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Formulation, Nutrient Estimation, and Shelf-Life Analysis of Non-Dairy Foxtail Ice-Cream Pudding

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Abstract

Millets, especially Setaria italica (foxtail millet), are ancient grains valued for their short growth cycle, drought resistance, and rich nutritional composition. In recent years, millets have gained renewed interest in functional food development due to their high protein, fibre, and phytochemical content. Coconut milk, with its distinct taste and nutrient density, complements such formulations well. Together, these ingredients provide a promising foundation for creating dairy-free, gluten-free, and sugar-free desserts that align with current dietary trends. This study aimed to develop a nutritious and functional ice cream pudding incorporating foxtail millet. The objectives included conducting a sensory evaluation to assess key attributes such as appearance, texture, taste, flavour, and overall acceptability. Subsequently, the nutritional composition of the most preferred formulation was analysed. To ensure product stability, shelf-life testing was performed through titratable acidity measurement. Three pudding samples were developed using foxtail millet, coconut milk, honey, and varying fat substitutes and thickeners (coconut oil, cashew paste, rice flour, corn flour). The study was conducted in the kitchen lab of St. Joseph's Degree and PG College, Hyderabad. Sensory evaluation was performed using a 9-point hedonic scale by 30 untrained panelists. The best-rated sample underwent nutritional analysis at Vasudha Enviro Labs Pvt Ltd., and its shelf life was assessed by titratable acidity. Sample B, which was made with rice flour and coconut oil, received the highest acceptability score of 7.4 out of 9, particularly in taste and texture. Nutritional analysis of Sample B showed that it contained 422.5 kcal per 100 grams, with 17.5 grams of protein, 4.6 grams of fat, 55.9 grams of carbohydrates, 1.5 grams of fibre, and 6.4 milligrams of calcium. Titratable acidity was found to be 0.135%, indicating microbial stability and freshness within acceptable storage standards for non-dairy frozen desserts. The foxtail millet-based ice cream pudding demonstrates strong potential as a high-protein, energy-rich, clean-label dessert ideal for lactose-intolerant, health-conscious, and nutritionally vulnerable individuals due to its favourable sensory qualities and shelf stability.

Keywords: Foxtail Millet, Non-Dairy Dessert, Sensory Evaluation, Shelf-Life, Plant-Based Nutrition

Introduction

Millets, part of the Poaceae family, are ancient grains dating back to 8,000 BCE in China's Yellow River Valley, where they were key to dryland agriculture due to their drought resilience. African millets,

including pearl millet and sorghum, were domesticated around 2500-2000 BCE and introduced to India by 1700 BCE, thereby enhancing nutritional security in arid regions across the continent. Millets are categorized into major types, such as pearl and finger millet, and minor types, including foxtail and proso millet, based on their agronomic and nutritional significance.

Table 1: Classification Of Millets (Source: Rao et al., 2021, IJCRT)

	Common Name	**Scientific Name**
Major Millets	Pearl millet	*Pennisetum glaucum*
	Finger millet	*Eleusine coracana*
	Sorghum	*Sorghum bicolor*
Minor Millets	Foxtail millet	*Setaria italica*
	Proso millet	*Panicum miliaceum*
	Little millet	*Panicum sumatrense*
	Barnyard millet	*Echinochloa* spp.
	Kodo millet	*Paspalum scrobiculatum*

Nutritionally, millets are gluten-free and rich in fibre, protein, and essential minerals. They have various health benefits: pearl millet boosts immunity, finger millet supports bone health, foxtail millet aids digestion and improves lipid profiles, proso millet benefits the heart, and barnyard millet regulates blood sugar. Foxtail millet, one of the oldest cultivated crops, has a quick maturation period and provides significant nutrients. Studies show it may lower blood glucose and LDL cholesterol while offering antioxidant and anti-inflammatory effects. Traditionally used in porridges and flatbreads, healthful foxtail millet is also versatile in modern dishes.

According to recent studies, the nutrient content of foxtail millet per 100g.

