic mutations affecting insulin production or action, diseases of the pancreas, drug-induced diabetes, and diabetes associated with certain medical conditions[2].

1.3 Causes of diabetes

Age: The risk of Type 2 diabetes increases with age, especially after 45.

Genetics: A family history of Type 1 diabetes increases the risk, although the exact genes involved are still being researched.

Autoimmune response: The body's immune system mistakenly attacks and destroys the insulin-producing cells in the pancreas, leading to a lack of insulin.

Insulin resistance: The body's cells become less sensitive to insulin, so they don't respond as effectively to it, leading to a buildup of glucose in the bloodstream.

Lifestyle factors: Being overweight or obese, physical inactivity, and an unhealthy diet can all contribute to insulin resistance and the development of Type 2 diabetes.

Hormonal changes: During pregnancy, hormones released by the placenta can cause insulin resistance, making it harder for the body to regulate blood sugar.

Lifestyle factors: Being overweight or obese before pregnancy and not having a healthy lifestyle can also increase the risk.

Environmental factors: While not fully understood, certain infections or environmental triggers may play a role in triggering the

autoimmune response in genetically predisposed individuals.

Other factors: High blood pressure, high cholesterol, and prediabetes can also increase the risk of developing Type 2 diabetes.

MATERIAL AND METHOD

Material

The raw material which is used in the antidiabetic chocolate preparation Fenugreek Seed, Guava leaves, Jamun seeds and cardamom powder are added in required quantity. The mentioned plant seeds and leaves were collected from local market. This study was performed to expedite a new formulations and evaluation of a herbal antidiabetic chocolate to know there effectiveness as a low blood Sugar[9].

Formulation Table

Table no. 7 formulation Table for Antidiabetic Chocolate

Sr. no.	Ingredient	Quantity Taken			Uses
		F1	F2	F3	
1	Fenugreek Seed	5.0g	3.0g	2.0g	Antidiabetic agent
2	Guava leave powder	2.0g	5.0g	3.0g	Antidiabetic agent
3	Jamun seed powder	3.0g	2.0g	5.0g	Antidiabetic agent
4	Dark chocolate	60.0g	60.0g	60.0g	Antioxidant
5	Cocoa butter	20.0g	20.0g	20.0g	Solidifying agent
6	Sucralose	1.0g	1.0g	1.0g	Sweetening agent
7	Cardamom powder	1.0g	1.0g	1.0g	Flavouring agent
8	Coffee	1.0g	1.0g	1.0g	Flavouring agent
9	Lemon oil	0.1ml	0.1ml	0.1ml	Preservative

Equipment: Necessary laboratory equipment and apparatus were used for preparation.

1. Mixing Bowls:- Used for blending and mixing the ingredients to prepare the chocolate formulation.

2. Measuring Instruments:- Weighing balance for accurately measuring ingredients.

3. Mortar pestle or Grinder:-Used to grind or blend ingredients such as Fenugreek, Guava and Jamun into powder form.



4. Heating Apparatus:- Water bath for melting the dark chocolate.
5. Stirring Rods or Spatulas:-Used for thorough mixing and homogenization of the formulation.
6. Refrigerator:-Used to freeze the chocolate formulation.
7. Chocolate Mould:- Used to give proper shape to the liquid chocolate before it sets[2].

Methodology

Step 1 : Prepare the Herbal Ingredients

1. Measure out the fenugreek seed powder, guava leaf powder, jamun seed powder, cardamom powder, coffee powder, and lemon oil into a small bowl.
2. Dried it naturally for 4-5 days.
3. If using dried herbs Fenugreek seed , guava leaves and jamun seed crush them into a fine powder or small pieces using a mortar and pestle or grinder.
4. Pass both powder through sieve number 85.
5. Ensure all herbal powders are fine and well-mixed. This helps in evenly distributing them throughout the chocolate.

Step 2 : Melt the Cocoa Butter

1. Place the cocoa butter in a heat proof bowl or a double boiler.
2. Heat gently over low heat, stirring occasionally to ensure the butter melts smoothly without burning.

Step 3 : Melt the Dark Chocolate

1. Once the cocoa butter has melted, add the dark chocolate broken into small pieces to the same bowl or double boiler.
2. Stir continuously until the chocolate is fully melted and smooth.

Step 4 : Mix in the Herbal Powders and Excipients

1. Once both the cocoa butter and chocolate are fully melted and well-mixed, add the measured herbal powders (fenugreek seed , guava leaf, jamun seed, cardamom, coffee and lemon oil).
2. Add the sucrose and Stir well to ensure all the powders are evenly distributed in the melted chocolate.

Step 5 : Stir in the Mixture

1. Stir the chocolate thoroughly to ensure the herbs and powders are well-blended into the cocoa butter and chocolate mixture[2].
2. This step is crucial to ensure that the active compounds in the herbal ingredients are evenly distributed throughout the chocolate.

Step 6 : Pour Into Molds

1. Once the mixture is smooth and consistent, pour it into silicone molds or spread it into a parchment-lined baking sheet.
2. Tap the molds gently on the countertop to remove any air bubbles.

