Development and Optimization of Kodo Millet Ice cream

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Abstract:

The increasing demand for functional and health-promoting food products has encouraged the incorporation of nutrient-rich ingredients into conventional dairy products. Kodo millet (Paspalum scrobiculatum), an underutilized cereal grain known for its high dietary fiber, protein content, and antioxidant potential, was incorporated into ice cream to develop a nutritionally enhanced frozen dessert. This study aimed to formulate kodo millet-based ice cream and evaluate its nutritional composition and antioxidant properties.

Ice cream samples containing kodo millet were prepared using standard processing techniques, including pasteurization, homogenization, aging, freezing, and hardening. Nutritional analysis was conducted to determine moisture, protein, fat, carbohydrate, ash, and dietary fiber contents. Antioxidant activity was assessed using DPPH radical scavenging assay, ABTS radical cation scavenging assay, phosphomolybdenum assay, and ferric (Fe^{3+}) reducing power assay.

The incorporation of kodo millet significantly increased the dietary fiber content of the ice cream while maintaining desirable product characteristics. Antioxidant analyses revealed enhanced free radical scavenging activity with increasing levels of kodo millet incorporation.

The DPPH and ABTS assays demonstrated improved radical scavenging capacity, while phosphomolybdenum and Fe^{3+} reducing power assays confirmed the enrichment of antioxidant compounds in the formulated product.

The results indicate that kodo millet can be effectively utilized in ice cream formulations to develop a nutritionally enriched and antioxidant-rich functional food product. The study highlights the potential of kodo millet as a sustainable ingredient for value-added dairy products and provides a foundation for further research on sensory quality, storage stability, and consumer acceptance for commercial applications.

,**Keywords**: Kodo millet, functional ice cream, nutritional composition, antioxidant activity, DPPH assay, ABTS assay, functional foods.

1.Introduction:

Consumer awareness of the link between diet and health has increased the demand for functional foods with benefits beyond basic nutrition. Ice cream is a widely consumed dairy product but is generally high in fat and sugar and low in dietary fiber and bioactive compounds. Incorporating functional ingredients into ice cream can improve its nutritional and health-promoting properties.

Kodo millet (Paspalum scrobiculatum) is a nutrient-rich, climate-resilient cereal containing dietary fiber, protein, minerals, and bioactive compounds such as phenolics and flavonoids. These compounds possess antioxidant,

anti-inflammatory, antidiabetic, and cardioprotective properties. Its high fiber content also supports digestive health and glycemic control.

Kodo millet has significant antioxidant potential and can serve as a natural source of bioactive compounds in food products. Although millets have been used in various foods, limited studies have explored their application in ice cream. Therefore, this study aimed to develop kodo millet ice cream and evaluate its nutritional composition and antioxidant activity using various assays. The study may contribute to the development of innovative functional dairy products and promote the utilization of underutilized millets.

2.Materials and Method:

2.1 Materials

Kodo millet (Paspalum scrobiculatum) grains were procured from a local market and cleaned to remove foreign materials. Fresh milk, cream, sugar, skim milk powder, and stabilizer were obtained from local commercial sources and used for ice cream preparation. All chemicals and reagents used for antioxidant analysis, including 2,2-diphenyl-1-picrylhydrazyl (DPPH), 2,2′-azino-bis-(3-ethylbenzothiazoline-6-sulfonic acid) (ABTS), potassium persulfate, ammonium molybdate, sulfuric acid, sodium phosphate, potassium ferricyanide, ferric chloride, and trichloroacetic acid, were of analytical grade.

2.2 Preparation of Kodo Millet Flour

The cleaned kodo millet grains were washed thoroughly and dried at room temperature. The dried grains were milled using a laboratory grinder to obtain a fine flour. The flour was sieved through a suitable mesh size to ensure uniform particle distribution and stored in airtight containers until further use.

