

Formulation Optimization and Quality Characterization of Multiseed Bars

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Abstract—The present study focused on the formulation and quality evaluation of multiseed bars using different cereal flakes (rice, corn, wheat, and ragi) with a blend of nutritionally rich seeds such as amaranth, muskmelon, pumpkin, chironji, flax, chia, sesame, and watermelon seeds. The formulated bars were assessed for sensory acceptability, physicochemical properties, nutrient composition, antioxidant activity, microbial quality, and shelf life. Of the different formulations, corn and ragi flakes bars received the highest overall acceptability scores. The moisture and ash content ranged from 3.64–4.68% and 1.60–2.60% respectively, indicating good storage stability. Ragi flake bar had higher protein, fibre, and mineral content. Antioxidant activity assessed by DPPH assay showed concentration-dependent radical scavenging activity, while microbial and peroxide value analysis confirmed the product safety for 30 days at ambient temperature. The study concludes that the multiseed bars are nutritionally dense, antioxidant-rich, and suitable as convenient snack foods.

Index Terms—Multi seed bar; Cereal flakes; Physicochemical properties; Nutrient composition; Sensory evaluation; DPPH assay; Shelf life

I. INTRODUCTION

Nutri bars, also known as energy bars are widely consumed worldwide as highly nutritive on-the-go food products (Barakat et al 2023). Nutri seed bars can be defined as meal replacers or dietary supplements, as they are generally rich in calories and essential nutrients. They are formulated using cereals, grains, and other ingredients along with natural sweeteners. These bars serve as complete and convenient sources of energy and are categorized as Ready-to-Eat (RTE) products that effectively satisfies the hunger. Based on their nutritional composition, nutri bars can be

classified into energy bars, fruit bars, protein bars, or sports bars (Boukid et al 2022).

Owing to the increasing consumer demand for nutritious, healthy, and convenient foods, nutri bars are designed for individuals who requires rapid energy intake and lack time for complete meals, with a focus on improving the nutritional composition of whole-grain-based products. (Allai et al 2022)

Cereal flakes such as rice, corn, wheat, and ragi are widely used as base ingredients in the formulation of energy / nutrition bars due to their functional properties. These cereal flakes serve as primary sources of complex carbohydrates, providing energy while contributing structural integrity and texture of the bars. The seeds and nuts are utilized to increase its nutrient content. Seeds play a vital role in enhancing the nutritional and functional quality of the bars and are a great source of vegetarian protein, energy, fats, fibre, and antioxidants.

In the present study, to formulate nutrised bars with various seeds such as amaranth, muskmelon, pumpkin, chironji, flax, chia, sesame, and watermelon seeds were selected for their functional and nutritional properties. Cereal flakes including rice, corn, wheat, and ragi, were incorporated in different formulations. The formulated nutrised bars were evaluated for sensory acceptability, physicochemical characteristics, nutrient composition, microbial quality, and shelf life. The objective of the present study was to formulate and standardize nutrient-dense, antioxidant-rich multiseed bars by incorporating diverse cereal flakes and functional seeds and to evaluate their sensory acceptability, physicochemical characteristics, nutrient composition, antioxidant activity, microbial quality, and shelf-life stability under ambient storage conditions.

II. MATERIALS AND METHODS

Selection of ingredients

The ingredients such as oats, rice, corn, wheat and ragi flakes, dates syrup, honey, amaranth seeds, muskmelon seeds, pumpkin seeds, chironji seeds, flax seeds, chia seeds, sesame seeds, watermelon seeds, foxtail millet and butter were purchased from the local market.

Formulation and standardization of Nutri seed bars

The Nutri seed bars was formulated and standardized to develop good nutritional quality product. The Four variations (V₁, V₂, V₃, and V₄) of multiseed bars were formulated using a standardized formulation. Each formulation consists of 20g oats, 10g millets, 5g fat, 35 ml sugar syrup and 2g of flakes. A blend of seeds such as amaranth, chia, chironji, watermelon, flax, muskmelon, pumpkin, and sesame were added at a uniform level of 5 g for all variations. The variations were formulated by incorporating 2g of different cereal flakes namely V₁ rice flakes, V₂ corn flakes, V₃ wheat flakes and V₄ ragi flakes.

The dry ingredients were roasted in an open pan at 80 °C for 5 minutes and then cooled to room temperature. The roasted ingredients were ground into a coarse powder. Sugar syrup was prepared by melting butter in a pan, then added dates syrup and honey. This mixture was heated to 200°C for 5 minutes. The dry ingredients were then mixed with the sugar syrup until a thick paste was obtained. The mixture was evenly spreaded on a greased oven tray and pressed to achieve a uniform thickness. The tray was placed in a preheated baking oven at 120 °C for 5 minutes. After baking, the bars were cooled, sliced into uniform bar shapes and then packed and stored.

