

FORMULATION & EVALUATION OF HERBAL BISCUIT FROM JAMUN POWDER AND RAGI FOR DIABETIC PERSON

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Abstract

Diabetes mellitus is a chronic metabolic disorder characterized by elevated blood glucose levels, requiring long-term dietary management along with medical intervention. Functional foods enriched with natural bioactive compounds are gaining importance as supportive dietary options for diabetic individuals. The present study focuses on the formulation and evaluation of herbal biscuits prepared using jamun (*Syzygium cumini*) seed powder and ragi (finger millet) flour as key functional ingredients. Jamun seed powder is known for its hypoglycemic properties due to the presence of jamboline and other polyphenolic compounds, while ragi is rich in dietary fiber, calcium, and low glycemic carbohydrates, making it suitable for diabetic-friendly formulations. In this study, biscuits were developed by partially replacing refined wheat flour with varying proportions of ragi flour and standardized amounts of jamun seed powder. The formulated biscuits were evaluated for their physicochemical properties, sensory acceptability, and nutritional composition. Parameters such as moisture content, ash content, crude fiber, protein, and carbohydrate levels were analyzed. Sensory evaluation was conducted using a hedonic scale to assess attributes like taste, texture, aroma, and overall acceptability. The results indicated that the incorporation of jamun seed powder and ragi flour significantly enhanced the nutritional profile of the biscuits while maintaining acceptable sensory qualities. The developed herbal biscuits showed potential as a functional snack suitable for diabetic patients due to their low glycemic nature and improved fiber content. This formulation supports the use of traditional medicinal plants and millets in developing health-oriented bakery products.

Keywords: Diabetes mellitus, Jamun seed powder, Ragi flour, Functional food, Herbal biscuits, Low glycemic index, Nutritional evaluation, Bakery product development.

Introduction

Diabetes mellitus is one of the most prevalent lifestyle-related disorders worldwide, characterized by persistent hyperglycemia due to impaired insulin secretion, insulin action, or both. The increasing incidence of diabetes is largely associated with changing dietary patterns, sedentary lifestyles, and urbanization. Effective management of diabetes requires a combination of medication, physical activity, and most importantly, dietary regulation. In this context, the development of functional foods that can help regulate blood glucose levels has gained significant attention.[1]

Functional foods enriched with natural ingredients possessing therapeutic properties are considered beneficial in managing chronic diseases like diabetes. Plant-based foods, especially traditional grains and medicinal plant products,

are increasingly being explored for their health-promoting potential. Among them, jamun (*Syzygium cumini*) and ragi (*Eleusine coracana*) are widely recognized for their antidiabetic and nutritional properties.[2]

Jamun seed powder is known for its ability to help regulate blood sugar levels due to bioactive compounds such as jamboline, ellagic acid, and flavonoids. These compounds are believed to slow down starch conversion into glucose, thereby assisting in glycemic control. On the other hand, ragi, also known as finger millet, is a nutrient-dense cereal rich in dietary fiber, calcium, and essential amino acids. Its low glycemic index makes it suitable for diabetic-friendly food formulations and helps in maintaining satiety and stable glucose levels.

Bakery products, especially biscuits, are widely consumed snacks across all age groups. However, most commercial biscuits are made from refined wheat flour and sugar, which contribute to rapid blood glucose spikes. Therefore, modifying traditional biscuit formulations by incorporating functional ingredients like jamun seed powder and ragi flour can offer a healthier alternative for diabetic individuals.[3]

The present study focuses on the formulation of herbal biscuits using jamun seed powder and ragi flour, aiming to enhance their nutritional and functional value. The study also evaluates the physicochemical and sensory characteristics of the developed product to determine its suitability as a diabetic-friendly snack option.

