Natural Resources for Human Health
eISSN: 2583-1194

Original Research

Received 21 July 2026
Revised 30 Aug 2026
Accepted 14 Sep 2026

Natural Resources for Human Health 2026, Vol. 6 (21s): 564–577

KEYWORDS:
older adults; nutrient-dense foods; Soft Energy Ball; millet; protein-enriched porridge; sensory evaluation; calcium; iron

Formulation and Evaluation of Nutritional Characters of Nutrient dense Food Products for Older Adults

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ABSTRACT: Background: Nutritional deficiencies is a common concern among older persons, which may be linked to insufficient energy and protein intake. Nutrient-dense food products containing cereals, millets, legumes, nuts, seeds, and milk-derived substances may be useful dietary formats for improving nutrient intake.

Objective: The study sought to create and nutritionally define two food products for use in older-adult nutrition: a Soft Energy Ball and Protein-Enriched Millet Porridge Powder.

Methods: Two food products were created and standardized by combining cereal, millet, legume, nut, seed, and milk-derived constituents. The Soft Energy Ball was made with dates, groundnuts, sesame seeds, skimmed milk powder, flaxseed, and cardamom, while the Protein-Enriched Millet Porridge Powder was made with ragi, foxtail millet, roasted Bengal gram, whey protein isolate, skimmed milk powder, flaxseed, moringa leaf powder, and jaggery. Ten semi-trained panel members evaluated five formulations (F1-F5) of each product on a 9-point hedonic scale for look, color, aroma, texture, consistency, and overall acceptability. The formulation that had the highest observed overall acceptability was chosen for nutritional and mineral analysis. AMMAGENOMICS Food Testing Laboratory analyzed the selected F4 formulations for energy, carbohydrate, protein, fat, and dietary fiber, while calcium and iron were measured using inductively coupled plasma mass spectrometry (ICP-MS). Nutritional and mineral values were reported per 100 grams of product.

Results: The Soft Energy Ball had 438.15 kcal of energy, 60.65 g of carbohydrate, 10.47 g of protein, 17.07 g of fat, 4.89 g of dietary fiber, 403.54 milligrams of calcium, and 2.29 mg of iron per 100 grams. Per 100 g, the Protein-Enriched Millet Porridge Powder contained 393.57 kcal of energy, 72.28 g carbohydrate, 16.52 g protein, 4.26 g fat, 3.77 g dietary fiber, 547.40 mg calcium, and 3.25 mg iron. F4 had the highest overall acceptance, with a mean score of 8.20 ± 0.45 for the Protein-Enriched Millet Porridge Powder and 8.30 ± 0.48 for the Soft Energy Ball. The Soft Energy Ball had more energy and fat than

Natural Resources for Human Health
eISSN: 2583-1194

the Protein-Enriched Millet Porridge Powder, which had more protein, calcium, and iron per 100 g.

Conclusion: Both products demonstrated positive sensory acceptability and distinct nutritional profiles, supporting their consideration for further research in older-adult nutrition.

1. INTRODUCTION

1.1 Nutritional Vulnerability among Older Adults

Aging causes physiological, functional, and behavioral changes that might affect dietary consumption and nutritional status. Older persons may have a decreased appetite, changes in taste and smell, dental or swallowing problems, altered gastrointestinal function, and a decreased ability to prepare or consume meals. These factors can contribute to an insufficient intake of calories and necessary nutrients. Nutritional vulnerability in later age is thus a continuum impacted by physiological changes, food consumption, functional capacity, and social situations (Starr et al., 2015).

Malnutrition is a major concern in older people, and it can occur in the community as well as in institutions and clinics. The danger is especially significant when dietary intake fails to exceed nutritional requirements or when disease and functional limitations raise nutritional demands. Dent et al. (2023) underlined that malnutrition in older individuals is complex and linked to poor health outcomes. As a result, techniques that promote optimal nutrient intake through practical food choices remain relevant in older-adult nutrition.

1.2 Inadequate Protein and Energy Supply in Later Life

Adequate caloric and protein consumption is especially crucial as we age, as physiological changes can affect body composition and muscle tissue maintenance. Age-related changes in muscle growth and function are linked to increased attention to dietary protein requirements, especially when consumption is insufficient (Nishimura et al., 2023). Inadequate protein-energy intake may thus lead to nutritional vulnerability, as well as age-related muscle mass and function loss.

Dietary techniques for increasing the calorie and protein content of meals have been studied in elderly populations. Dietary enrichment with normal foods has been shown in some trials to enhance energy intake, but the evidence for improved protein intake and other nutritional outcomes is less consistent (Trabal & Farran-Codina, 2015). Similarly, evaluations of fortified and nutrient-dense foods show that these approaches can boost calorie and protein intake in some elderly people, especially in care settings (Mills et al., 2018; Sossen et al., 2021). These findings emphasize the potential utility of food-based techniques that deliver nutrients in convenient dietary formats.