Step 7 : Set the Chocolate

1. Place the molds in the refrigerator or freezer to set. Allow the chocolate to harden for at least 1-2 hours.

Step 8 : Store the Chocolate

2. After the chocolate has fully hardened, remove it from the molds or break it into pieces if you used a baking sheet.
3. Store the anti-diabetic chocolate in an airtight container in a cool, dry place or in the refrigerator for longer shelf life[1].

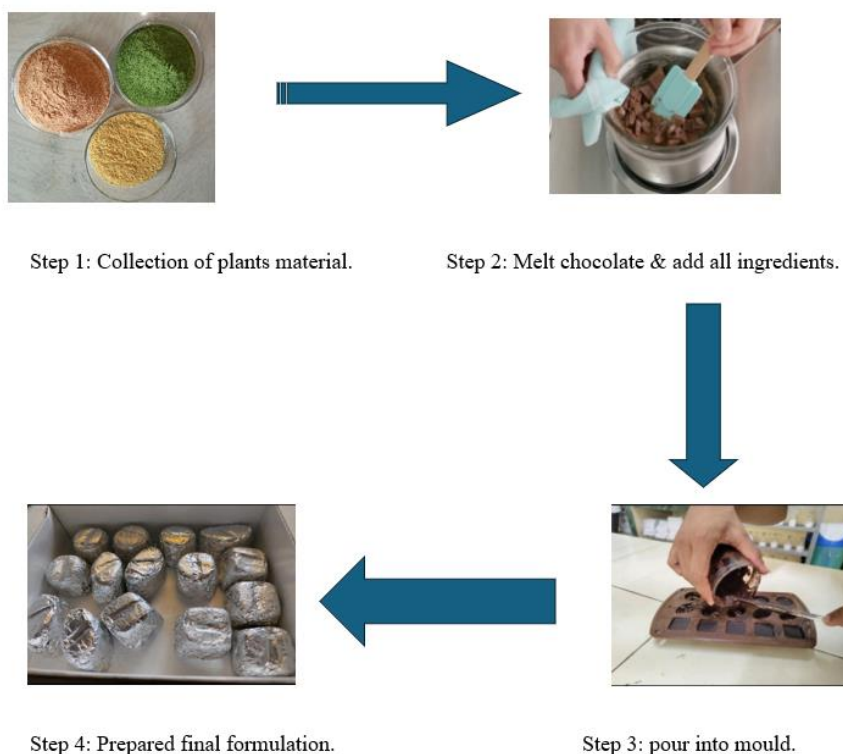


Fig no. 9 formulation process

1. Evaluation

1. Physical Appearance

- **Colour:** Observe the colour visually.
- **Texture:** Evaluate the texture of the chocolate.
- **Mouth Feel:** Place chocolate in the mouth and feel its texture.
- **Taste of Chocolate:** Taste the chocolate.
- **pH:** The pH formulation was determined using digital pH paper.
- **Hardness:** Perform a hardness test by pressing a specified dimensioned and loaded object (indenter) into the surface of the

material being tested. The hardness is determined by measuring the depth of indenter penetration or by measuring the size of the impression left by an indenter[7].

2. Chemical Test

- **Test for Carbohydrate (Fehlings Test):-** A solution containing equal quantities of Fehlings solution A and B was added and heated. The formation of a brick-red precipitate indicates the presence of carbohydrates.
- **Test for Protein (Biuret Test/General Test):-** Chocolate formulation was mixed with 4% NaOH and a few drops of 1% copper sulphate solution. The formation of a violet color indicates the presence of protein.

- **Test for Amino Acids:-** The test solution was heated, and 5% Ninhydrin solution was added. Boil for 10 minutes. The formation of a purple or bluish color indicates the presence of amino acids[1].

3. Weight Variation

The weight of four chocolate recipes was weighed separately and collectively. The weight of all the chocolates used to calculate the average weight. The average weight was then compared with the individual weights using the following formula to determine the percentage deviation.

$$\% \text{ Deviation} = \frac{\text{Individual Weight} - \text{Average Weight}}{\text{Average Weight}} \times 100$$

4. Blooming test:

- **Fat Bloom** – When the thin layer of fat crystals form on the surface of chocolate formulation. This will cause the chocolate to lose its gloss and a soft white layer will appear, giving the finished article an unappetizing look. Fat bloom is caused by the recrystallization of fat and/or a migration of a filling fat to the chocolate layer. Storage at a constant temperature will delay the appearance of fat bloom.
- **Sugar Bloom** – This is rough and irregular layer on top of chocolate formulation. This is caused by condensation (when chocolate is taken out of the refrigerator). This moisture will dissolve the sugar in the chocolate. When the water evaporates, sugar recrystallizes into rough, irregular crystals on surface. This results into unpleasant look[5].

5. Physical Stability: To check physical stability, samples of chocolate were kept in closed containers for 1 month at 28°C. After 1 month, test samples of chocolate were

observed for physical appearance and drug degradation.

