

Original Research

Formulation And Evaluation of Lactose-Free Milk Chocolate Using Bajra (Pearl Millet) Milk

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Abstract

Lactose intolerance is a common digestive condition caused by the deficiency of the enzyme lactase, which is responsible for breaking down lactose into glucose and galactose in the small intestine. When lactose is not properly digested, it leads to gastrointestinal discomfort such as bloating, diarrhea, and abdominal pain. Since dairy products are a major source of calcium and other essential nutrients, individuals with lactose intolerance often face difficulty in meeting their nutritional requirements due to limited consumption of milk and milk products. Therefore, the development of suitable dairy-free alternatives is important to support their nutritional needs. Pearl millet (Bajra) is a nutrient-rich cereal grain that can serve as an effective alternative to dairy-based ingredients. It contains significant amounts of protein, carbohydrates, dietary fiber, and essential minerals such as iron, calcium, phosphorus, magnesium, and zinc along with B-complex vitamins. Compared to many staple cereals, pearl millet provides higher energy, good protein quality, and better digestibility. It is naturally gluten-free and lactose-free, making it suitable for lactose-intolerant individuals. In addition, pearl millet provides health benefits such as controlling blood sugar levels, supporting heart health, and offering anti-inflammatory properties. Hence, the present study focuses on developing dairy-free milk chocolate using pearl millet as a value-added functional ingredient to provide a nutritious alternative for lactose-intolerant individuals.

Keywords: Pearl millet, Bajra, Lactose intolerance, Dairy-free chocolate, Functional food, Nutritional alternative, Calcium.

Introduction

The year 2023 is celebrated as the International Year of Millets. Millets are small-seeded hardy crops that grow well in dry regions or rain-fed regions. Its ayurvedic properties as Madhura in Rasa, Ruksha, and UshnaVirya and pacifies Vata and Kapha Dosha. (Kumari P *et al.*). Pearl millet (PEARL MILLET) grown mostly in marginal environments, is a resilient cereal crop, in the arid and semi-arid tropical regions of Africa and Asia (Rao *et al.*, 2006).

Pearl millet is recognized as an important crop in developing countries to overcome with food shortages and meeting the nutritional demands of a rising population. It is an essential source of dietary calories and protein for a wide segment of the poor population in their daily diet (Simwemba CG *et al.*, 1984). Bajra grains are also a rich depository of the fat-soluble retinol (vitamin A) and tocopherol (23 mg/100 g). Pearl millet grains contain 0.38mg of thiamine, 0.21 mg riboflavin, and 2.8 mg of niacin ((Hulse JH *et al.*, 1980). Bajra grains contain minerals like iron, phosphorus, magnesium, and calcium in containing appreciable amounts (Burton *et al.* 1992)

Pearl Millet grain is also rich in important micronutrients such as Fe and Zn and has a more complete amino acid profile than maize or sorghum (Ejeta *et al.*, 1987). Taken in totality, these qualities make Pearl Millet a major contributor of dietary protein, Fe, and Zn intake in a variety of rural populations in India and sub-Saharan Africa (Kodkany *et al.*, 2013).

Due to its gluten-free, lactose-free, and nutritious nature, it is gaining popularity as a grain. The benefits of Bajra as it helps control blood sugar spikes, prevents chronic conditions, and promotes heart health (Chopra RN *et al.*, 1956; Obidike J *et al.*, 2021) Due to its anti-inflammatory properties, consuming pearl millet in winter can boost the functioning of the respiratory tract, i.e., trachea and lung, which usually ease breathing.

Pearl millet is the most widely grown millet in semi-arid regions. In pearl millet the starch content of the grain varies from 62.8 to 70.5%, soluble sugar 1.2 to 2.6% and amylose 21.9 to 28.8% [Ed Gopalan, 2003]. Pearl millet's insoluble dietary fiber is present and the α amylase activity is 8 to 15 times greater in pearl millet than in wheat (Iren, 2004).

Pearl millets contains almost 9 to 13% protein, but to a large extent variation of 6 to 21% of protein content have also been observed (Saldivar, 2003). Bajra or pearl millets

comprises of several essential micro nutrients that are needed by the body (Ed Gopalan and Deosthale. NIN, 2003).

The total mineral content in pearl millets is 2.3 mg/100g which is quite high as compared to other commonly consumed cereals. It is also rich in several other vitamins like B-vitamins, potassium, phosphorous, magnesium, iron, zinc, copper and manganese. (Adeola O, 1994) Though pearl millets are nutritious, they are under-utilized in several countries, and how to consume. (Obilana A.B., 2004; Olatungi O., 1982).