- Energy: 331kcal
- Carbohydrates: 60.9 gms
- Protein: 12.3 gms
- Fat: 4.3 gms
- Fiber: 8 gms
- Calcium: 31mg
- Iron: 2.8 mg

Animal studies have shown that foxtail millet extract can reduce blood glucose levels by as much as 70%, lower triglycerides, and LDL cholesterol, and increase HDL levels. Its hypolipidemic, anticancer, antioxidant, and anti-inflammatory effects make it a promising grain for developing functional foods and nutraceuticals. It is also a good source of crude fibre, aiding in digestion and promoting bowel movements, which has a laxative effect that supports a balanced digestive system, like most millets. Foxtail millet also provides numerous health benefits, including cancer prevention and hypoglycemic effects.

Traditionally used in porridges, flatbreads, and fermented beverages, foxtail millet is now increasingly found in modern food products, including biscuits, noodles, health bars, and ice cream. (8)

Figure 1: Food products made from millets

Ice cream pudding is a dessert that combines the creamy texture of ice cream with the richness of pudding. Dairy-free ice cream pudding is a version of ice cream pudding that replaces traditional dairy products (such as milk, cream, or butterfat) with non-dairy alternatives. These alternatives can include:

1. Plant-based milks (almond milk, coconut milk, cashew milk)
2. Vegan-friendly sweeteners and flavorings

2. MATERIALS

The present work, "Formulation, Nutrient Estimation, and Shelf-Life Analysis of Non-Dairy Foxtail Ice-Cream Pudding," was done at the Nutrition Lab of St. Joseph's Degree & PG College in Hyderabad.

2.1 INGREDIENTS

The required ingredients for foxtail ice cream pudding, such as Foxtail millet, coconut milk, honey, rice flour, corn flour, cashew, coconut oil, vanilla, cardamom, and salt, were obtained from local markets.

For the formulation of the foxtail ice cream pudding, a total of three samples were made sample A, sample B, and sample C. The same procedure was followed for all samples, and the composition was observed as shown in Table 2

Table 2, Composition of Ingredients

Ingredients	Sample A	Sample B	Sample C
Foxtail Millet	100gm	100gm	100gm
Coconut Milk	125 ml	125 ml	125 ml
Honey	100gm	100gm	100gm
Rice Flour	-	15gm	-
Corn Flour	15gm	-	15gm
Cashew	-	-	15gm
Coconut Oil	10gm	10gm	-
Vanilla Essence	2-3 drops	2-3 drops	2-3 drops
Cardamom powder	2gm	2gm	2gm

2.2 Formulation of Foxtail ice cream pudding.

Three formulations were created: Sample A, which combines corn flour and coconut oil; Sample B, featuring rice flour and coconut oil; and Sample C, made with corn flour and cashew paste. The preparation

involves cooking the millet, blending it with a base, adding a thickener, straining the mixture, and chilling it for over two hours. Sensory evaluation was conducted with 30 untrained panelists using a 9-point hedonic scale to assess appearance, aroma, flavour, texture, and overall acceptability. Additionally, a nutritional analysis was performed at Vasudha Enviro Labs Pvt. Ltd. in Hyderabad to estimate the nutrient composition of the developed food product, focusing on energy, carbohydrates, protein, fat, fiber, and calcium content. A shelf-life test was also conducted to evaluate microbial stability and fermentation by assessing titratable acidity.

Variations included

- Sample A: Corn flour + Coconut oil
- Sample B: Rice flour + Coconut oil
- Sample C: Corn flour →+ Cashew paste

Fig 2 Ingredients

fig 2 Dry ingredients

fig 3 Soak foxtail millet

fig 4 Extraction of coconut milk

boiled foxtail millet.

fig 5 Boiled soak millet with

Fig 6 Blend the

Fig7 cook it with other ingredient

fig 8 Add rice flour and cook for another 15 minutes

fig 9 Refrigerate 2hr.

2.3 Method Of Preparation Of Sample:

- **Soak and Cook Millet:** Rinse, soak, and cook the millet in water until it is tender and soft.
- **Blend:** Mix cooked millet with coconut milk, honey, salt, vanilla extract, and soaked (fat substitute) (coconut oil and cashew paste), according to the sample composition.
- **Stabilize:** Cook with a thickener (corn flour and rice flour), according to the sample composition, and strain for a creamy consistency.
- **Chill**: Refrigerate for 2 hours or overnight.