1.3 The need for nutrient-dense and practical food formats.

The nutrient density of various foods may be an essential issue for older persons who have a lower appetite or eat less. Nutrient-dense food formulations combine multiple ingredients to give calories, protein, minerals, fiber, and other nutrients in tiny amounts of food. Such formulations may also provide alternatives to traditional meals when appetite, chewing abilities, or meal preparation are compromised.

Food format is another factor to consider when developing products for older persons. Soft or readily prepared items may be beneficial for people who struggle with traditional food textures or meal preparation. Energy balls and powdered cereal-based preparations are two distinct forms for combining many nutrient-dense elements into a single product. However, the nutritional value of a created product is determined by its specific formulation, which necessitates direct analytical characterisation rather than inference based merely on the nutrient makeup of individual constituents.

1.4 The Potential of Millet, Legume, Nut, Seed, and Milk Derived Ingredients

Cereals and millets are good sources of dietary carbs and contain various levels of protein, minerals, fiber, and other nutrients. Millets have gained increased attention due to their nutritional value and possible function in a variety of cereal-based cuisines (Samtiya et al., 2023). Ragi, in example, is widely used in cereal-based preparations and can provide calcium and other nutrients to prepared products.

Legumes, nuts, and seeds can enhance the nutritional diversity of food formulations. Bengal gram provides protein and other nutrients, whereas groundnuts, sesame seeds, and flaxseed supply protein, fat, fiber, and minerals. Milk-derived substances, such as skimmed milk powder and whey protein isolate, can be used to boost protein content while also contributing calcium. Moringa leaf powder can be used to provide nutrients in composite food recipes.

Dates add sweetness and can act as a binding agent in energy ball compositions. Previous research on date-based functional food products found that date paste is a prominent structural component of energy bars and comparable goods (Barakat & Alfheeaid, 2023). Thus, combinations of cereal, millet, legume, nut, seed, fruit, and milk-derived ingredients serve as a foundation for creating food products with complimentary nutritional properties.

1.5 Reasons for Developing Two Food Products

The current study focuses on two food formats with distinct formulation properties. The Soft Energy Ball was created with dates, groundnuts, sesame seeds, skimmed milk powder, flaxseed, and cardamom, resulting in a compact, soft product that contains energy, protein, fat, fiber, and minerals. The Protein-Enriched Millet Porridge Powder was made with ragi, foxtail millet, roasted Bengal gram, whey protein isolate, skimmed milk powder, flaxseed, moringa leaf powder, and jaggery. The combination was designed to provide a cereal- and millet-based meal with a higher protein content from selected legume and dairy-derived ingredients.

Sensory attributes are an important aspect of food product development because nutritional composition alone cannot determine a food's practical appeal. Appearance, color, aroma, texture, consistency, and overall acceptability can all influence how evaluators react to a manufactured product. As a result, sensory evaluation was included in the current investigation to determine the formulation with the highest observed overall acceptance prior to nutritional and mineral analysis.

1.6 Research Gap

Individual ingredients such as millets, legumes, nuts, seeds, dates, and milk-derived components have been extensively studied for their nutritional properties; however, the nutritional makeup of a specific manufactured product cannot be determined solely from ingredient-level data. Direct laboratory analysis is necessary to determine the nutritional and mineral composition of the finished product.

In addition, sensory acceptability and nutritional composition are complimentary aspects of food product creation. A formulation may have a favorable nutritional profile but needs to be optimized for sensory properties. In contrast, sensory acceptance in the absence of nutritional composition information provides limited evidence on the created product's nutrient contribution. As a result, taking formulation, sensory qualities, and laboratory-based nutritional and mineral composition into account at the same time allows for a more comprehensive product-level assessment.

As a result, the current study focused on product development, sensory evaluation, and laboratory-based nutritional and mineral characterisation of two food products with prospective applications in older-adult nutrition.

1.7 Study Rationale and Objectives

Given the nutritional problems associated with aging and the need for practical nutrient-dense food formats, the current study focused on the development and nutritional assessment of two food products with potential use in older-adult nutrition.

The study intended to:

- Create and standardize Soft Energy Balls and Protein-Enriched Millet Porridge Powder from cereal, millet, legume, nut, seed, and milk-derived ingredients.
- Use a 9-point hedonic scale to assess the sensory and acceptability of proposed formulations.
- Determine the nutritional composition of the selected formulations, including calories, carbohydrate, protein, fat, and dietary fiber. 4. Determine the calcium and iron levels of the formulations.

The study focused on product creation, sensory evaluation, and laboratory-based nutritional and mineral characterization, but did not analyze nutritional or functional results in older persons.

2. MATERIALS & METHODS

2.1 Study Design and Product Development

The current study was designed as a food product development, sensory evaluation, and laboratory-based nutritional characterization study. Two food products, the Soft Energy Ball and Protein-Enriched Millet Porridge Powder, were developed and standardized for future use in older adult nutrition. Five formulations (F1-F5) were developed for each product and tested for sensory properties. The formulation with the highest observed overall acceptability was chosen for further nutritional and mineral analysis.

The product development process included selecting and preparing ingredients, roasting where appropriate, cooling, grinding, sieving, weighing, blending or mixing, kneading where needed, portioning, shaping, and packing. The generated products were then evaluated for sensory characteristics as well as nutritional and mineral composition in a laboratory setting.