Dairy products provide approximately 75 percent of the calcium available in the U.S. food supply (Gerrior S *et al.*, 1997). Adult patients with lactose intolerance should maintain a calcium intake of 1,200 to 1,500 mg per day, including actual dairy products up to their individual threshold for symptoms. Milk intake commonly has to be limited to less than 250 to 375 mL (8 to 12 oz) per day. Patients should consider drinking lactose-reduced milk or taking calcium supplements. Patients should also be advised to avoid medications that contain lactose as filler and certain food products that may contain unrecognized lactose.

Hence, the study focuses on preparing dairy-free milk chocolate for lactose-intolerant patients. The value-added food product was developed to manage their symptoms and to attain calcium and other micronutrient requirements.

Objectives

The main objective of the present study was to incorporate the highly beneficial bajra millet milk powder into the recipe of Chocolate. Hence the study was undertaken with the following objectives to:

- To prepare bajra millet milk powder
- To develop and standardize chocolate incorporated with bajra millet milk powder
- To evaluate the phytochemical composition of the developed chocolate
- To determine the nutrient content of the bajra millet milk powder incorporated chocolate

2.Review Of Literature

Millets are increasingly recognized as a nutrient-dense and climate-resilient superfood, widely consumed across Asia and Africa in forms such as porridge, bread, and fermented products. They are rich in protein, dietary fiber, vitamins, and essential minerals like iron, magnesium,

and phosphorus, while being naturally gluten-free, making them suitable for individuals with gluten intolerance. Additionally, millets contribute to the prevention of lifestyle-related disorders such as type II diabetes, obesity, and micronutrient deficiencies.

Among millets, bajra (pearl millet) stands out for both its nutritional richness and agricultural sustainability. It requires less water, fertilizers, and pesticides, and shows strong resistance to drought, pests, and diseases, making it ideal for cultivation in climate-vulnerable regions. Economically, it supports smallholder farmers and holds growing potential as an export crop. Nutritionally, pearl millet contains moderate carbohydrates, higher protein and fat content, and significant insoluble dietary fiber compared to other cereals like sorghum. Its low glycemic index (GI ~55) and high amylase activity make it particularly beneficial in managing non-insulin-dependent diabetes mellitus (NIDDM) by helping control postprandial blood glucose levels.

Overall, while millets like bajra offer substantial health, environmental, and economic benefits, strengthening the farm-to-fork value chain is essential to fully realize their potential in modern food systems.

3. Methodology

The present study titled “*Formulation and Evaluation of Lactose-Free Milk Chocolate Using Bajra (Pearl Millet) Milk*” was conducted using the following materials and methods.

3.1. MATERIALS

3.1.1. Selection of Functional Ingredients

Bajra (pearl millet) milk powder was selected as the primary functional ingredient for this study. The ingredient was ensured to be free from microbial contamination and impurities to maintain product safety and quality.

3.1.2. Place of Collection

Bajra millet grains were procured from local markets in Elayirampennai.

3.1.3. Other Ingredients

Additional ingredients required for chocolate preparation, including cocoa powder, icing sugar, and coconut oil, were also purchased from local markets in Elayirampennai.

3.1.4. Equipment Used for Analysis

A. Weighing Balance

A digital weighing balance was used for accurate measurement of raw materials during product

formulation and for weighing chemicals during analysis. Precision in measurement ensured consistency and reliability of results.

B. Hot Air Oven

A hot air oven was employed for drying and sterilizing glassware and utensils. It was also used to remove moisture from bajra milk, aiding in moisture content determination.

C. Centrifuge

A centrifuge was utilized to separate components of varying densities in the chocolate samples. This facilitated the isolation of different compounds present in the bajra milk powder incorporated chocolate.

D. Mixer Grinder (Mixie)

A mixer grinder was used to grind bajra grains and blend ingredients uniformly during chocolate preparation.

E. Colorimeter

A colorimeter was used to measure light absorbance and assess the nutrient composition of the developed chocolate samples.

3.1.5. Chemicals Used for Analysis

Analytical grade (AR) chemicals and distilled water were used for the estimation of phytochemical constituents and nutrient composition of the samples.

3.2. METHODS

3.2.1. Preparation of Bajra Milk Powder

Bajra milk powder was prepared following standard processing techniques involving soaking, grinding, extraction, and drying.

