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Development and Nutritional Characterization of Nutrient-Rich Kodo Millet-Based Ready-to-Drink Energy Mix

Research Article

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Abstract

In the present era of hectic lifestyles and irregular dietary habits, meeting daily nutritional requirements has become challenging for many individuals. Considering this issue, a cost-effective ready-to-drink energy mix was formulated to provide nearly one-third of the recommended daily nutritional needs of an adult. The developed product was rich in essential macronutrients and served as a good source of energy, dietary fiber, protein, iron, and calcium. Sensory evaluation was carried out using a 9-point hedonic scale by 15 semi-trained panelists, and the product showed good overall acceptability. Cost analysis, including raw material cost, overhead expenses, and profit margin, indicated that the product was economically feasible. Shelf-life stability was evaluated for 30 days through microbial assessment using the standard plate count method and the labeling of the product was designed according to the guidelines prescribed by the Food Safety and Standards Authority of India (FSSAI) 2025.

Keywords: Kodo Millet; Energy Mix; New Food Product; FSSAI, Ready-To-Drink

Introduction

Looking upon the millet production according to estimates from the Food and Agriculture Organization (FAO, 2025) [1] and the United States Department of Agriculture (USDA, 2025) [2], global millet production in 2025–2026 is estimated to be around 30–32 million metric tonnes annually. India is the leading producer, contributing approximately 12–14 million tonnes, followed by Niger, China, Nigeria, Mali, and Sudan.

With the rapid growth of the global population, rising economic development, and increasing income levels, the demand for food production and processing has expanded significantly. To meet the evolving preferences and nutritional needs of consumers, the food industry has witnessed substantial growth and diversification in food products. However, this expansion has also led to a considerable increase in food waste and the generation of food processing by-products, creating major environmental and sustainability concerns (Soni and Saxena, 2021) [3].

Millets have been widely consumed and domesticated for at least 10,000 years in Eastern Asia (Rishitha and Soni 2024) [4] and have been a staple food for thousands of years because they can be cultivated in a variety of unfavourable climates, including hot and dry climates with little rainfall. Millet can be developed into a substitute

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nutrient-dense food to meet the dietary requirements of a growing population (Yousaf *et al*., 2021) [5].

In North America and Europe, millets are increasingly gaining attention as valuable ingredients in multigrain, gluten-free, and functional food products, although they are not yet considered staple cereals in mainstream diets. In contrast, millets continue to serve as staple grains across many regions of Asia and Africa, where they are traditionally consumed in the form of porridges, fermented and unfermented breads, beverages, and snack products, particularly among rural and economically vulnerable populations. The rising global demand for nutritious and climate-resilient foods has further renewed scientific and commercial interest in millet-based products worldwide (Muskan *et al., 2025)* [6].

Kodo millet (*Paspalum scrobiculatum* L.) is considered one of the important minor millets cultivated mainly in India and parts of Africa due to its high climate resilience and nutritional value. Although exact global production statistics for kodo millet alone are limited because it is often grouped under "small millets" in international databases, recent literature indicates that India is the largest producer and cultivator of kodo millet, particularly in states such as Madhya Pradesh, Chhattisgarh, Tamil Nadu, Karnataka, and Maharashtra. Current studies suggest that kodo millet contributes significantly to the small millet sector due to its adaptability to drought-prone and low-fertility soils, supporting food and nutritional security in semi-arid regions (Mishra *et al.,2025)* [7].

Therefore, the goal of the current study is to create a product that meets the daily needs for macro and micronutrients by combining Kodo millet with other components like red gram dal, almonds, sesame seeds, and jaggery powder.

Significance of the Study

All essential bodily functions, including those involving protein, carbohydrate, fats, amino acids, and fibre, depend on energy. Small millet can be used to make energy drink powder and other instant mixes. It can also be used in traditional recipes and value-added goods to increase the nutritional content of the final product.

Kodo millet is a type of small millet that is utilized in traditional recipes and value-added goods because of its high fibre content, complex carbohydrate, low fat level, and high-quality amino acid profile. Therefore, the study's objective was to create a ready-to-drink mix that is affordable and can meet between one-third to one-fourth of an adult's daily energy needs because it contains millet, pulse, oil seeds, nuts, and jaggery powder, all of which effectively meet the body's needs for energy, protein, fat, carbohydrates, calcium, and iron. All income levels may afford it because it is convenient and economical.

Objectives of the Study

- To standardize and develop ready to drink energy powder incorporating Kodo millet.
- To conduct sensory evaluation of the developed energy.
- To determine the proximate nutritional composition of the formulated energy mix.
- To assess the shelf-life and cost of the developed mix.
- To design an appropriate food label for the formulated product.