2.2 Ingredients & Formulation

The Soft Energy Ball is made with seedless dates, roasted groundnuts, roasted sesame seeds, skimmed milk powder, roasted flaxseed, and cardamom. The standardized formulation contained 100 g seedless dates, 50 g roasted groundnuts, 20 g roasted sesame seeds, 20 g skimmed milk powder, 10 g toasted flaxseed, and 1 g cardamom, for a total formulation weight of around 201 g.

The Protein-Enriched Millet Porridge Powder was made with ragi flour, foxtail millet flour, roasted Bengal gram flour, whey protein isolate, skimmed milk powder, flaxseed, moringa leaf powder, and jaggery powder. The standardized formulation included 30 g ragi flour, 20 g foxtail millet flour, 15 g roasted Bengal gram flour, 15 g whey protein isolate, 10 g skimmed milk powder, 5 g flaxseed, 3 g moringa leaf powder, and 2 g jaggery powder per 100 g of product.

Five formulations (F1-F5) were created for each product by altering the quantities of formulation ingredients during product standardization. The formulations were sensory evaluated, and the formulation with the highest overall acceptance was chosen for further investigation.

2.3 Preparing the Soft Energy Ball

The dates were inspected and cleaned, and any unwanted pieces were removed. Groundnuts, sesame seeds, and flaxseed were toasted separately and left to cool. The roasted groundnuts and flaxseed were ground to an appropriate consistency. The prepared dates were blended into a cohesive paste and mixed with the remaining ingredients according to the recipe. The mixture was completely combined and kneaded to make a homogenous mass.

The produced mass was portioned and formed into roughly 20 g balls. The standardized formulation produced around 201 g of product, which equates to approximately 10 servings.

The process sequence was:

Sort, clean, roast, cool, grind, mix, knead, portion, roll, and package.

The prepared product was stored in clean, food-grade sealed containers pending further testing.

2.4 Making Protein-Enriched Millet Porridge Powder

The raw ingredients were inspected and cleansed to remove any foreign contaminants. Ingredients that required roasting were roasted separately and let to cool before proceeding with preparation. Ragi, foxtail millet, roasted Bengal gram, and flaxseed were crushed to a fine powder and sieved to ensure a fairly consistent particle size.

The needed amounts of ragi flour, foxtail millet flour, roasted Bengal gram flour, whey protein isolate, skimmed milk powder, flaxseed, moringa leaf powder, and jaggery powder were weighed according to the formulas. The materials were thoroughly combined to produce a homogenous powder. The produced powder was stored in clean, food-grade containers pending further testing.

To make porridge, mix 25 g of the powder with around 200 mL of water or milk and boil with continuous stirring until the required consistency is achieved.

The process sequence was:

Clean, roast, grind, sieve, weigh, mix, package, and store.

2.5 Product Standardization and Portioning.

Both goods were standardized in terms of constituent amounts, processing techniques, product consistency, uniformity, and portion size. Each product received five formulations (F1-F5) for sensory comparison. The Soft Energy Ball was standardized at around 20 g per serving, while the Protein-Enriched Millet Porridge Powder was standardized at 100 g per recipe.

Following sensory screening, the formulation with the best overall acceptability was chosen for further nutritional and mineral analysis.

2.6 Sensory Evaluation.

Sensory evaluation was carried out on five formulations (F1-F5) of each developed product by ten semi-trained panel members. The sensory features were assessed using a 9-point hedonic scale ranging from 1 (extreme dislike) to 9 (extreme like).

The features tested were look, color, fragrance, texture, consistency, and overall acceptability.

The hedonic scale is interpreted as follows:

Score: Hedonic reaction.

Likes: 9 (very), 8 (very much), 7 (moderately), 6 (slightly), 5 (neither like nor dislike), 4 (slightly), 3 (moderately), and 2 (very much).

Individual scores were recorded for each formulation and sensory quality, with one indicating intense dislike. The mean sensory scores for each attribute were calculated, and the formulation with the highest observed mean score for overall acceptability was chosen for each product.

2.7 Nutrition Analysis

Samples of the selected F4 formulations were sent to the AMMAGENOMICS Food Testing Laboratory for nutritional analysis. The Soft Energy Ball was analyzed under Job No. 3980, while the Protein-Enriched Millet Porridge Powder was analyzed under Job No. 3979.

Energy, carbohydrate, protein, fat, and dietary fiber were the nutritional factors measured. Analyzes were carried out in accordance with the applicable laboratory standard operating procedures, which included AMGCS/FOOD/SOP/061, AMGCS/FOOD/SOP/026, AMGCS/FOOD/SOP/030, AMGCS/FOOD/SOP/027, and AMGCS/FOOD/SOP/028, as applicable to the corresponding parameters.

Nutritional data were provided per 100 grams of product.

2.8 Mineral Analysis.

Calcium and iron concentrations were measured in the selected F4 formulations. Mineral determination was performed using inductively coupled plasma mass spectrometry (ICP-MS) in accordance with laboratory technique CVR/INS/SOP ICP MS/003.