3.2.2. Development and Standardization of Chocolate

Chocolate samples were developed by incorporating bajra milk powder in varying proportions. Standardization was carried out to achieve optimal texture, taste, and overall acceptability.

3.2.3. Sensory Evaluation

The developed chocolate samples were subjected to sensory evaluation using a panel to assess attributes such as taste, texture, color, flavor, and overall acceptability.

3.2.4. Phytochemical Analysis

The chocolate samples were analyzed for the presence of phytochemicals using standard laboratory procedures.

3.2.5. Nutrient Analysis

Nutritional composition, including macronutrients and micronutrients, was determined using established analytical methods.

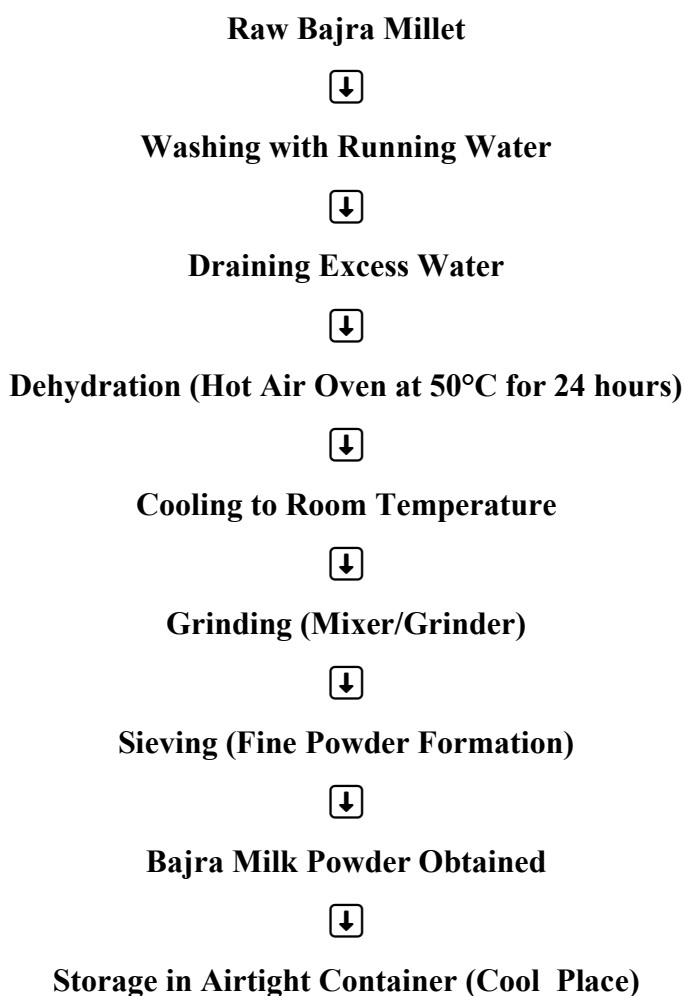
3.2.6. Statistical Analysis

The obtained data were statistically analyzed to determine significance and reliability of the results.

3.3 Methods of Bajra Milk Powder

3.3.1 Preparation of Bajra Milk powder

Figure 1 illustrates the process of preparing bajra milk powder using the hot air oven method.



3.2.1 Development and standardization of Bajra milk powder incorporated chocolate

The dehydrated samples were incorporated into the common preparation of chocolate by replacing milk powder and acceptability tests were carried by 5-panel members. Sensory evaluation is a scientific tool that uses the human senses to examine the properties that influence

the quality of the product. The ingredients used for preparing chocolate incorporated with Bajra milk powder.

Table 1

Ingredients used for the preparation of bajra millet milk incorporated chocolate

INGREDIENTS	CONTROL	SAMPLE A (BAJRA MILK POWDER INCORPORATED DARK CHOCOLATE)	SAMPLE B (BAJRA MILK POWDER INCORPORATED WHITE CHOCOLATE)
Bajra millet powder	-	20g	30g
Sugar powder	20g	20g	20g
Cocoa powder		10g	-
Coconut oil	50g	50g	50g
Milk powder	30g		

Processing of dehydrated Bajra millet milk powder incorporated chocolate

The ingredients used for preparing dark chocolate and white chocolate were incorporated with bajra millet milk powder. The ingredients such as bajra millet milk powder, sugar powder, coconut oil, and cocoa powder were grinded into a fine liquid. Preparation for bajra milk powder



Plate 4 shows the prepared Bajra millet milk powder incorporated chocolate



Plate 4

Prepared Bajra millet milk powder incorporated chocolate

3.2.3 Sensory Evaluation of Bajra Millet Milk Powder Incorporated Chocolate

Sensory evaluation was conducted using five panelists to assess quality based on human sensory perception. A hedonic scale was employed to evaluate colour, flavour, texture, taste, and overall acceptability. The mean scores of all attributes were calculated to determine the most acceptable product.