2.4 Sensory Evaluation

A hedonic rating test is a sensory evaluation method used to assess consumer liking or preference for a product. It measures the degree of pleasure or enjoyment a consumer experiences when consuming a product. It was conducted as part of the sensory evaluation for a developed product, in the kitchen laboratory of the Nutrition department, at St. Joseph's Degree and PG College, Attapur, Hyderabad. With the untrained panel members, who were the students and staff of the Nutrition department. To assess consumer liking and preference. Participants rated the product based on appearance, aroma, flavour, texture, and overall acceptability using a standardized scale (extremely like 9) to (extremely dislike 1). The results provided valuable insights into participant preferences, enabling a deeper understanding of the product's strengths and weaknesses.

Table 3: 9-Point Hedonic Scale

S. No.	Remarks	Score
1	Like extremely	9
2	Like very much	8
3	Like moderately	7
4	Like slightly	6
5	Neither like nor dislike	5
6	Dislike slightly	4
7	Dislike moderately	3
8	Dislike very much	2
9	Dislike extremely	1

2.5 Titrable Acidity Test in Shelf-Life Studies

Titrable acidity is essential for tracking microbial stability and chemical changes in ice cream during storage. A rise in acidity over time signals microbial spoilage or sugar fermentation, which is particularly critical for non-dairy formulations where lactic acid bacteria or spoilage organisms may proliferate if storage conditions are inadequate (5).

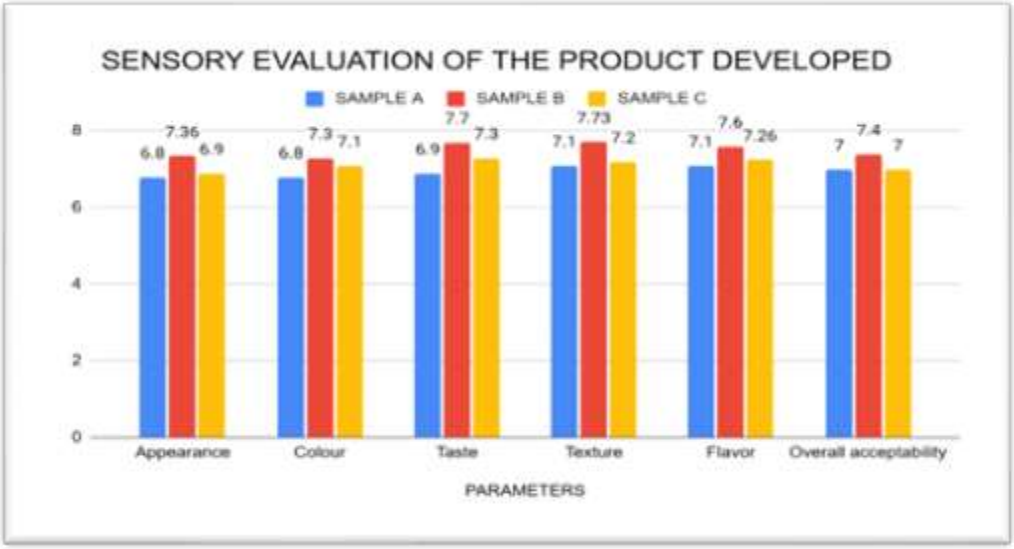
3. Results & Discussion

3.1 Sensory evaluation.

The results of the sensory evaluation. Sample A received ratings of 6.8 for appearance and colour, 6.9 for taste, 7.1 for texture and flavour, and an overall acceptability score of 7. While Sample A performed reasonably well, there is room for improvement, particularly in terms of appearance and colour.