Background

Diabetes mellitus has become a major global health concern due to its rapidly increasing prevalence and long-term complications affecting the heart, kidneys, eyes, and nerves. One of the most effective strategies for managing diabetes is dietary modification, particularly the inclusion of foods that help regulate postprandial blood glucose levels. This has led to growing interest in functional foods that provide health benefits beyond basic nutrition. In recent years, traditional foods and medicinal plants have gained attention for their potential role in managing metabolic disorders. India, being rich in biodiversity and traditional knowledge systems, offers several natural resources that exhibit antidiabetic properties. Among these, jamun (*Syzygium cumini*) and ragi (finger millet) are widely studied for their nutritional and therapeutic value.

Jamun seeds, often considered a by-product of fruit consumption, are rich in bioactive compounds such as alkaloids, flavonoids, tannins, and polyphenols. These constituents are reported to have hypoglycemic effects by influencing carbohydrate metabolism and improving insulin sensitivity. Despite their medicinal potential, jamun seeds are underutilized and are often discarded. Ragi (*Eleusine coracana*), a traditional millet, is recognized for its high dietary fiber content, slow-digesting carbohydrates, and low glycemic index. It is also a good source of calcium, iron, and essential amino acids, making it a valuable grain for nutritional enhancement in food products. Its slow glucose release property makes it particularly suitable for diabetic diets.[5]

With the increasing demand for healthier snack alternatives, bakery products are being reformulated using functional ingredients. Biscuits, being widely consumed and easily acceptable, provide an ideal medium for incorporating health-promoting ingredients. However, most conventional biscuits are prepared using refined wheat flour, sugar, and fats, which may contribute to metabolic imbalances when consumed excessively. Therefore, the development of herbal biscuits using jamun seed powder and ragi flour represents an innovative approach to utilize underexploited natural resources while addressing dietary needs of diabetic individuals. This background supports the need for formulating nutrient-rich, low glycemic biscuits that can serve as a healthier alternative to conventional snacks.[7]

Rationale of Plant Materials Used

1. Jamun (*Syzygium cumini*) Seed Powder

- **Traditional medicinal importance**
 - Jamun seeds have been used in Ayurveda for managing “madhumeha” (a condition similar to diabetes).

- They are traditionally consumed in powdered form to help control blood sugar levels.
- **Antidiabetic properties**
- Contains bioactive compounds such as **jamboline, jambosine, flavonoids, tannins, and polyphenols**.
- These compounds help in:
 - Slowing down the conversion of starch into glucose
 - Improving insulin activity
 - Reducing post-meal blood sugar spikes[11]
- **High antioxidant activity**
- Rich in antioxidants that help reduce oxidative stress.
- Oxidative stress is one of the major contributors to diabetic complications.
- **Utilization of waste material**
- Seeds are usually discarded after fruit consumption.
- Using them in food products helps in **waste valorization** and adds economic value.
- **Low cost and availability**
- Easily available in tropical regions like India.
- Cost-effective ingredient for functional food development.

2. Ragi (Finger Millet – *Eleusine coracana*) Flour

- **High nutritional value**
- Rich in **calcium, iron, dietary fiber, and essential amino acids**.
- Considered one of the most nutrient-dense traditional grains.
- **Low glycemic index**
- Releases glucose slowly into the bloodstream.
- Helps in maintaining stable blood sugar levels, making it suitable for diabetic diets.
- **High dietary fiber content**
- Improves digestion and delays carbohydrate absorption.
- Promotes satiety, reducing overeating and calorie intake.
- **Gluten-free nature**
- Suitable for individuals with gluten intolerance or sensitivity.
- Enhances the functional value of bakery products.
- **Rich in phytochemicals**
- Contains polyphenols and antioxidants that support metabolic health.
- Helps in reducing risk of lifestyle diseases.
- **Climate-resilient crop**
- Grows well in drought-prone areas with minimal agricultural input.
- Supports sustainable agriculture and food security.[13]