2.3 Preparation of Kodo Millet Ice Cream

Kodo millet ice cream was prepared using a standard ice cream manufacturing process. The required quantities of milk, cream, sugar, skim milk powder, and kodo millet flour were blended thoroughly to obtain a uniform mixture. The mix was pasteurized at 80–85°C for 15 minutes and subsequently homogenized to ensure uniform dispersion of ingredients. The homogenized mix was cooled to 4°C and aged for 12–18 hours. After aging, the mix was frozen in an ice cream freezer with continuous agitation to incorporate air and achieve the desired texture. The frozen product was packed in suitable containers and hardened at –18°C for 24 hours before analysis.

Kodo Millet Grains

↓

Cleaning and Sorting

↓

Boiling with Milk

↓

Cooling

↓

Grinding

↓

Ice Bath Treatment

↓

Transfer to Containers

↓

Freezing (8–12 h)

Flowchart of kodo millet ice-creams preparation

Figure 1: Ice bath method

2.4 Proximate Composition Analysis

The nutritional composition of the prepared ice cream samples was determined using standard analytical procedures.

2.4.1 Moisture Content

Moisture content was determined by the hot-air oven method. A known weight of sample was dried at 105°C until a constant weight was obtained. Moisture content was calculated as the percentage weight loss during drying.

2.4.2 Crude Protein

Protein content was determined by the Kjeldahl method. The nitrogen content obtained was multiplied by a conversion factor of 6.25 to estimate crude protein content.

2.4.3 Fat Content

Fat content was estimated using the Soxhlet extraction method with petroleum ether as the extraction solvent.

2.4.4 Ash Content

Ash content was determined by incinerating the sample in a muffle furnace at 550°C until a light gray ash was obtained.

2.4.5 Carbohydrate Content

Total carbohydrate content was calculated by difference using the following equation:

Carbohydrate (%) = 100 – [Moisture (%) + Protein (%) + Fat (%) + Ash (%)]

2.4.6 Dietary Fiber Content

Dietary fiber content was determined using standard enzymatic-gravimetric methods and expressed as percentage of sample weight.

2.5 Antioxidant Activity Analysis

2.5.1 DPPH Radical Scavenging Assay

The antioxidant activity of ice cream extracts was evaluated using the DPPH radical scavenging method. Briefly, 1 mL of sample extract was mixed with 3 mL of DPPH solution and incubated in the dark for 30 minutes at room temperature. The absorbance was measured at 517 nm using a UV–Visible spectrophotometer. Radical scavenging activity was calculated as:

$$\% \text{ Inhibition} = [(A_0 - A_1) / A_0] \times 100$$

Where A_0 is the absorbance of the control and A_1 is the absorbance of the sample.

2.5.2 ABTS Radical Cation Scavenging Assay

ABTS radical cation solution was prepared by reacting ABTS stock solution with potassium persulfate and allowing the mixture to stand in the dark for 12–16 hours. The ABTS solution was diluted to obtain an absorbance of approximately 0.70 ± 0.02 at 734 nm. Sample extract was added to the ABTS solution and incubated for 6 minutes. Absorbance was measured at 734 nm, and scavenging activity was calculated as percentage inhibition.

2.5.3 Phosphomolybdenum Assay

Total antioxidant capacity was determined using the phosphomolybdenum method. An aliquot of sample extract was mixed with phosphomolybdenum reagent containing sulfuric acid, sodium phosphate, and ammonium molybdate. The reaction mixture was incubated at 95°C for 90 minutes, cooled to room temperature, and absorbance was recorded at 695 nm. Results were expressed as absorbance values indicating antioxidant capacity.

2.5.4 Ferric (Fe^{3+}) Reducing Power Assay

Reducing power was evaluated by mixing sample extract with phosphate buffer and potassium ferricyanide followed by incubation at 50°C for 20 minutes. After addition of trichloroacetic acid, the mixture was centrifuged and the supernatant was reacted with ferric chloride solution. Absorbance was measured at 700 nm. Increased absorbance indicated greater reducing power and antioxidant potential.