3.2.4 Phytochemical Analysis

The extract was prepared by dissolving 2 g of sample in 10 ml of 80% ethanol, kept for 24 hours, and centrifuged. The supernatant was used for phytochemical screening.

- **Tannins:** Ferric chloride test indicated by blue/green-black colour.
- **Saponins:** Formation of stable emulsion with olive oil.
- **Flavonoids:** Red colour with NaOH solution.
- **Steroids (Salkowski's test):** Red coloration with concentrated H₂SO₄.
- **Glycosides:** Reddish-brown ring and bluish-green upper layer upon reaction.
- **Phenolic compounds:** Dark green colour with ferric chloride.
- **Terpenoids:** Reddish-brown coloration with chloroform and H₂SO₄.

3.2.5 Nutrient Analysis

The biochemical composition of both control and incorporated chocolate samples was analyzed.

- **Calcium:** Determined by precipitation as calcium oxalate, followed by titration with standard KMnO₄.
- **Iron:** Estimated using Wong's method, involving formation of ferric thiocyanate and colorimetric measurement at 480 nm (AOAC, 2011).

3.2.6 Statistical Analysis

Mean values were calculated using MS Excel.

4. RESULTS AND DISCUSSION

The results obtained from the study titled "*Formulation and Evaluation of Lactose-Free Milk Chocolate Using Bajra (Pearl Millet) Milk*" are presented and discussed under the following headings:

4.1 Sensory evaluation of bajra millet milk powder incorporated chocolate

4.2 Phytochemical analysis of bajra millet milk powder incorporated chocolate

4.3 Nutrient analysis of bajra millet milk powder incorporated chocolate

4.1 Sensory Evaluation of Bajra Millet Milk Powder Incorporated Chocolate

The developed bajra millet milk powder incorporated chocolate was evaluated by a panel of judges using sensory parameters. The mean scores for colour, flavour, texture, taste, and overall acceptability were calculated for both dark and white chocolate variants and analyzed statistically. The results are presented in **Table 2**, while the graphical representation of the sensory evaluation is shown in **Figure 1**.

Table 2
Sensory evaluation of bajra millet milk powder incorporated chocolate

Criteria	Control	Sample A (Dark chocolate)	Sample B (White chocolate)
Colour	4.2 ± 0.9	3.8 ± 0.57	4.8 ± 0.27
Flavour	4.3 ± 0.84	3.6 ± 0.41	4.6 ± 0.41
Texture	4 ± 0.79	3.8 ± 0.57	4.6 ± 0.41
Taste	4.2 ± 0.57	3.9 ± 0.22	4.8 ± 0.27
Overall Acceptability	4.2 ± 0.57	4.1 ± 0.54	4.5 ± 0.5

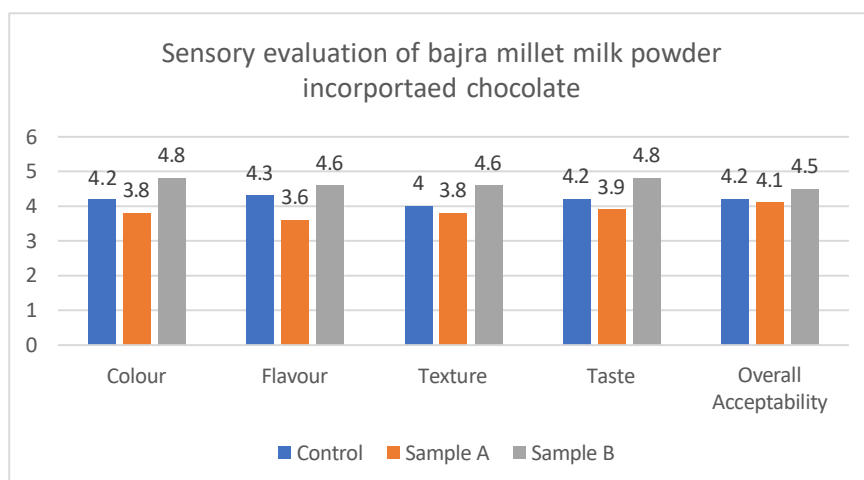


Figure: 1 Sensory evaluation of bajra millet milk powder incorporated chocolate

Table 2 and Figure 1 show the mean score of the selected chocolate incorporated with bajra millet milk powder. The evaluation of organoleptic attributes of bajra millet milk powder incorporated chocolate for colour, flavour, texture, flavour, and overall acceptability was excellent for white chocolate incorporated with bajra millet milk powder, with a mean score of 4.5 ± 0.5 , which was higher than dark chocolate incorporated with bajra millet milk powder.