Organoleptic Evaluation of Nutriseed bars

The Nutriseed bars were given to 20 semi-trained panel members for evaluation of organoleptic characteristics of the products. Characteristics such as colour and appearance, texture, flavour and taste were evaluated. A 9-point hedonic rating scale was used for sensory evaluation.

Analysis of Physico-chemical properties

Physico chemical characteristics such as moisture and ash were analysed using standard procedures.

Moisture content of the Nutriseed bar was determined by oven-drying method. A known weight of sample was dried at 105 °C to constant weight, and the loss in weight was expressed as moisture content. AOAC method (2005). Ash content was determined by AOAC method (2005). A known weight of finely ground sample was incinerated in a muffle furnace at 550 °C until constant weight was obtained, and the residue was expressed as total ash.

Analysis of Nutrient composition of formulated Nutriseed bar

Carbohydrate, fat, protein, fibre, iron, calcium, vitamin C, magnesium and phosphorous were analysed in the formulated products. The total carbohydrates were tested by Anthrone method. The intensity of the green colour was measured at 630 nm using a spectrophotometer. (AOAC, 2005). Crude fat content was determined by Soxhlet extraction method. A known weight of the ground sample was extracted with petroleum ether (40–60 °C). The resultant ether extract was evaporated and fat content was calculated AOAC method (2000). The protein was determined by Micro-kjeldahl method. The percentage of nitrogen was calculated and percentage of protein was estimated in the sample by multiplying with factor 6.25 by AOAC method (2000). Crude fibre was estimated by AOAC method (2005) in which the sample was subjected to successive acid and alkali digestion and the residue obtained was expressed as crude fibre. Vitamin C content was determined by AOAC method (2010). This method determines the vitamin C concentration in a solution by redox titration using iodine.

Mineral analysis

Calcium, magnesium, iron and phosphorus were analysed by Atomic Absorption spectrophotometric method.

Antioxidant activity- DPPH assay

Antioxidant activity was determined using the DPPH radical scavenging assay. Sample extracts at different concentrations (10–150 µg/mL) were mixed with DPPH solution and incubated in the dark room for 30 min. The intensity of absorbance was measured at 517 nm using spectrophotometer against methanol as blank. (Brand-Williams, 1995)

Microbial analysis

The total bacterial count in samples indicates the number of bacteria present in the samples AOAC method (1990)

Chemical quality of the formulated products

Peroxide value

Peroxide value was estimated by the method given by Syed et al (2018)

Shelf-life analysis of nutri seed bar

Nutrised bars were packed in aluminium foil film as sachets and stored at ambient temperature. The samples were taken at regular intervals of 15 days and analysed for changes in microbial load, chemical quality, and sensory attributes on storage (30 days).

Statistical analysis

The data obtained for the nutrised bars were statistically analysed by using Paired ‘t’ test.

III. RESULTS AND DISCUSSION

Table 1 Mean sensory scores of the formulated multiseed nutri bars

Criteria	Rice flake (V ₁)	Corn flake (V ₂)	Wheat Flake (V ₃)	Ragi flake (V ₄)
Colour and Appearance	8.1 ±0.72	8.2±0.83	7.9±0.85	8.0±0.69
Texture	7.6±0.88	7.8±0.88	7.7±0.73	7.8±0.95
Flavour	7.8±0.83	8.1±0.85	8.1±0.89	8.6±0.88
Taste	7.8±0.89	8.6±0.88	8.0±0.89	8.6±0.88
Overall acceptability	7.9±0.88	8.1±0.83	8.0±0.76	8.1±0.79

V₁ rice flake = 20:10:2:5, V₂ corn flake = 20:10:2:5, V₃ wheat flake = 20:10:2:5, V₄ ragi flake = 20:10:2:5

The sensory evaluation of the formulated nutrised bars showed good acceptability, with colour and appearance scores ranging from 7.9 ± 0.88 to 8.2 ± 0.83 and texture scores from 7.6 ± 0.88 to 7.8 ± 0.95, which were higher than the moderate scores reported for traditional millet nutri bars (6.60 ± 1.17) (Pushpendra et al 2025). The flavour and taste scores of the ragi flakes were 8.6 ± 0.88 similar to the study of Shreya (2023), where the flavour and taste mean scores ranged 7.9–8.6 in finger millet-based nutri bars. Among all variations, the corn and ragi flakes bars recorded the highest overall acceptability scores with similar scores of 8.1±0.83 & 8.1±0.79 respectively. The study by Ahmad et al (2017), demonstrated that the corn flakes enhance the cereal bar palatability and the higher finger millet incorporation results in good sensory acceptance in nutri bars (Meera et al 2025). These results confirmed that the corn flakes bar achieved higher consumer acceptability than other

variations due to its crispy texture, appearance and taste of the nutri bar.