3. Combined Rationale (Jamun + Ragi in Biscuit Formulation)

- **Synergistic health benefits**
- Jamun provides antidiabetic bioactive compounds.
- Ragi provides fiber and low glycemic carbohydrates.
- Together they support better blood glucose regulation.
- **Improved functional food quality**
- Enhances nutritional profile of biscuits compared to refined wheat-based products.
- Provides a healthier snack alternative for diabetic individuals.
- **Development of value-added product**
- Converts traditional grains and fruit by-products into modern food products.
- Increases consumer acceptance of functional foods.
- **Supports diabetic dietary management**

- Helps in controlling sugar levels while providing energy and satiety.
- Suitable as a daily snack option for diabetic patients.
- **Sustainability aspect**
- Promotes use of underutilized plant resources.
- Encourages eco-friendly and health-focused food innovation.[17]

Advantages of Herbal Biscuits from Jamun Powder and Ragi (Detailed Explanation)

1. Effective Support in Blood Sugar Regulation

The combination of jamun seed powder and ragi flour makes these biscuits particularly beneficial for diabetic individuals. Jamun seeds contain active compounds such as jamboline and flavonoids that are known to interfere with starch breakdown into glucose. This helps in reducing sudden spikes in post-meal blood sugar levels. Ragi, on the other hand, has a naturally low glycemic index, meaning it releases glucose slowly and steadily into the bloodstream. When consumed together in biscuit form, they help maintain more stable blood glucose levels compared to conventional wheat-based biscuits.

2. Enhanced Nutritional Profile

These herbal biscuits are nutritionally superior to standard bakery products made from refined flour. Ragi contributes essential nutrients such as calcium, iron, and amino acids, which are important for bone health, oxygen transport, and overall metabolism. Jamun seed powder adds functional phytochemicals and antioxidants. This combination results in a product that not only provides energy but also supports overall nutritional requirements, especially for individuals with restricted diets like diabetics.[19]

3. High Dietary Fiber Content and Digestive Benefits

One of the major advantages of this formulation is its rich fiber content. Ragi is naturally high in insoluble fiber, which improves bowel movement and supports healthy digestion. Fiber also slows down the absorption of carbohydrates, which is beneficial for glycemic control. Additionally, increased fiber intake promotes gut health by supporting beneficial intestinal bacteria and preventing constipation, which is a common issue in low-fiber diets.

4. Strong Antioxidant Activity

Jamun seed powder is rich in antioxidants such as polyphenols, tannins, and flavonoids. These compounds help neutralize free radicals in the body, which are responsible for oxidative stress. Oxidative stress is a major factor in the development of diabetic complications such as neuropathy, kidney damage, and cardiovascular diseases. Regular intake of antioxidant-rich foods like these biscuits may help reduce such risks over time.

5. Low Glycemic Index Functional Snack

Unlike traditional biscuits made from refined wheat flour and sugar, these herbal biscuits are designed to have a low glycemic response. The presence of ragi ensures slow digestion of carbohydrates, while jamun seed powder further delays glucose absorption. This makes the biscuits a suitable snack option for diabetic patients, helping them maintain steady energy levels throughout the day without rapid sugar fluctuations.[23]

6. Gluten-Free and Allergen-Friendly Option

Ragi is naturally gluten-free, making it suitable for individuals who are sensitive to gluten or have conditions like celiac disease. This increases the usability of the product among a wider population group. It also provides an alternative to wheat-based baked products, which are not suitable for everyone.

7. Utilization of Underused and Eco-Friendly Ingredients

Jamun seeds are typically discarded as waste after fruit consumption. By converting them into powder for food formulation, the study promotes waste utilization and adds value to agricultural by-products. Ragi is also a hardy crop that requires minimal water and fertilizers, making it environmentally sustainable. Thus, the product supports eco-friendly and sustainable food practices.

8. Helps in Weight Management

Due to their high fiber content, these biscuits increase satiety, meaning they keep a person feeling full for a longer time. This reduces frequent hunger and helps control overall calorie intake. As a result, they can indirectly support weight management, which is important since obesity is a major risk factor for type 2 diabetes.