Calcium and iron values were expressed in milligrams per 100 grams of product.

2.9 Data Presentation and Analysis.

Sensory evaluation data for formulations F1-F5 were collected for each sensory attribute and presented as mean sensory scores. Overall acceptability scores were utilized to determine which formulation produced the highest observed overall acceptability for each product.

To make it easier to compare the two developed products, the nutritional and mineral composition was reported per 100 g. Where portion-level values were presented, they were derived proportionally based on laboratory results expressed per 100 grams.

2.10 Ethical Consideration

Sensory evaluation involved ten semi-trained panel members and was confined to assessing product sensory features and acceptance on a 9-point hedonic scale. The study did not include dietary interventions, clinical assessments, or evaluations of nutritional or functional outcomes in older persons.

3. RESULTS AND DISCUSSION.

3.1 Formulation Development and Standardization

Five formulas (F1-F5) were created for each of the two products: the Soft Energy Ball and the Protein-Enriched Millet Porridge Powder. The formulations were created utilizing the cereal, millet, legume, nut, seed, fruit, and milk-derived constituents listed in the Materials and Methods section. Ten semi-trained panel members rated each formulation on a 9-point hedonic scale.

Sensory evaluation was utilized to determine which formulation had the highest observed overall acceptance. Among the five formulas, F4 had the best overall approval for both products. The F4 acceptability score was 8.20 ± 0.45 for the Protein-Enriched Millet Porridge Powder and 8.30 ± 0.48 for the Soft Energy Ball. As a result, F4 was chosen for further laboratory-based nutritional and mineral characterisation.

The standardized Soft Energy Ball was divided into roughly 20 g portions, whilst the Protein-Enriched Millet Porridge Powder was standardized as a dry powder formulation and characterized per 100 g. The selection of a formulation based on sensory response prior to laboratory characterization resulted in a well-defined product development process that took sensory appeal into account alongside nutritional composition.

The creation of nutrient-dense food formats is important to the larger challenge of providing nutritional needs throughout the life cycle. Beal et al. (2024) noted that older individuals are a nutritionally sensitive population and underlined the necessity of nutrient-dense foods and various dietary sources in achieving nutrient requirements. The current study's goal was not to demonstrate a health effect, but to create and define food products that had various nutrient-contributing constituents.

3.2 Sensory evaluation of protein-enriched millet porridge powder

The sensory evaluation scores for the five Protein-Enriched Millet Porridge Powder formulations are shown in Table 1. The appearance scores varied from 7.10 ± 0.57 in F1 to 8.30 ± 0.48 in F4. Colour scores varied from 7.20 ± 0.63 to 8.20 ± 0.42, while fragrance values ranged from 6.90 ± 0.74 to 8.20 ± 0.63. Texture values ranged from 6.80 ± 0.79 in F1 to 8.10 ± 0.57 in F4, while consistency scores varied from 6.90 ± 0.74 to 8.20 ± 0.42.

F4 had the highest observed mean score for each of the five sensory qualities. The overall acceptance scores were 6.96 ± 0.65 for F1, 7.34 ± 0.58 for F2, 7.94 ± 0.50 for F3, 8.20 ± 0.45 for F4, and 7.64 ± 0.61 for F 5. Thus, F4 had the highest observed overall acceptability and was chosen for further nutritional and mineral investigation.

Table 1. Sensory evaluation scores of Protein-Enriched Millet Porridge Powder formulations

Formulation	Appearance	Colour	Scent	Texture	Consistency	Overall acceptability
F1	7.10 ± 0.57	7.20 ± 0.63	6.90 ± 0.74	6.80 ± 0.79	6.90 ± 0.74	6.96 ± 0.65
F2	7.40 ± 0.52	7.50 ± 0.53	7.30 ± 0.67	7.20 ± 0.63	7.30 ± 0.67	7.34 ± 0.58
F3	8.00 ± 0.47	8.10 ± 0.57	7.90 ± 0.57	7.80 ± 0.63	7.90 ± 0.57	7.94 ± 0.50
F4	8.30 ± 0.48	8.20 ± 0.42	8.20 ± 0.63	8.10 ± 0.57	8.20 ± 0.42	8.20 ± 0.45
F5	7.70 ± 0.67	7.80 ± 0.63	7.60 ± 0.70	7.50 ± 0.71	7.60 ± 0.70	7.64 ± 0.61

Values are mean ± SD; n = 10 semi-trained panel members.

The progressive increase in sensory scores from F1 to F4 indicates that the formulation changes made during standardization altered the product's sensory qualities. The lower F5 scores compared to F4 suggest that the subsequent formulation revision did not result in a higher observed sensory response.

The Protein-Enriched Millet Porridge Powder included ragi, foxtail millet, roasted Bengal gram, whey protein isolate, skimmed milk powder, flaxseed, moringa leaf powder, and jaggery. Previous food product development studies have indicated the utilization of composite formulations based on cereals and millet. Geetha et al. (2023), for example, created a millet-based

ready-to-use composite mix including cereals, millets, pulses, and oilseeds and assessed its nutritional and sensory properties. Their findings show that multiple plant-based ingredients can be incorporated into composite meal formats while maintaining acceptable sensory features.