6. Antimicrobial assay:

Cup Plate and Pour Plate Method:

Nutrient agar medium is used for the antimicrobial assay. Nutrient agar was prepared by its prescribe procedure and autoclaved at 121°C for 45 minutes. The sterilized media was allowed to cool at 37°C 38°C. Plate were filled with nutrient agar solution and allowed for solidification. After solidification, the microorganisms from the subculture were inoculated into the nutrient agar medium. Sub-cultured Bacteria were inoculated by striking on the surface media of the petri plate and subjected to incubation. Later 4 wells were drawn with help of borer in each plate to receive Herbal Extract, Individual Formulation herbal Formulation and the marketed reference standard. These were immediately poured into it and kept for incubation for 24 hours at 37°C for growth of microorganisms and the test and standard samples to diffuse through it. After the incubation was measured by zone meter and recorded[11].



Fig no.10 Chemical Test



Fig no .11 Antimicrobial assay



Fig no .12 pH test

2. RESULT AND DISCUSSION

Antidiabetic Chocolate was Formulated and Evaluated by Using Fenugreek seed powder , guava leaves powder and Jamun seed powder. As per Ayurveda, there exists a huge collection of plants with antidiabetic potential. Only few of them have been scientifically proven and a lot more have yet to be explored and proved.

Table no. 8 Evaluation parameter

Sr. No.	Test	F1	F2	F3
1	Colour	Dark Brown	Dark Brown	Dark Brown
2	Texture	Smooth	Smooth	Smooth
3	Taste	Sweet	Sweet	Sweet
4	Consistency	Solid	Solid	Solid
5	pH	6.8	6.4	6.5
6	Stability	Stable	Stable	Stable
7	Environmental impact assessment	Biodegradable	Biodegradable	Biodegradable
8	Aroma test	Sweet & Floral	Sweet & Floral	Sweet & Floral
9	Hardness	11.46	11.36	11.40
10	Sugar bloom	No	No	No
11	Fat bloom	No	No	No

Table no . 9 chemical test

Sr. no.	Name of test	Test group	Control group
1	Carbohydrate	+	+
2	Protein	+	+
3	Amino acid	-	-

Table no. 10 Zone of inhibition

Content	Zone of inhibition
Standard	D – 17 mm
Formulation code 1	D – 16.5 mm
Formulation code 2	D – 15 mm
Formulation code 3	D – 14 mm

- 1. Colour:-** The chocolate formulations (F1, F2, and F3) exhibited a consistent dark brown colour, indicating uniformity in the chocolate preparation process.
- 2. Texture:-** All formulations showed a smooth texture, suggesting proper blending and homogenization of ingredients.
- 3. Taste:-** The chocolates were uniformly sweet in taste across all variations (F1, F2 and F3), indicating balanced sweetness levels.
- 4. Consistency:-** The consistency of the chocolates was solid, indicating proper solidification during the cooling process.
- 5. pH:** The pH values of the formulations were within a close range (6.4 to 6.8), indicating slight variation but overall stability in acidity levels.
- 6. Shelf Life Test:** All formulations were tested for shelf life at room temperature, suggesting potential stability in storage conditions.
- 7. Environmental Impact Assessment:-** The chocolates were found to be biodegradable, indicating their eco-friendly nature and minimal environmental impact.
- 8. Aroma Test:-** The chocolates exhibited a sweet and floral aroma, enhancing the sensory experience for consumers.
- 9. Microbial contamination:**

After three days, the anti-microbial activity of the prepared herbal antidiabetic chocolate was

observed and was found to be about 1-2cm around the well prepared

SUMMARY AND CONCLUSION

In the present study, the herbal Antidiabetic Chocolate was successfully formulated and evaluated natural active constituents in Fenugreek, guava, jamun powder extract manifested superior inhibition against diabetic activity than present in the commercially available antidiabetic chocolate. Therefore, these compounds were extracted and incorporated in herbal chocolate bases to prepare superior Antidiabetic chocolate with less or no side effects with the low money inputs. Although the removal is not 100%, a major number can, and maintained a good health which is an important wealth for our daily life[2]. Based on the study conducted, it can be concluded that the natural active constituents present in Fenugreek seed Powder Extract exhibit superior inhibition against diabetic activity compared to commercially available antidiabetic chocolate. Among the formulations tested, batch S3 emerged as the optimized batch, providing satisfactory sweetening properties, pH levels, and Stability profile. The incorporation of herbal ingredients such as guava leaves powder, jamun powder and Fenugreek powder leaves powder into the chocolate formulation proved successful, as these ingredients contain active constituents like 4-hydroxyisoleucine, galactomannan, diosgenin, flavonoids and phenolic compounds known for their antidiabetic properties. Additionally, the inclusion of dark chocolate in the formulation is beneficial for improving insulin sensitivity and



regulating Blood sugar levels, potentially reducing the risk of type 2 diabetes and improving glucose metabolism[3]. Furthermore, the dosage range of the herbal extracts used in the formulation ensures safe consumption without risking any side effects. Overall, the study highlights the potential of herbal chocolates enriched with guava leaves, jamun seed powder and Fenugreek seed powder extracts as a safe And effective option for managing diabetes. Further research and evaluation may provide additional insights into their efficacy and Long-term effects on diabetes management[1].

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