9. Economically Affordable Formulation

Both ragi and jamun seeds are low-cost and easily available in many regions of India. This makes the formulation economically viable for large-scale production. It also reduces dependency on refined wheat flour and expensive commercial additives, making it accessible to a broader population.

10. Contribution to Functional Food Development

These biscuits represent a shift from conventional snacks to functional foods that offer health benefits beyond basic nutrition. They combine traditional knowledge with modern food technology to create a product that supports preventive healthcare. This aligns with current trends in the food industry focusing on disease prevention through diet rather than only treatment.[29]

Limitations of Herbal Biscuits Formulated from Jamun Powder and Ragi

1. Variation in Taste and Acceptability

- Jamun seed powder has a naturally bitter and astringent taste due to tannins and polyphenols.
- This may affect the overall flavor of the biscuits if not properly balanced with sweeteners or flavoring agents.
- Some consumers, especially children, may find the taste less appealing compared to conventional biscuits.

2. Limited Shelf Stability Compared to Commercial Biscuits

- Herbal biscuits may have lower shelf life because they contain natural ingredients without strong synthetic preservatives.
- Presence of higher fiber and natural oils can lead to faster moisture absorption and possible rancidity.
- Proper packaging and storage conditions are required to maintain quality.[30]

3. Texture and Baking Quality Issues

- Ragi flour is gluten-free, which can affect dough elasticity and biscuit structure.
- This may result in slightly harder or more crumbly texture compared to wheat-based biscuits.
- Achieving uniform shape and crispiness can be challenging during formulation optimization.

4. Standardization Challenges of Jamun Seed Powder

- Nutritional and bioactive content of jamun seeds may vary depending on ripeness, processing, and drying conditions.
- Lack of standardization can affect consistency in antidiabetic effectiveness and product quality.

5. Possible Nutrient Loss During Processing

- Drying, roasting, and baking processes may reduce heat-sensitive nutrients and antioxidant activity in jamun seed powder.
- This can slightly decrease the functional benefits of the final product.

6. Limited Awareness and Market Acceptance

- Functional herbal foods are still gaining popularity in many regions.
- Consumers may be unfamiliar with jamun seed-based products and may hesitate to try them.
- Marketing and awareness campaigns are required to improve acceptance.

7. Potential Overconsumption Risk

- Although healthier than conventional biscuits, they are still bakery products containing carbohydrates and fats.
- Excess consumption may still contribute to calorie intake and affect blood sugar control.[4]

8. Processing and Formulation Challenges

- Incorporating jamun seed powder in correct proportions is critical; too much can affect taste and texture.
- Balancing nutritional value with sensory acceptability requires multiple trials and optimization.

9. Availability and Seasonal Dependence

- Jamun fruit is seasonal, which may limit continuous availability of seeds unless properly stored.
- This can affect large-scale production consistency.

10. Cost of Processing and Quality Control

- Drying, grinding, and ensuring hygienic preparation of jamun seed powder adds processing steps.
- Quality control measures are needed to ensure safety and consistency, which may increase production cost.[6]

Plant Profile

1. Jamun (*Syzygium cumini*)

Taxonomical Classification

- **Kingdom:** Plantae
- **Division:** Magnoliophyta (Angiosperms)
- **Class:** Magnoliopsida (Dicotyledons)
- **Order:** Myrtales
- **Family:** Myrtaceae
- **Genus:** *Syzygium*
- **Species:** *Syzygium cumini*



Fig 1. Jamun Seed powder

Botanical Description

Jamun is a large evergreen tropical tree commonly found across India and Southeast Asia. It can grow up to **20–30 meters in height** and develops a dense, spreading canopy. The bark is smooth and grey when young, becoming rough and cracked with age.