Kaur et al. (2023) also addressed the nutritional potential of millet-based formulations, reviewing the nutritional composition, functional features, and product-development applications of minor millets. Samtiya et al. (2023) described millets as sources of carbohydrate, protein, fiber, and minerals, highlighting their use in a variety of dietary products. These findings give a broader foundation for the usage of ragi and foxtail millet in the current formulation.

F4's favorable sensory response served as the basis for its selection for laboratory characterisation. However, the sensory panel was made up of semi-trained persons who were not exclusively older adults. As a result, the findings cannot be regarded as proof of consumer acceptability in the target population.

3.3 Sensory Evaluation of Soft Energy Ball.

The sensory scores for the five Soft Energy Ball formulations are shown in table 2. The appearance scores varied from 7.20 ± 0.63 in F1 to 8.40 ± 0.52 in F4. Color scores varied from 7.30 ± 0.67 to 8.30 ± 0.48, and fragrance values from 7.10 ± 0.57 to 8.30 ± 0.48. Texture scores ranged from 6.90 ± 0.74 to 8.20 ± 0.63, while consistency values varied from 7.00 ± 0.67 to 8.30 ± 0.48.

F4 has the highest observed mean score across all five sensory attributes. The overall acceptance scores were 7.10 ± 0.57 for F1, 7.54 ± 0.52 for F2, 8.04 ± 0.48 for F3, 8.30 ± 0.48 for F4, and 7.74 ± 0.61 for F5. F4 thus had the highest observed overall acceptance and was chosen for further laboratory research.

Table 2. Sensory evaluation scores of Soft Energy Ball formulations

Formulation	Appearance	Colour	Scent	Texture	Consistency	Overall acceptability
F1	7.20 ± 0.63	7.30 ± 0.67	7.10 ± 0.57	6.90 ± 0.74	7.00 ± 0.67	7.10 ± 0.57
F2	7.60 ± 0.52	7.70 ± 0.48	7.50 ± 0.53	7.40 ± 0.70	7.50 ± 0.53	7.54 ± 0.52
F3	8.10 ± 0.57	8.20 ± 0.42	8.00 ± 0.67	7.90 ± 0.57	8.00 ± 0.67	8.04 ± 0.48
F4	8.40 ± 0.52	8.30 ± 0.48	8.30 ± 0.48	8.20 ± 0.63	8.30 ± 0.48	8.30 ± 0.48
F5	7.80 ± 0.63	7.90 ± 0.57	7.70 ± 0.67	7.60 ± 0.70	7.70 ± 0.67	7.74 ± 0.61

Values are mean ± SD; n = 10 semi-trained panel members.

The Soft Energy Ball had dates, groundnuts, sesame seeds, skimmed milk powder, flaxseed, and cardamom. F4 obtained the highest observed sensory reaction among the five formulations, as evidenced by its consistently high rankings in appearance, color, fragrance, texture, and consistency.

Previous research has shown that date paste or dates can be used as a structural component in energy-ball and energy-bar formulations. Barakat and Alfheeaid (2023) examined the nutritional, functional, and sensory properties of date-based energy bars and identified date palm fruit as a key ingredient in such products. More recently, Alsuhebani et al. (2025) created date-based high-protein energy balls with milk protein ingredients and studied their nutritional and functional properties. Their research provides a direct illustration of the application of date-based energy-ball forms containing protein-rich substances.

The current Soft Energy Ball differs in ingredient composition and study purpose from earlier items. It was created with dates, groundnuts, sesame seeds, skimmed milk powder, flaxseed, and cardamom, and its sensory properties were tested before nutritional characterisation. As a result, the listed studies give contextual support for the product format rather than direct proof for the nutritional values determined in the current study.

As with the porridge formulation, no inferential statistical analysis was conducted. As a result, F4 is defined as having the highest observed overall acceptability, rather than being statistically superior to the other formulations.

3.4 Nutritional Content of Selected Soft Energy Balls

Table 3 shows the nutritional makeup of the selected F4 Soft Energy Ball. The product offered 438.15 kcal/100 g and contains 60.65 g carbohydrate, 10.47 g protein, 17.07 g fat, and 4.89 g dietary fiber.

Table 3. Nutritional composition of the selected Soft Energy Ball (F4 formulation)

Nutritional parameter	Result per 100 g
Energy	438.15 kcal
Carbohydrate	60.65 g
Protein	10.47 g
Fat	17.07 g
Dietary fibre	4.89 g

Note: Values represent the laboratory analysis of the selected F4 formulation.

The nutritional profile represents the overall composition of the ingredients employed in the formulation. Dates were the greatest component and provided the carbohydrate base, while groundnuts, sesame seeds, skimmed milk powder, and flaxseed added protein, fat, fiber, and minerals.