2.6 Statistical Analysis

All experiments were carried out in triplicate and the results were expressed as mean ± standard deviation. Statistical analysis was performed using appropriate statistical software. Significant differences among samples were evaluated using one-way analysis of variance (ANOVA) at a significance level of $p < 0.05$.

3.Result:

3.1 Nutritional Composition of Kodo Millet Ice Cream

The nutritional composition of kodo millet ice cream is presented in Table 1. The formulated ice cream exhibited satisfactory nutritional characteristics with appreciable amounts of protein, carbohydrates, and dietary fiber. The incorporation of kodo millet contributed to an increase in dietary fiber content compared to conventional ice cream formulations. Moisture content was within the acceptable range for frozen dairy desserts, while fat and protein contents contributed to the desirable texture and nutritional quality of the product.

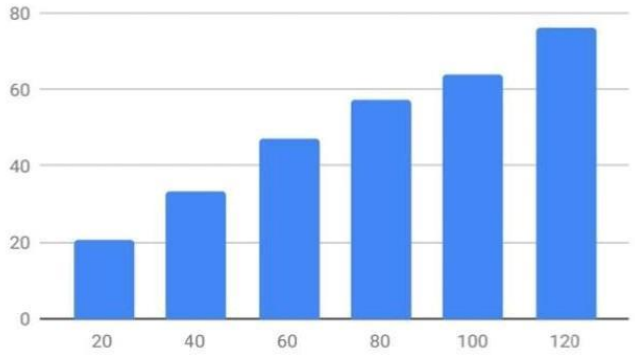
The ash content indicated the presence of essential minerals derived from both milk and kodo millet. Overall, the nutritional analysis demonstrated that the incorporation of kodo millet enhanced the nutritional profile of the ice cream, particularly with respect to fiber enrichment.

Ingredients	**Amount/100g**	**Purpose**
Kodo millet	25g	Rich in mineral and gluten free
Milk	35g	Moisture, protein, mineral
Fresh cream	20g	Creaminess and mouth full
Sugar	10g	Sweetner
Coco powder	5g	Flavour
Xanthan gum	0.1-0.2g	Stabilizer

Table 1 : Nutrition composition of kodo millet ice cream

3.2 DPPH Radical Scavenging Activity

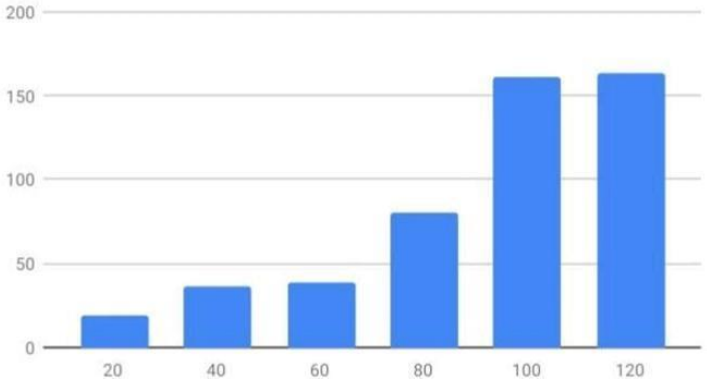
The DPPH radical scavenging activity of kodo millet ice cream demonstrated its ability to neutralize free radicals. The formulated sample exhibited significant antioxidant activity, indicating the presence of bioactive compounds such as phenolic constituents contributed by kodo millet. The percentage inhibition observed suggested an improved antioxidant potential compared with conventional ice cream.