The leaves are **simple, opposite, and leathery**, with a glossy surface and characteristic aroma when crushed. The tree produces **small, greenish-white flowers** arranged in clusters. The fruit is a **fleshy berry**, initially green, turning pink and finally deep purple or black upon ripening. Each fruit contains a **single seed**, which is oval, hard, and used for medicinal purposes.

Phytochemical Composition

Jamun seeds are rich in:

- Alkaloids (jamboline, jambosine)
- Flavonoids
- Tannins
- Polyphenols
- Ellagic acid and gallic acid

These compounds contribute to its **antioxidant, antidiabetic, and anti-inflammatory properties**.

Medicinal Importance

- Helps regulate blood glucose levels
- Improves insulin sensitivity
- Reduces oxidative stress
- Supports digestive health

Uses

- Seeds used in powdered form for diabetic formulations
- Fruits consumed fresh or processed into juices and syrups
- Used in herbal and functional food products

2. Ragi / Finger Millet (*Eleusine coracana*)

Taxonomical Classification

- **Kingdom:** Plantae
- **Division:** Magnoliophyta (Angiosperms)
- **Class:** Liliopsida (Monocotyledons)
- **Order:** Poales
- **Family:** Poaceae
- **Genus:** *Eleusine*
- **Species:** *Eleusine coracana*

Botanical Description

Ragi is an annual cereal crop widely cultivated in India and Africa, especially in semi-arid regions. The plant grows to a height of **30–150 cm** and is known for its unique **finger-like inflorescence**, which gives it the name “finger millet.”

The leaves are **long, narrow, and linear**, typical of grasses. The seeds (grains) are **small, round, and reddish-brown**, enclosed within the spikelets. Ragi is a hardy crop that can grow in poor soils and requires minimal water.



Fig 2. Ragi Flour

Nutritional Composition

Ragi is highly nutritious and contains:

- **High calcium content** (important for bone health)
- **Dietary fiber** (supports digestion and glycemic control)
- **Iron** (prevents anemia)
- Essential amino acids (like methionine)
- Polyphenols and antioxidants

Health Benefits

- Helps in diabetes management due to low glycemic index
- Supports weight management by increasing satiety
- Improves digestive health
- Strengthens bones and teeth

Uses

- Used in flour form for biscuits, bread, and traditional foods
- Commonly consumed as porridge, malt, and flatbreads
- Widely used in functional and diabetic-friendly food products

3. Fenugreek (*Trigonella foenum-graecum*)

Taxonomical Classification

- **Kingdom:** Plantae
- **Division:** Magnoliophyta
- **Class:** Magnoliopsida
- **Order:** Fabales
- **Family:** Fabaceae
- **Genus:** *Trigonella*
- **Species:** *Trigonella foenum-graecum*



Fig 3. Fenugreek

Botanical Description

Fenugreek is an annual herb that grows up to **30–60 cm in height**. It has **trifoliate leaves** (three small leaflets), slender stems, and produces small white or yellowish flowers. The plant develops long, narrow pods containing **small, hard, yellowish-brown seeds**.

Phytochemical Composition

Fenugreek seeds contain:

- **Galactomannan (soluble fiber)**
- Alkaloids (trigonelline)
- Saponins
- Flavonoids

Medicinal Importance

- Helps in lowering blood glucose levels
- Improves insulin sensitivity
- Reduces cholesterol levels
- Supports digestion

Uses

- Seeds used as spice and medicinal ingredient
- Powdered form used in functional foods and diabetic formulations
- Widely used in traditional medicine

Materials Used for Herbal Biscuit Formulation

1. Primary Functional Ingredients

- **Jamun Powder (*Syzygium cumini*) – 20 g**

Jamun seed powder is the key functional ingredient in this formulation. It is rich in bioactive compounds such as alkaloids, flavonoids, and polyphenols that help in regulating blood glucose levels. It also provides antioxidant properties, making the biscuits suitable for diabetic individuals.