The caloric value of 438.15 kcal/100 g exceeded that of the Protein-Enriched Millet Porridge Powder, which delivered 393.57 kcal/100 g. The Soft Energy Ball also included 17.07 g fat/100 g, compared to 4.26 g/100 g in the porridge powder. This difference is consistent with the addition of groundnuts, sesame seeds, and flaxseed in the Soft Energy Ball. These substances provide dietary fat in addition to other nutrients, which may contribute to the greater energy density seen.

The approximate 20 g standardized amount had 87.63 kcal. This part-level number indicates the nutritional contribution of the standardized product portion, but it should not be used to determine dietary adequacy because individual energy requirements were not analyzed.

Table 4. Mineral composition of the selected Soft Energy Ball (F4 formulation)

Mineral	Result per 100 g	Approximate amount per 20 g
Calcium	403.54 mg	80.71 mg
Iron	2.29 mg	0.46 mg

Note: Values represent the laboratory analysis of the selected F4 formulation. Values per 20 g were calculated proportionally from the results per 100 g.

The selected Soft Energy Ball had 403.54 mg calcium and 2.29 mg iron per 100 g. Sesame seeds and skimmed milk powder were used as calcium-rich ingredients, therefore the calcium content is important for the formulation. However, the laboratory study only measured the finished result and did not account for the specific contributions of each constituent. Similarly, the observed iron concentration represents the final product and does not indicate mineral bioavailability.

3.5 Nutritional Content of Selected Protein-Enriched Millet Porridge Powder

Table 5 shows the nutritional makeup of the selected F4 Protein-Enriched Millet Porridge Powder. The product had 393.57 kcal per 100 g and contains 72.28 g carbohydrate, 16.52 g protein, 4.26 g fat, and 3.77 g dietary fiber.

Table 5. Nutritional composition of the selected Protein-Enriched Millet Porridge Powder (F4 formulation)

Nutritional parameter	Result per 100 g
Energy	393.57 kcal
Carbohydrate	72.28 g
Protein	16.52 g
Fat	4.26 g
Dietary fibre	3.77 g

Note: Values represent the laboratory analysis of the selected F4 formulation.

The Protein-Enriched Millet Porridge Powder had 16.52 g protein/100 g, compared to 10.47 g/100 g in the Soft Energy Ball, a difference of 6.05 g/100 g. The greater protein concentration is due to the inclusion of whey protein isolate, roasted Bengal gram, and skimmed milk powder in the formulation.

The incorporation of numerous protein-contributing elements into a grain and millet-based matrix is compatible with the larger development of composite food products. Geetha et al. (2023) described a millet-based composite mix combining cereals, millets, pulses, and oilseeds that provided measurable protein and energy contributions. Kaur et al. (2023) and Samtiya et al. (2023) have also investigated the nutritional and product development possibilities of millet-based formulations.

The porridge powder has a lower fat level than the Soft Energy Ball. The difference reflects the two products' differing formulation structures. The Soft Energy Ball had higher amounts of groundnuts, sesame seeds, and flaxseed, while the porridge powder had more cereal, millet, and protein ingredients.

Table 6. Mineral composition of the selected Protein-Enriched Millet Porridge Powder (F4 formulation)

Mineral	Result per 100 g
Calcium	547.40 mg
Iron	3.25 mg

Note: Values represent the laboratory analysis of the selected F4 formulation.

The Protein-Enriched Millet Porridge Powder included 547.40 mg of calcium and 3.25 mg of iron per 100 grams. These values were higher than those for the Soft Energy Ball. The difference was 143.86 mg/100 g calcium and 0.96 mg/100 g iron.

Ragi, skimmed milk powder, whey protein isolate, Bengal gram, flaxseed, and moringa leaf powder were all used in the composition. These ingredients offer various potential mineral sources for the composite formulation. Nonetheless, the reported laboratory values represent the end product and should not be used as direct proof of mineral absorption or bioavailability.

3.6 Comparative Nutritional and Mineral Profile of the Developed Products

The nutritional and mineral profiles of the two selected F4 formulations are compared in Table 7.

Table 7. Comparative nutritional and mineral composition of the developed products

Parameter	Soft Energy Ball	Protein-Enriched Millet Porridge Powder	Absolute difference
Energy (kcal/100 g)	438.15	393.57	44.58
Carbohydrate (g/100 g)	60.65	72.28	11.63
Protein (g/100 g)	10.47	16.52	6.05
Fat (g/100 g)	17.07	4.26	12.81
Dietary fibre (g/100 g)	4.89	3.77	1.12
Calcium (mg/100 g)	403.54	547.40	143.86
Iron (mg/100 g)	2.29	3.25	0.96

Note: Absolute difference represents the absolute numerical difference between the two products.

Natural Resources for Human Health
eISSN: 2583-1194



Figure 1. Developed Nutri Ladoo (Soft Energy Ball): a protein- and calcium-rich food product.



Figure 2. Developed Protein-Enriched Millet Porridge Powder: a nutrient-dense millet-based food product

The Soft Energy Ball had 438.15 kcal/100 g compared to 393.57 kcal/100 g for the Protein-Enriched Millet Porridge Powder, for an absolute difference of 44.58 kcal/100 g. It also had a greater fat and dietary fiber level, with 12.81 g/100 g and 1.12 g/100 g.