4.2 Analysis of phytochemicals in bajra millet milk powder incorporated chocolate

Phytochemicals are the chemicals of plant origin. Phytochemicals (from Greek phyto meaning “plant”) are chemicals produced by plants through primary or secondary

metabolism. They generally have biological activity in the plant host and play a role in plant growth or defence against competitors, pathogens, or predators. The phytochemicals tests were done for bajra millet milk powder incorporated chocolate. The obtained results are shown in Table 3.

Table 3

Analysis of phytochemicals in bajra millet milk powder incorporated chocolate

Phyticonstituent s	Bajra millet milk powder, incorporated milk powder
Phenol	Presence
Saponin	Presence
Tannins	Presence
Glycoside	Absence
Flavonoids	Presence
Terpenoids	Presence
Steroids	Absence



Plate 5

Phytochemical analysis of Bajra millet milk powder incorporated chocolate

4.1. Nutrient analysis of bajra millet milk powder incorporated chocolate

The nutrient content of selected bajra millet milk powder incorporated chocolate was analysed and the results are given in the table 5.

Table 4

Nutrient analysis of selected bajra millet milk powder incorporated chocolate

Nutrients	Control (100g)	Sample (100g)
Iron	2 mg	7 mg
Calcium	165 mg	182 mg

The nutrient content of bajra millet milk powder incorporated chocolate was found as 7 mg iron and 182 mg calcium.

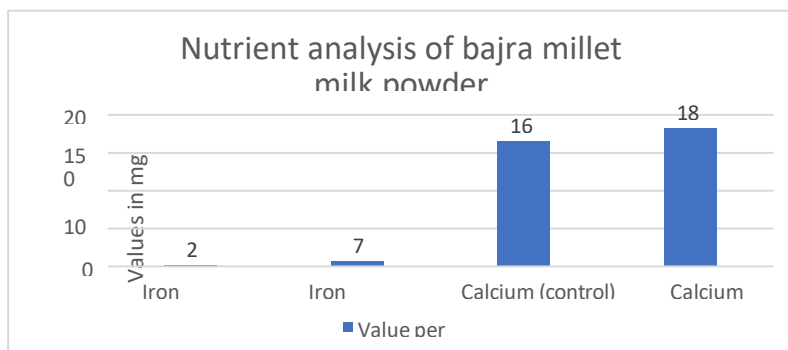


Figure 2

Nutrient analysis of bajra millet milk powder incorporated chocolate

Table 4 and Figure 2 show that the iron content in the control white chocolate was 2 mg, but the bajra millet milk powder incorporated white chocolate contained 7 mg.

Table 4 and Figure 2 show that the calcium content in the control white chocolate was 165 mg, but the bajra millet milk powder incorporated white chocolate contained 182 mg.



Plate 6



Plate 7

Analysis of iron

Analysis of calcium

Plate 6 shows the analysis of iron done for Bajra millet milk powder incorporated white chocolate and Plate 7 shows the analysis of Calcium done for Bajra millet milk powder incorporated white chocolate

5.CONCLUSION

Bajra (pearl millet) milk powder-infused white chocolate was created as a lactose-free alternative for people with lactose intolerance, leveraging the naturally nutrient-rich features of bajra, particularly its high calcium and iron content. In this study, bajra milk powder was added to or substituted for traditional milk solids in white chocolate, and the mineral makeup of the final product was examined. The results demonstrated the increased nutritional value of the bajra-incorporated white chocolate by showing that it had far greater amounts of calcium and iron than regular white chocolate. This improvement is explained by bajra's natural abundance of vital micronutrients, which makes the product useful for treating mineral deficiencies as well as lactose intolerance. All things considered, adding bajra milk powder to white chocolate is a good way to create a useful, nutrient-rich confection with potential health advantages and broader dietary applicability.

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