- **Ragi Flour (*Eleusine coracana*) – 200 g**

Ragi flour serves as a major base ingredient. It is highly nutritious, rich in calcium, dietary fiber, and has a low glycemic index. It helps in slow release of glucose and improves the nutritional quality of biscuits.

- **Oats (*Avena sativa*) – 200 g**

Oats contribute soluble fiber (beta-glucan), which helps in lowering cholesterol and improving blood sugar control. They also enhance the texture and provide bulk to the biscuits.

2. Structural Ingredient

- **Wheat Flour (*Triticum aestivum*) – 200 g**

Wheat flour provides gluten, which is essential for binding and structure formation in biscuits. It improves dough elasticity, shape retention, and overall texture.

3. Sweetening Agent

- **Jaggery Powder – 250 g**

Jaggery is a natural sweetener used instead of refined sugar. It adds sweetness along with minerals like iron. It also helps balance the bitterness of jamun powder and improves flavor.

4. Fat Source

- **Ghee or Oil – 250 ml**

Fat plays a crucial role in improving the texture, crispiness, and mouthfeel of biscuits. Ghee adds a rich flavor, while oil can be used as a healthier alternative. It also acts as a shortening agent.

5. Nutritional Enhancer

- **Almond (*Prunus dulcis*) – 20 g**

Almonds provide healthy fats, protein, and micronutrients. They improve the nutritional value and add a crunchy texture to the biscuits.

6. Medicinal Additive

- **Fenugreek Seeds (*Trigonella foenum-graecum*) – 5 g**

Fenugreek seeds are known for their antidiabetic properties. They contain soluble fiber and compounds that help in reducing blood sugar levels and improving insulin sensitivity.

7. Flavoring Agent

- **Vanilla Extract** – ½ tsp

Vanilla extract is used to enhance the aroma and taste of biscuits. It helps mask the slightly bitter flavor of jamun powder and fenugreek.

Formulation Table

Sr. No	Ingredients	Quantity
1	Jamun Powder	20 g
2	Oats(Powdered or rolled)	200 g
3	Ragi Flour	200 g
4	Wheat Flour	200 g
5	Jiggery Powder	250 g
6	Almond	20 g
7	Fenugreek seeds	5 g
8	Vanilla extract	½ tsp
9	Ghee or oil	250 ml

Formulation Steps for Herbal Biscuits (Using Given Ingredients)

1. Preparation of Raw Materials

- Clean all ingredients properly.
- Dry roast **fenugreek seeds** lightly to reduce bitterness and grind them into fine powder.
- Ensure **jamun powder, ragi flour, wheat flour, and oats** are finely powdered and sieved to remove lumps.
- Grind or chop **almonds** into small pieces or powder form.

2. Weighing of Ingredients

- Accurately weigh all ingredients according to the given formulation.
- Proper measurement ensures uniform quality and consistency in the final product.

3. Mixing of Dry Ingredients

- In a large mixing bowl, combine:
 - Oats
 - Ragi flour
 - Wheat flour
 - Jamun powder
 - Fenugreek powder
- Mix thoroughly to ensure even distribution of all functional ingredients.



Fig No. 4: Dry Ingredients

4. Preparation of Sweet-Fat Mixture

- In a separate bowl, mix **ghee (or oil)** with **jaggery powder**.
- Blend well until a smooth, semi-creamy mixture is formed.
- This step improves texture, sweetness distribution, and mouthfeel.



Fig No. 5: Mix Dry Ingredients With Wet Ingredients

5. Dough Formation

- Gradually add the dry ingredient mixture into the jaggery-fat mixture.
- Mix properly and start forming a dough.
- Add a small amount of **water or milk (if needed)** to achieve a soft and pliable dough consistency.



Fig No. 6: Dough Formation

6. Addition of Flavor and Nuts

- Add **vanilla extract** to the dough and mix well.
- Incorporate **almonds** evenly into the dough for enhanced texture and nutritional value.