In contrast, the Protein-Enriched Millet Porridge Powder has 6.05 g more protein, 143.86 mg more calcium, and 0.96 mg more iron per 100 grams. It also has a greater carbohydrate content (11.63 g/100 g).

The differences in nutritional profiles can be attributed to the two products' differential constituent mix. The Soft Energy Ball was made up primarily of dates, almonds, and seeds, whilst the porridge powder includes ragi, foxtail millet, Bengal gram, whey protein isolate, skimmed milk powder, flaxseed, moringa leaf powder, and jaggery.

The findings also show why direct laboratory characterisation is essential in food product development. Although the nutrient composition of individual ingredients can provide insight into their potential contribution, the final nutritional composition is determined by ingredient proportions and the finished product's composition.

The nutritional values acquired in this study can be compared to earlier publications on composite millet products. Geetha et al. (2023) found quantifiable protein, fat, carbohydrate, and calorie values in a millet-based ready-to-use composite mix, demonstrating the viability of combining cereals, millets, pulses, and oilseeds into a composite food format. The current study also included cereal/millet and other nutrient-dense components, albeit the formulation and evaluated nutritional values differed.

3.7 Relationship with Nutritional Vulnerability in Older Adults

The importance of nutrient-dense food development is especially clear in the context of nutritional vulnerability among older adults. Nutritional vulnerability can result from decreased nutritional intake, physiological changes, functional limits, socioeconomic situations, and other factors influencing food access and consumption (Starr et al., 2015; Dent et al., 2023).

Beal et al. (2024) noted that older persons, particularly older women, can be nutritionally vulnerable and underlined the necessity of nutrient-dense dietary sources in providing nutrient requirements throughout the life cycle. The current study approaches this issue from a product creation standpoint, mixing several nutrient-contributing ingredients into two different meal shapes rather than attempting to directly assess nutritional status.

Food availability and socioeconomic level can also have an impact on nutrition. In a comprehensive analysis, Pereira et al. (2022) discovered links between food insecurity and nutritional status in older persons, including connections with malnutrition in some of the articles analyzed. Srivastava and Muhammad (2022) investigated socioeconomic vulnerability and frailty among community-dwelling elderly individuals in India. These data suggest that nutritional vulnerability is influenced not only by dietary composition, but also by larger social and economic factors. The current study did not include cost, food security, household access, or socioeconomic position, so the generated goods cannot be considered solutions to these broader issues.

3.8 The importance of nutrient-dense and protein-contributing food formats

Adequate protein consumption is critical throughout aging because age-related physiological changes might affect muscle protein metabolism and nutritional requirements. Nishimura et al. (2023) examined the dietary protein requirements and recommendations for healthy older persons, emphasizing the significance of appropriate protein intake in later life.

Evidence from older populations further supports the therapeutic importance of protein-energy deficiency and related wasting diseases. Chan et al. (2023) found links between malnutrition, sarcopenia, and frailty and poor post-discharge outcomes in older persons referred to rehabilitation. These findings explain why sufficient nutrition is crucial in older populations, but they do not prove that the items created in the current study prevent or improve these illnesses.

Evidence on nutritional supplementation also provides a broader perspective. Thomson et al. (2022) investigated the efficacy and cost-effectiveness of oral nutritional supplements in frail elderly persons who were malnourished or at risk of malnutrition. Similarly, systematic studies by Trabal and Farran-Codina (2015), Mills et al. (2018), and Sossen et al. (2021) looked at dietary enrichment, fortified foods, and nutrient-dense therapies in older people. Sossen et al. (2021) found that fortified, nutrient-dense, and enhanced food or drink treatments could boost energy and protein intake in residential aged-care populations.

These studies offer contextual support for examining food-based solutions, but they should not be taken as direct validation of the current products. The current investigation focused on product composition and sensory qualities rather than food consumption or clinical outcomes.

3.9 Sensory Aspects of Older Adult Food Development.

Sensory features are especially important when considering food products for older people, since changes in sensory perception, dietary preferences, texture, and familiarity can all influence acceptability. Laureati et al. (2006) investigated the sensory acceptability of traditional meal preparations among the elderly, highlighting the significance of sensory evaluation when selecting food products for older consumers.

The current study used a semi-trained panel to assess appearance, color, fragrance, texture, consistency, and general acceptability. F4 demonstrated the best overall acceptability for both goods. However, the panel did not consist solely of elderly

persons. As a result, while the current data demonstrate sensory response under the study conditions, they do not prove acceptance among older customers.

The Soft Energy Ball may be appealing as a soft product type, but the Protein-Enriched Millet Porridge Powder is a preparation that may be ingested after reconstitution. However, the practical applicability for older persons with chewing, swallowing, hunger, or other difficulties was not clearly assessed.

3.10 Shelf-life and Product Stability Considerations

The current study focused on formulation, sensory evaluation, and nutritional and mineral profile, but did not analyze shelf life. This is an interesting area for further research, especially for a powder-based formulation and a product including nuts and seeds.