Table 2 Physico-chemical characteristics of formulated multiseed nutri bars

Nutri seed bars	Moisture (g%)	Ash (g%)
Multiseed rice flakes bar	4.13	2.60
Multiseed corn flakes bar	4.68	1.95
Multiseed wheat flakes bar	3.69	1.60
Multiseed ragi flakes bar	3.64	2.00

The moisture and ash content of the nutri bars ranged from 3.64 - 4.68% and 1.60 - 2.60 % respectively. In contrast, Samyak Lalwani et al (2025), reported a higher moisture (8.04%) in popped millet-based snack bars. The ash content reported for millet-based snack bars ranged from 1.78 - 2.51% (Jatav et al 2025) which is the comparable to the values observed in the present study.

Table 3 Nutrient composition of formulated multiseed nutri bars

Nutrients	Rice flakes	Corn flakes	Wheat flakes	Ragi flakes
Energy (Kcal)	421	465	432	487
Carbohydrates (g %)	61.5	63.1	61.8	63.1
Protein (g %)	16.8	17.2	17.0	18.2
Fat (g%)	12	16	13	18
Fibre (g %)	2.5	2.8	2.6	2.8

Iron(mg %)	3.80	2.08	2.19	4.98
Vitamin C(mg %)	1.2	1.5	2.1	1.9
Calcium(mg%)	63	71	68	81
Phosphorous(mg%)	5	5.8	5.2	6.2
Magnesium (mg %)	8.0	12.0	9.1	13.1

The proximate and mineral composition of the formulated multiseed nutri bars varied according to the type of cereal flakes incorporated (Table 3). Among the four variations, the ragi flake bar exhibited the highest energy value (487 kcal), carbohydrate (63.1g), protein (18.2g), fat (18g), fibre (2.8g), iron (4.98mg), vitamin C (1.9mg), calcium(81mg), phosphorous (6.2mg) and

magnesium(13.1mg).It corroborates with the study of Jatav et al (2025),who reported that the incorporation of finger millet, pearl millet and sorghum in ready to eat nutri bar significantly improved the mineral and nutrient content. The results confirmed that the variation with ragi flakes influenced the nutritional quality of the multiseed nutri bars for functional properties.

Table 4 DPPH assay of formulated multiseed nutri bars at different concentrations

multiseed bar	10µg	25µg	50µg	100µg	150µg	IC ₅₀
Activity (%)						
Multiseed rice flakes bar	0.5	5.5	16.4	3.7	7.8	117.96
Multiseed corn flakes bar	1.22	8.0	18.8	40.6	77.5	106.28
Multiseed wheat flakes bar	0.81	6.4	18.7	38	74.5	110.60
Multiseed ragi flakes bar	1.45	9.3	20.1	41.3	80.8	102.58

The DPPH free radical scavenging activity of nutrised bars was performed at different concentrations of 10,25,50,100,150 µg. The data revealed that the rice flakes had highest DPPH scavenging activity of 117.96 % at 50 µg/ml. Similarly in a study,the foxtail millet meal replacement bars exhibited DPPH scavenging activity of approximately 86.7% at higher concentrations (Susan and Nazni, 2020). In addition, millet–soy fortified snack bars

showed enhanced antioxidant activity, with DPPH values in the range of 96–115 µmol TEAC/100 g, depending on formulation (Bolarinwa et al 2022). Comparatively the higher scavenging activity observed in the present nutrised bars attributed to the combined effect of cereals, millets and seeds which are rich sources of phenolic compounds and other bioactive constituents.