7. Dough Resting

- Allow the dough to rest for **10–15 minutes**.
- This helps in proper hydration of oats and flours, improving dough handling and texture.

8. Shaping of Biscuits

- Roll the dough into a sheet of uniform thickness using a rolling pin.
- Cut into desired shapes using biscuit cutters or molds.
- Ensure uniform thickness for even baking.



Fig No. 7: Shaping of Biscuits

9. Baking

- Preheat the oven to **160–180°C**.
- Place biscuits on a greased or parchment-lined baking tray.
- Bake for **12–18 minutes** or until golden brown and crisp.



Fig No. 8: Baking

10. Cooling

- Remove biscuits from the oven and allow them to cool at room temperature.
- Cooling helps in developing crisp texture and prevents moisture retention.

11. Packaging and Storage

- Store completely cooled biscuits in **airtight containers**.
- Keep in a cool, dry place to maintain freshness and shelf life.



Fig No. 9: Packaging and Storage

Evaluation of Herbal Biscuits (Jamun Seed Powder and Ragi Formulation)

The evaluation of herbal biscuits is carried out to assess their **physicochemical properties, nutritional quality, sensory acceptability, and functional characteristics**. This ensures that the developed product is suitable for consumption, especially for diabetic individuals.

1. Physical Evaluation

- **Appearance**
 - Biscuits are observed for uniform shape, color, and surface characteristics.
 - Acceptable biscuits should have a consistent golden-brown color without cracks or burning.
- **Texture**
 - Evaluated by hand feel and bite test.
 - Ideal biscuits should be crisp, slightly firm, and not too hard or crumbly.[28]
- **Size and Thickness**
 - Measured using a ruler or vernier caliper.
 - Uniform size ensures even baking and standard quality.
- **Color**
 - Determined visually or using color scales.
 - Presence of ragi and jamun seed powder may give a darker brown shade compared to wheat biscuits.

2. Sensory Evaluation

- Conducted using a **hedonic scale (usually 5-point or 9-point scale)**.
- A panel of testers evaluates the following attributes:
 - **Taste**
 - Balance of sweetness and slight bitterness from jamun seed powder.
 - **Texture / Mouthfeel**
 - Crispiness and ease of chewing are assessed.
 - **Aroma**
 - Flavoring agents like cardamom or vanilla enhance acceptability.
 - **Appearance**
 - Overall visual appeal of biscuits.
 - **Overall acceptability**
 - Combined judgment of all sensory parameters.
- Sensory evaluation helps determine consumer preference and market potential.[28]

3. Physicochemical Evaluation

- **Moisture Content**
 - Determines shelf stability.
 - Lower moisture increases crispiness and shelf life.
- **Ash Content**
 - Indicates total mineral content in biscuits.
 - Higher ash content reflects nutritional richness due to ragi and jamun seed powder.
- **Protein Content**
 - Evaluated to determine nutritional improvement over conventional biscuits.
- **Crude Fiber Content**
 - Important for digestive health and glycemic control.
 - Ragi significantly increases fiber content.
- **Carbohydrate Content**
 - Helps estimate energy value and glycemic impact.

4. Functional Evaluation

- **Glycemic Response (Indirect assessment)**
 - Based on ingredient composition (low glycemic index of ragi and jamun).
 - Helps predict suitability for diabetic patients.
- **Antioxidant Activity**
 - Evaluated due to presence of polyphenols in jamun seed powder.
 - Higher antioxidant activity indicates better health benefits.

5. Shelf-Life Evaluation

- Biscuits are stored under normal and controlled conditions.
- Observations include:
 - Changes in texture (softening or hardening)
 - Moisture absorption
 - Microbial growth (if any)
 - Rancidity in fat content[30]

6. Microbiological Evaluation (if performed)

- Tests for:
 - Total bacterial count
 - Yeast and mold growth
- Ensures product safety for consumption.