Geetha et al. (2023) investigated the shelf-life of a millet-based composite mix and observed changes in physicochemical and microbiological parameters throughout storage. Their findings show that nutritional characterisation alone is insufficient to determine product stability, and storage studies may be required when producing composite food products.

As a result, further research on the current items should look into moisture changes, microbiological quality, physicochemical properties, oxidative stability (where applicable), and changes in sensory characteristics during storage. Such studies would provide the information needed to determine an appropriate storage period and packaging conditions.

3.11 Strengths and Limitations.

The present study's main strength was the combination of product formulation, sensory evaluation, and laboratory-based nutritional and mineral characterisation. Five formulations were created for each product and tested before the F4 formulations were chosen for laboratory analysis. This established a clear product development pipeline in which sensory response was addressed before nutritional characterisation.

Another advantage was the immediate evaluation of the chosen formulas. The given nutritional and mineral values thus describe the finished goods rather than relying exclusively on theoretical calculations based on individual constituent composition.

However, the study has a number of drawbacks. First, sensory evaluation was limited to 10 semi-trained panel members and did not include older-adult customers. As a result, the sensory findings cannot be extrapolated to the intended group. Second, no inferential statistical analysis was undertaken, and F4 was chosen based on the highest observed overall appeal rather than statistically proven superiority.

Third, the study did not evaluate shelf life stability, physicochemical properties, microbiological stability, nutritional bioavailability, or nutrient retention during storage. Fourth, the nutritional statistics for the Protein-Enriched Millet Porridge Powder are for the dry powder, not the porridge after it has been diluted with water or milk.

Finally, the trial was not planned as an intervention, therefore it did not look at dietary intake, nutritional status, body composition, muscle mass, muscle strength, physical performance, sarcopenia, frailty, or clinical results. As a result, the findings should be interpreted solely in terms of product-level sensory, nutritional, and mineral characterisation.

3.12 Overall Interpretation.

Taken together, the data show that both produced products might be made into sensory-acceptable goods under the current evaluation settings, with F4 achieving the highest overall acceptability for each product. The test results revealed differing nutritional profiles between the two versions.

The Soft Energy Ball had more energy, fat, and dietary fiber per 100 g than the Protein-Enriched Millet Porridge Powder, which had more protein, carbs, calcium, and iron. These distinctions reflect the various ingredient combinations and product formats.

The findings are consistent with the larger literature that supports the investigation of nutrient-dense and composite food formats for addressing nutritional issues in older populations, while the current study is confined to product creation and characterisation. Previous research on dietary enrichment, fortified foods, oral nutritional supplements, millet-based composite products, and date-based energy balls provides relevant context but does not establish the efficacy of the specific products developed here (Alsuhebani et al., 2025; Geetha et al., 2023; Mills et al., 2018; Sossen et al., 2021; Thomson et al., 2022).

Further research should concentrate on shelf-life stability, physicochemical properties, microbiological safety, nutrient bioavailability, prepared-product composition, and sensory evaluation in older-adult groups. Intervention-based studies would therefore be necessary to see if frequent consumption of these items has any quantifiable effects on dietary intake, nutritional status, or functional outcomes.

CONCLUSION

The current study effectively generated and standardized two nutrient-dense food products, a Soft Energy Ball and a Protein-Enriched Millet Porridge Powder, by combining cereal, millet, legume, nut, seed, fruit, and milk-derived ingredients. Ten semi-trained panel members evaluated five product compositions on a 9-point hedonic scale. Among the studied formulations, F4 had the highest overall acceptance for both products and was thus chosen for nutritional and mineral characterisation.

The selected Soft Energy Ball included 438.15 kcal, 10.47 g protein, 17.07 g fat, 4.89 g dietary fiber, 403.54 mg calcium, and 2.29 mg iron per 100 g. The Protein-Enriched Millet Porridge Powder contained 393.57 kcal, 16.52 g protein, 4.26 g fat, 3.77 g dietary fiber, 547.40 mg calcium, and 3.25 mg iron per 100 g. The two products had varied nutritional profiles, which reflected changes in ingredient mix and product packaging.

The findings give product-level information about the sensory features as well as the nutritional and mineral composition of the produced formulations, indicating that they may be relevant for further research in the context of older adult nutrition. However, the study did not investigate nutrient absorption, shelf-life stability,

dietary consumption, nutritional status, or clinical and functional outcomes in older persons. More study with older-adult populations, storage studies, physicochemical characterization, nutrient bioavailability, and intervention-based evaluation are needed to determine the practical and nutritional implications of these products.

Acknowledgement

The author would like to acknowledge the laboratory support provided for the nutritional and mineral analysis of the developed food products. The authors also acknowledge the technical assistance received during product preparation and laboratory analysis.

Funding

No external funding was received for the development of the products, laboratory analysis, or preparation of this manuscript. The study was supported by the authors' own resources.

Conflict of Interest Statement

The authors declare that they have no conflict of interest associated with this work.

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