Material and Methods

- **Location of the study**

The ready to drink energy mix was developed in the cookery lab, Dept of Nutrition and Dietetics, Nims University Rajasthan, Jaipur.

- **Procurement of raw material**

Kodo millet, red gram, sesame seeds, almond, and jaggery powder were some of the raw materials that were purchased from the local market of Jaipur city.

- **Processing of raw material**

All of the ingredients processed using a variety of techniques (such as washing, shade drying, grinding, and sieving) to get the required outcome. The finished mix was then kept at room temperature in an airtight container for further procedures.

- **Standardization and development of the energy mix**

Market survey

A market survey was carried out in Jaipur's local markets and online platforms which revealed that there are a few multi-millets mixes available to meet the daily nutritional needs of energy, carbohydrates, protein, and fat in addition to dietary fibres.

Pilot study

A pilot study was conducted in order to prepare the desired product in which Kodo millet was mixed in different proportions with red gram dal, almonds, sesame seeds and jaggery powder which was later tested by the hit and trial method and the most suitable composition was selected on the basis of their sensory characteristics.

Development of the product

In order to develop a ready-to-drink energy mix, Kodo millet was combined with red gram powder, sesame seed powder, almond powder, and jaggery powder to prepare a 100g of the mix. Four distinct variations and a control were developed where in all ingredients were combined in varying amounts; KMP1(control) (40% wheat), KMP2 (30% Kodo), KMP3 (40% Kodo), KMP4 (50% Kodo), and KMP5 (60% Kodo). The developed energy mix variations are shown in (Table 1).

Table 1: Variations of the developed energy mix

Ingredients/variation (g)	KMP1(control)	KMP2	KMP3	KMP4	KMP5
Kodo millet	-	30g	40g	50g	60g
Wheat	40g	-	-	-	-
Red gram	30g	40g	30g	20g	10g
Sesame seed	10g	10g	10g	10g	10g
Almond	10g	10g	10g	10g	10g
Jaggery Powder	10g	10g	10g	10g	10g
Total	100g	100g	100g	100g	100g

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- **Sensory Evaluation of the ready to drink energy mix**

Sensory evaluation of the developed variations was conducted where 15 semi-trained panellists were chosen based on the results of a sensitivity threshold test that was performed on 30 individuals. Using a nine-point hedonic rating scale, the product's sensory evaluation was conducted. The panellists were given the developed product to taste and rate it based on its colour, taste, aftertaste, appearance, texture, flavour, and overall acceptability. Statistical analysis of the developed product was done, in which mean and standard deviations were calculated.

- **Proximate Analysis of the Product**

For the most acceptable product of after the sensory evaluation, proximate analysis was done using the standard methods of (AOAC, 2023) [8] to analyze the macronutrients and micronutrients composition of the developed product.

- **Determination of the Shelf Life of the Product**

The developed product was kept at room temperature (25-30°C) and relative humidity (40-60%) for a maximum of 30 days. Polypropylene was the material used for packaging. In order to assess the storage quality, samples from the best-accepted product were taken in triplicates at the beginning, zero, fifteen, and thirty-day points in the storage period. The total viable count (standard plate method) was used to assess the products' microbial burden.

Analysis of Nutritive Value and Cost of the Developed Product

The most recent market list is used to determine the produced product's cost, which also accounts for expenses.

- **Development of Food Label of the Product**

The food product's label was created in accordance with the most recent Food Safety and Standards Authority of India (FSSAI) 2020 [9] guidelines for food packaging and labelling.

Table 2: Methods Used for Proximate Analysis of the Product

S. No.	Chemical Constituents	Method	References
1	Moisture	Hot Air oven method	AOAC, 2023
2	Ash	Dry Ash method	AOAC, 2023
3	Carbohydrates	Difference Method	AOAC, 2023
4	Protein	Micro-Kjeldahl method (KELPLUS)	AOAC, 2023
5	Fat	Soxhlet method	AOAC, 2023
6	Dietary Fiber	Acid-alkali wash method	AOAC, 2023
7	Total Calories	Atwater General Factor Method	AOAC, 2023
8	Iron	Wong's method	AOAC, 2023
9	Calcium	Titration method	AOAC, 2023

Table 3: Methods for determination of shelf life of the developed product

Method	Protocol
Total plate count	IS:5402(P-1):2021 [13]
Yeast and mold count	IS: 5403:1999 [14]

Table 4: List of ingredients

S.No.	Ingredients
1	Kodo Millet
2	Red Gram Dal
3	Almonds
4	Sesame Seeds
5	Jaggery Powder