Table 4. Sensory evaluation score

Parameters	Sample A	Sample B	Sample C
Appearance	6.8	7.36	6.9
Colour	6.8	7.3	7.1
Taste	6.9	7.7	7.3
Texture	7.1	7.73	7.2
Flavor	7.1	7.6	7.26
Overall acceptability	7	7.4	7



Sample B consistently received higher ratings across all categories, making it the preferred choice over Samples A and C. It scored 7.36 for appearance, significantly higher than Sample C's 6.9. For colour, Sample B achieved 7.3, surpassing Sample C's 7.1. In taste, Sample B scored 7.7 compared to Sample C's 7.3, indicating a stronger flavour. Sample B also outperformed Sample C in terms of texture and flavour, with scores of 7.7 and 7.3, respectively. Additionally, it had a flavour score of 7.6, compared to Sample C's 7.26. Overall, Sample B's acceptability score is 7.4, higher than Sample C's 7, confirming its superior sensory qualities. Sample B outperformed the others, particularly in taste and texture, and has been selected for nutrient estimation testing at VASUSHA ENVIRO LABS Pvt Ltd.

3.2 Nutritional Profile:

The test report on Foxtail Ice Cream Pudding analyses its nutritional profile. The sample was in excellent condition and analysed by Vasudha Enviro Labs Pvt. Ltd. in Hyderabad.

Table 5. Result of Nutritional Analysis

Nutrient	Amount per 100 grams
Calories	422.5 kcal
Dietary Fiber	1.5 grams
Protein	17.5 grams

Carbohydrates	55.9 grams
Fat	4.6 grams
Calcium	6.4 milligrams

The foxtail ice cream pudding contains a significant amount of energy, particularly for those with higher caloric needs. It is primarily from complex carbohydrates; however, it aligns with low-fat nutritional preferences. Notably, it offers a high protein beneficial for athletes and vegetarians. However, the calcium content is low compared to the daily recommended intake and may not provide sufficient support for bone health.

Fig.10

VASUDHA
enviro labs Pvt. Ltd.

TEST REPORT

CUSTOMER NAME & ADDRESS	TEST REPORT NO.	VCR – 0521- 0625
Ms. Safia Unnisa Zeba, St. Josephs Degree College Attapur.	REPORT ISSUE DATE	03rd July 2025
	REGISTRATION NO.	VEL/3932
	REGISTRATION DATE	23rd June 2025
	CUSTOMER REFERENCE	
	REFERENCE DATE	
SAMPLE DESCRIPTION: Foxtail Ice-Cream Pudding	ANALYSIS STARTING DATE	23rd June 2025
	ANALYSIS COMPLETION DATE	02nd July 2025
SAMPLE CONDITION: Good	STORAGE CONDITION	Room temperature
	CONDITION UPON RECEIPT	Acceptable
QUANTITY RECEIVED: 100 gm		
SAMPLE COLLECTED OR SUBMITTED: By Vasudha		

TEST RESULTS

S.NO	TEST PARAMETER	Method	UNITS	Results
1.	Energy	Calculated	kcal/100g	422.5
2.	Total Carbohydrates	ISSAI/ AOAC 20th Edition	g/100g	55.9
	Dietary fiber		g/100g	1.5
3.	Total Fat		g/100g	4.6
4.	Protein		g/100g	12.5
5.	Calcium		mg/100g	6.4

Note: This Report is for the samples submitted

Authorized Signatory

3.2 Shelf Life:

To test the shelf-life of the developed product, sample B was stored in a controlled environment at -18◦C for 21 days, then the titratable acidity test was performed for foxtail millet-based ice cream pudding, which was measured as 0.135% as lactic acid equivalent, determined through titration with 0.1N sodium hydroxide and phenolphthalein indicator. This acidity level is within the acceptable range (0.12%–0.20%) for non-dairy frozen products, indicating chemical stability and microbiological safety. The result suggests that there is no microbial activity or fermentation, highlighting the product's freshness and effective formulation. The low acidity also reflects a favorable sensory profile, free from sourness. Overall, this demonstrates the potential of millet-based formulations in creating stable, clean-label, plant-based frozen desserts.

Conclusion

A functional, dairy-free ice cream pudding was successfully developed using foxtail millet and coconut milk. Among the three samples, Sample B (with rice flour & coconut oil) was most preferred (mean score: 7.4/9) for taste and texture. It provided 422.5 kcal, 17.5 g protein, and 4.6 g fat per 100 g. The titratable acidity of 0.135% confirmed microbial stability for more than 20 days. This clean-label, gluten-free, sugar-free, high-protein dessert is ideal for lactose-intolerant, health-conscious, and plant-based consumers.

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