Table 5 Mean sensory scores of the formulated multiseed nutri bars on storage

Criteria	Rice flake (V1)		Corn flake(V2)		Wheat Flake(V3)		Ragi flake (V4)	
	0 day	30thday	0 day	30thday	0 day	30thday	0 day	30thday
Colour and Appearance	8.1 ±0.72	7.1±1.1	8.2±0.83	7.3±1.1	7.9±0.85	7.3±1.1	8.0±0.69	6.85±1.1
Texture	7.6±0.88	6.4±0.9	7.8±0.88	6.5±0.9	7.7±0.73	6.35±1.0	7.8±0.95	6.3±1.0
Flavour	7.8±0.83	7.1±1.1	8.1±0.85	7.2±1.2	8.1±0.89	7.4±1.0	8.6±0.88	6.8±0.9
Taste	7.8±0.89	7.2±1.0	8.6±0.88	7.5±1.0	8.0±0.89	7.3±1.0	8.6±0.88	7.1±0.9
Overall acceptability	7.9±0.88	6.9±0.9	8.1±0.83	7.0±0.9	8.0±0.76	6.9±1.0	8.1±0.79	6.6±1.0

The table 5 shows that the sensory scores of the formulated multiseed nutri bars were decreased gradually during 30 days of storage. At 0 day, the corn flake bar (V₂) showed the highest scores for all sensory attributes, while the ragi flake bar (V₄) recorded the

lower scores. All variations scored good sensory acceptability at the initial stage. After 30 days, there is a decline in the sensory scores of all variations. However, corn flake (V₂) retained higher acceptability compared to other variations.

However, paired ‘t’ test confirmed there is no significant difference among the samples with P-values of 0.0049 for rice flake bar, 0.0028 for corn flakes bar, 0.0049 for wheat flakes bar and 0.005 for rice flakes bar ($P < 0.05$).

Table 6 Microbial quality of the formulated multiseed nutri bars on storage

Nutriseed bar	1st day	15th day	30th day
Multiseed rice flakes bar	2.0×10^{-2} cfu/g	4.5×10^{-2} cfu/g	10×10^{-2} cfu/g
Multiseed corn flakes bar	1.5×10^{-2} cfu/g	5.2×10^{-2} cfu/g	12×10^{-2} cfu/g
Multiseed wheat flakes bar	2.0×10^{-2} cfu/g	4.2×10^{-2} cfu/g	10×10^{-2} cfu/g
Multiseed ragi flakes bar	1.2×10^{-2} cfu/g	3.8×10^{-2} cfu/g	8.0×10^{-2} cfu/g

The table 6 shows that all nutriseed bars had varied degree of total plate count during storage, where the corn flake nutri bar had slightly higher total bacterial count range (1.5×10^{-2} to 12×10^{-2} cfu/g). Likewise, Geetha et al (2023), also reported that the total bacterial count increases from 4.5×10^2 to 8.1×10^3 cfu/g at the end of the storage period. The gradual rise in the total count may be attributed to its gain in moisture content on storage. It could be controlled using moisture barrier packaging material.

Table 7 Peroxide value of the formulated nutriseed bars at different intervals

Nutriseed bar	1st day	30th day
Multiseed rice flakes	15.6 mEq/kg	38.6 mEq/kg
Multiseed corn flakes	13 mEq/kg	30.8 mEq/kg
Multiseed wheat flakes	10.2 mEq/kg	15 mEq/kg
Multiseed ragi flakes	13.8 mEq/kg	19 mEq/kg

Peroxide value (PV) of all packaged samples showed gradual rise during storage. Initially the peroxide value ranged from 10.2 to 15.6 mEq/kg on first day. By 30th day of storage it ranged from 15 to 38.6 mEq/kg. The highest peroxide value was observed in rice flake bar (38.6 mEq/kg). Shukla et al (2020), reported that in multigrain energy bars, the peroxide values ranged from 0.90 to 30.9 mEq/kg during storage period. Overall, the gradual increase in peroxide value observed in the present study confirms the effect of storage duration on lipid oxidation in nutri seed bars.

IV. CONCLUSION

The study successfully demonstrated the formulation of nutritionally enriched multiseed nutibars using different cereal flakes with different combinations of multi seeds. All formulated nutri seed bars exhibited good sensory acceptability, physicochemical properties and nutrient composition. Among the variations, ragi and corn flakes bars showed higher overall acceptability, rich nutrients and antioxidant activity. The resultant products had less microbial load throughout the storage period of 30 days at ambient temperature. The incorporation of millet-based flakes and multiseeds enhances the functional properties with growing demand of plant based and ready to eat snacks product. With increasing market interest in ready to eat products, the multiseed nutibars present strong commercial potential in the food processing industry. The formulated product serves as a value-added, nutritionally enriched snack option to health-conscious consumers, athletes and working professionals preferring convenient energy foods.

ACKNOWLEDGEMENT

The study was conducted at Food Processing Centre, PSG College of Arts and Science, Coimbatore.

Data Availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Conflicts of interest

The authors declare no conflicts of interest

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