Table 5: Mean scores of organoleptic characteristics of the developed product

Sample code	Color	Taste	After Taste	Texture	Overall Acceptability
KMP1	6.3±1.1	6.4±0.9	6.0±1.0	6.3±0.1	6.8±1.4
KMP2	6.2±0.9	5.8±0.6	5.4±0.6	6.0±0.7	6.4±0.9
KMP3	6.3±0.9	6.0±0.8	5.6±0.7	5.8±0.9	6.7±0.7
KMP4	6.4±0.8	6.0±1.0	6.0±0.5	6.0±0.7	7.3±0.8
KMP5	6.1±1.1	5.4±0.6	5.8±0.9	5.7±0.7	6.6±1.1

Table 6: Proximate composition of the developed mix

Proximate parameter	Quantity (per 100 g)
Moisture	8.11± 0.20 g
Ash	2.13± 0.40 g
Energy	419.04± 0.34 kcal
Carbohydrates	64.44± 0.45 g
Protein	13.32± 0.62 g
Fat	12.00± 0.43 g
Insoluble dietary fiber	15.62± 0.15 g
Soluble dietary fiber	6.27± 0.23 g
Calcium	459.23± 0.18 mg
Iron	65.58± 0.12 mg

Results And Discussion

- **Procurement and Processing of raw material**

The online marketplace and the neighbourhood market were the sources of the raw materials. In order to eliminate any dirt, foreign particles, and anti-nutritional elements, all raw materials were processed. After being cleaned and soaking in water for eight hours, Kodo millet was shade-dried for six hours to eliminate any remaining moisture. After the dried Kodo millet was ground into fine flour using a mixer grinder, it was kept at room temperature in an airtight container.

- **Standardization and Formulation of the Product**

In order to create 100g of sample, Kodo millet flour was combined with red gram powder, sesame seed, almond, and jaggery powder to create a ready-to-drink energy powder. To create four distinct samples and a control, all the ingredients were combined in varying amounts. KMP1(control) which was 40% wheat, KMP2 which was 30% Kodo, KMP3 which was 40% Kodo, KMP4 which was 50% Kodo, and KMP5 which was 60% Kodo.

- **Sensory evaluation of the developed product**

The sensory evaluation of different developed variations was done using the 9- point hedonic rating scale which showed that the variation no. KMP4 has the highest mean score for color (6.4±0.8) and overall acceptability (7.3±0.8). Hence it was selected for the further

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proximate analysis. The overall results of the organoleptic evaluation of the developed product are shown in table no. 5 given below.

The Mean scores and standard deviation of organoleptic evaluation of the developed mix was found to be high in variation (KMP4) in all the parameters i.e., color, taste, after taste, texture and overall acceptability with a value of 6.4±0.8, 6.0±1.0, 6.0±0.5, 6.0±0.7 and 7.3±0.8 respectively. (Graph 1) depicts the mean scores of overall acceptability of the different developed variations of the energy mix.

- **Proximate Analysis of the Developed mix**

The proximate composition of the developed mix is given in table no. 6 which consist of macro and micro nutrient composition i.e., moisture, ash, energy, carbohydrates, protein, fat, insoluble and soluble dietary fibers along with calcium and iron content. The total moisture content of the developed product was found to be 8.11± 0.20 g / 100 g.

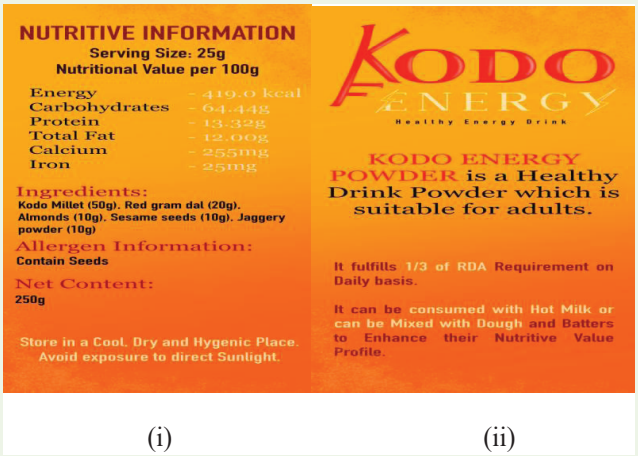
The developed Kodo millet-based mix has a total ash content of 2.13± 0.40 g /100g. Patil et al., (2020) [9] conducted a study on physical, functional, nutritional, phytochemical and antioxidant properties of Kodo millet (*Paspalum scrobiculatum*) and found that the Kodo millet has a total ash content of 1.960 g/100g of grain.

Energy is the primary requirement to do the desired work, the developed product has energy content of 419.04± 0.34 kcal /100g. Patel et al., (2018) [10] conducted a study on variety of Kodo millet and puffed Kodo and found that some variety of Kodo millet and found that the Kodo millet had energy value of 322 kcal/100g.