Graph 1 : DPPH radical scavenging activity

3.3 ABTS Radical Cation Scavenging Activity

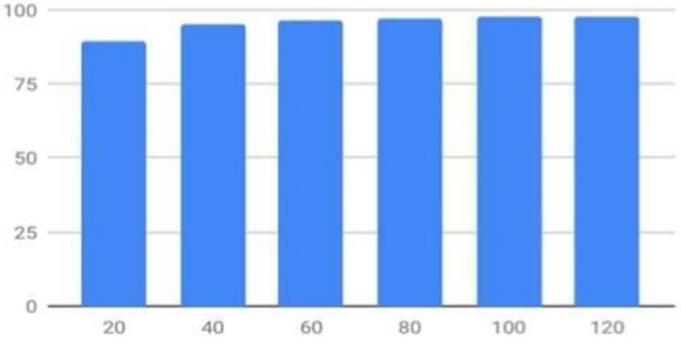
The ABTS assay further confirmed the antioxidant capacity of the kodo millet ice cream. The sample showed effective scavenging of ABTS radicals, reflecting the ability of the bioactive compounds to donate electrons and stabilize free radicals. The results were consistent with those obtained from the DPPH assay.



Graph 2 : ABTS Radical cation Scavenging activity

3.4 Phosphomolybdenum Antioxidant Activity

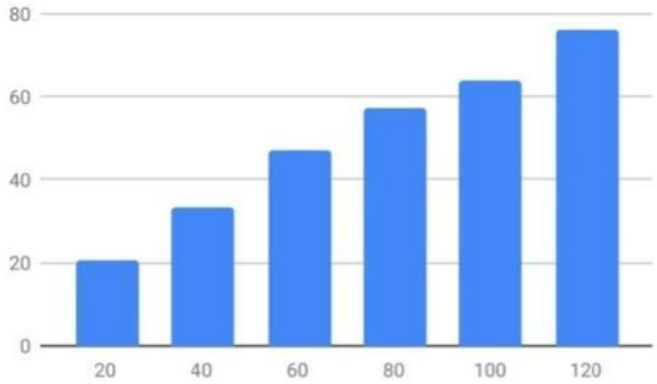
The phosphomolybdenum assay indicated the total antioxidant capacity of the formulated ice cream. Increased absorbance values reflected the enhanced antioxidant potential of the product, which may be attributed to the phenolic and flavonoid compounds present in kodo millet.



Graph 3 : Phosphomolybdenum Antioxidant Activity

3.5 Ferric (Fe^{3+}) Reducing Power

The reducing power assay demonstrated the electron-donating ability of the antioxidant compounds present in the sample. The kodo millet ice cream exhibited appreciable ferric reducing activity, suggesting its potential to act as a natural antioxidant source.



Graph 4 : Ferric (Fe^{3+}) Reducing power

3.6 Overall Findings

The results revealed that kodo millet can be successfully incorporated into ice cream to improve its nutritional and functional properties. The product showed enhanced dietary fiber content and significant antioxidant activity as evidenced by DPPH, ABTS, phosphomolybdenum, and ferric reducing power assays. These findings support the potential application of kodo millet in the development of value-added functional dairy products.

4.Conclusion:

The present study demonstrated the successful development of kodo millet-based ice cream with enhanced nutritional and antioxidant properties. Incorporation of kodo millet improved the dietary fiber content and contributed valuable nutrients, thereby enhancing the overall nutritional quality of the product. Antioxidant evaluation using DPPH, ABTS, phosphomolybdenum, and ferric (Fe^{3+}) reducing power assays confirmed the presence of bioactive compounds with significant free radical scavenging activity.

The findings indicate that kodo millet can be effectively utilized as a functional ingredient in ice cream formulations to produce a healthier frozen dessert with potential health benefits. The developed product combines the nutritional advantages of kodo millet with the sensory appeal of ice cream, offering an innovative approach to value addition in dairy products. Furthermore, the utilization of kodo millet supports the promotion of underutilized millets and contributes to the development of sustainable food products.

Overall, kodo millet ice cream represents a promising functional food with improved nutritional and antioxidant characteristics. Further studies on sensory evaluation, storage stability, and consumer acceptance are recommended to facilitate its commercialization and wider adoption in the food industry.

Figure 2 : Final product

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