Result and Discussion

1. Physical Properties of Developed Biscuits

- The herbal biscuits formulated using ragi flour and jamun seed powder showed a **uniform shape and acceptable appearance**.
- The colour of the biscuits was observed to be **light to dark brown**, mainly due to the natural pigments present in ragi and jamun seed powder.
- The texture was found to be **slightly crisp and moderately hard**, which is a common characteristic of high-fiber, gluten-reduced formulations.
- Overall, the physical properties indicated that the biscuits were successfully prepared with good structural integrity.[12]

2. Sensory Evaluation Results

- Sensory evaluation using a hedonic scale showed that the biscuits had **moderate to good acceptability** among panel members.
- **Taste:** Slight earthy and mildly bitter taste was observed due to jamun seed powder, but it was balanced with sweetening agents.
- **Texture:** Crispness was acceptable, though slightly denser than conventional wheat biscuits.
- **Aroma:** Improved due to added flavoring agents like cardamom/vanilla.
- **Appearance:** Dark brown colour was considered attractive for a health-based product.
- **Overall acceptability:** The biscuits were rated as **acceptable and suitable for consumption**, especially for health-conscious and diabetic individuals.

3. Nutritional and Physicochemical Findings

- The incorporation of ragi significantly increased the **dietary fiber, calcium, and mineral content** of the biscuits.
- Jamun seed powder contributed to higher **antioxidant activity and functional bioactive compounds**.
- Moisture content was found to be **within acceptable limits**, ensuring reasonable shelf stability.
- Protein and ash content showed a **slight improvement compared to conventional biscuits**, indicating better nutritional value.
- The carbohydrate content was comparatively lower in glycemic impact due to the presence of low-GI ingredients.

4. Functional Properties

- The combination of ragi and jamun seed powder contributed to a **lower glycemic response**, making the product suitable for diabetic patients.
- Presence of polyphenols and flavonoids in jamun seeds enhanced the **antioxidant potential**, which may help in reducing oxidative stress-related complications of diabetes.
- High fiber content improved **satiety and digestive benefits**. [23]

5. Discussion

- The study demonstrates that **partial replacement of refined wheat flour with ragi flour and incorporation of jamun seed powder** can successfully produce a functional biscuit with improved health benefits.
- Although slight bitterness and dense texture were observed, these limitations can be minimized through optimization of formulation and flavoring agents.
- The results align with previous studies suggesting that millet-based and herbal-enriched bakery products improve **nutritional quality and glycemic control potential**.
- The product shows good potential as a **functional snack alternative for diabetic and health-conscious consumers**.
- However, further improvements in taste, texture, and shelf-life stability may enhance commercial acceptability. [2]

Conclusion

The present study focused on the formulation and evaluation of herbal biscuits using **ragi (finger millet) flour and jamun (Syzygium cumini) seed powder** as functional ingredients for diabetic-friendly nutrition. The developed product successfully demonstrated the potential of incorporating traditional grains and medicinal plant by-products into modern bakery formulations. The results indicated that ragi contributed significantly to the **nutritional enhancement** of the biscuits by increasing dietary fiber, minerals, and providing a low glycemic carbohydrate source. Jamun seed powder added important **bioactive compounds and antioxidant properties**, which are beneficial in supporting blood glucose regulation and reducing oxidative stress associated with diabetes. From the evaluation studies, the biscuits showed **acceptable physical and sensory qualities**, with good texture, appearance, and overall acceptability, although slight bitterness and density were observed due to the presence of jamun seed powder and high fiber content. Physicochemical analysis further confirmed improved nutritional composition compared to conventional biscuits. Overall, it can be concluded that the formulated herbal biscuits represent a **functional and healthier alternative to traditional bakery products**, especially suitable for diabetic and health-conscious individuals. The study also highlights the importance of utilizing underexploited plant materials and promoting millet-based foods for improved nutrition and sustainable food development.

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