Graph 1: Graphical representation of organoleptic characteristics of the developed mix

(i) (ii)

Figure 2: Picture depicts the (i)front and (ii)back side of the food label of the developed product



(i) (ii)

Figure 3: Picture depicts (i)Left and (ii)Right side of the food label of the developed product

The total carbohydrates content in the developed product was found to be 64.44± 0.45 g /100g of the product. Patil et al., (2020) [9] conducted a study on physical, functional, nutritional, phytochemical and antioxidant properties of Kodo millet (*Paspalum scrobiculatum*) and found that the Kodo millet has estimated carbohydrate content per 100 g ranged from 71.11 to 72.24 g, with a mean of 71.800 g.

The total protein content in the developed product was 13.32± 0.62 g /100g of the product. The findings of Rajput *et al.* (2019) [16] reported that the total protein content in the cultivated Kodo millet grain was 7.85-8.85% in 100g of grain. The total fat content in the developed product was found to be 12.00± 0.43 g /100g of the product. Muragod *et al.* (2019) [11] reported that the total fat content is 1.3g/100g in Kodo millet grain.

The developed product had a total insoluble dietary fiber content of 15.62± 0.15 g /100g of the product. Srilekha *et al.* (2019) [12] also reported that Kodo millet flour had 4.06 ± 0.03 % of crude fiber in 100g of flour. The total soluble dietary fiber content in the developed product was reported to be 6.27± 0.23 g /100g of the product.

The total calcium content in the developed product was reported to be 459.23 ± 0.18 mg /100g of the developed product. Muragod *et al.* (2019) [11] reported the mineral content of Kodo millet has 32 mg of calcium per 100 g of the grain. The total iron content in the developed product was found to be 65.58± 0.12 mg /100g of the product. Patil et al., (2020) [9] in their study on Physical, functional, nutritional, phytochemical and antioxidant properties of Kodo millet found that the Kodo millet found that Kodo millet has 3.55 mg of iron per 100 g of grains.

- **Determination of the shelf-life of the developed mix**

Table 7: Determination of the shelf life of the developed mix

Method	0 day (cfu/g)	15 days (cfu/g)	30 days (cfu/g)
Total plate count	9×10^4	9.2×10^4	9.7×10^4
Yeast and mold count	3.9×10^2	4.12×10^2	4.13×10^2

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Table 8: Calculation of cost of the developed energy mix

Ingredients	Quantity (g)	Cost (Rs)
Kodo millet	50	10.5
Red gram	20	7.58
Almonds	10	8.6
Sesame seeds	10	14
Jaggery powder	10	3.0
Food Cost	100g	Rs.43.68/-
Overhead Charges (including labor, fuel, machinery, etc.)	20%	8.73
Profit	20%	8.73
Total	100g	Rs.61.14/-

Shelf-life evaluation of the developed kodo millet-based energy mix was carried out using standard microbiological methods, and the results are presented in (Table 7). Microbial quality was assessed by determining the bacterial, fungal, and coliform counts at different storage intervals under room temperature conditions using the standard plate count method. The findings indicated a gradual increase in bacterial count from the initial day to the 30th day of storage in the developed energy mix.

According to the guidelines of the Food Safety and Standards Authority of India (FSSAI, 2020) [13], the permissible microbial limit for total plate count in food products is 10^5 cfu/g, while the acceptable limit for yeast and mold count is 10^3 cfu/g. The microbial analysis of the developed product remained within these permissible limits throughout the storage period, indicating that the product was microbiologically safe and had a shelf life of up to 30 days under room temperature conditions. Consumption of food products within the recommended microbial limits is essential to ensure food safety and maintain overall health.

- **Cost of the developed energy mix**

Total Cost of the mix was calculated using the latest market price along with overhead charges at 20 per cent of expenditure on manufacturing which includes depreciation cost on machinery, equipment, building etc. and profit at 20 per cent was included. The detailed cost is given below in table no. 8.

- **Development of Food Label of the Developed mix**

The food label was created in accordance with the most recent Food Safety and Standards Authority of India (FSSAI) 2020 [13] regulations for food packaging and labelling, which included the elements listed below and the procreate application.

Conclusion

The present study successfully developed and standardized a Kodo millet-based ready-to-drink energy powder using red gram dal, almonds, sesame seeds, and jaggery powder in suitable proportions. Proximate analysis revealed that the developed product was rich in energy, protein, dietary fiber, calcium, and iron, making it nutritionally dense and beneficial for daily consumption. Shelf-life analysis further confirmed the product's stability and safety for storage. The food label was designed according to the latest guidelines of the Food Safety and Standards Authority of India (FSSAI). Overall, the developed energy powder proved to be a cost-effective, convenient, and nutrient-rich product capable of contributing nearly one-third of the daily nutritional requirements of an adult, particularly suitable for individuals with busy lifestyles and irregular dietary patterns.

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