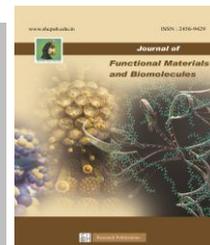




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FORMULATION AND EVALUATION OF A HOMEMADE PROTEIN SUPPLEMENT USING LOCALLY AVAILABLE NATURAL INGREDIENTS

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Abstract

Protein supplements play a pivotal role in maintaining optimal health, promoting muscle development, and preventing malnutrition. While commercially available protein supplements are widely consumed, they are often costly, may contain additives, and are not universally accessible. The development of homemade protein supplements using locally available natural ingredients offers a cost-effective, safe, and sustainable alternative. This review focuses on the selection of high-protein ingredients such as legumes, cereals, seeds, nuts, and dairy products, their nutrient composition, and strategies for formulation to optimize protein content, bioavailability, and palatability. Additionally, the evaluation methods for physicochemical, sensory, and nutritional quality are discussed. The review highlights the potential of natural ingredients to produce functional protein supplements suitable for diverse populations, addressing both nutritional needs and food security challenges.

1. Introduction

Protein is a fundamental macronutrient necessary for virtually every biological process in the human body. It is composed of amino acids, the building blocks that support muscle growth, tissue repair, enzyme synthesis, hormone production, and immune defence [1,2]. Adequate protein intake is critical not only for maintaining health in healthy adults but also during periods of increased physiological demand, such as pregnancy, lactation, growth in children, aging, and intensive physical activity [3]. Protein also plays a vital role in satiety regulation, body composition management, and metabolic health, making it a key nutrient in both preventative and therapeutic nutrition [10]. The recommended dietary allowance (RDA) for protein varies by age, sex, activity level, and health status. For a healthy adult, the RDA is generally 0.8 g of protein per kilogram of body weight per day; however, athletes and individuals engaged in resistance training often require 1.2-2.0

Keywords: Protein supplements; homemade; natural ingredients; legumes; seeds; nutrient bioavailability; formulation; functional foods.

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g/kg/day to optimise muscle protein synthesis [3,11]. Pregnant and lactating women have increased protein requirements to support fetal growth and milk production, while older adults may need higher intakes to counteract sarcopenia—the age-related loss of muscle mass and function [12,13].

Despite the critical role of protein, protein-energy malnutrition (PEM) remains a major public health concern worldwide, especially in low- and middle-income countries [4,5]. Insufficient intake of high-quality protein can lead to stunted growth in children, impaired immune response, delayed wound healing, and reduced cognitive function. In adults, prolonged inadequate protein intake contributes to muscle wasting, decreased functional capacity, and increased susceptibility to chronic diseases [14].

Table 1: Common Locally Available Ingredients for Homemade Protein Supplements

Ingredient Category	Examples	Protein Content (g/100g)	Additional Nutrients	References
Legumes	Chickpeas, Lentils, Soybeans, Black beans	18–36	Fiber, Iron, Lysine	[10,11,22]
Cereals	Oats, Rice, Quinoa, Barley	8–14	Methionine, Carbohydrates, B Vitamins	[14,15,24]
Seeds & Nuts	Pumpkin seeds, Almonds, Flaxseed, Sesame	15–30	Healthy fats, Magnesium, Vitamin E	[15–18]
Dairy	Milk, Yogurt, Cheese	3–10	Calcium, Probiotics, Casein/Whey	[19,20]
Fruits (for flavor/nutrients)	Dates, Bananas, Berries	1–2	Vitamins, Natural sugars, Fiber	[29]

Commercial protein supplements, including whey, casein, soy, and pea protein powders, have become popular for

addressing dietary gaps and supporting athletic performance [6,7]. Whey protein is highly digestible and rich in branched-chain amino acids, particularly leucine, which stimulates muscle protein synthesis. Casein, on the other hand, is digested more slowly, providing a sustained release of amino acids. Plant-based proteins such as soy and pea offer a suitable alternative for vegetarians and individuals with lactose intolerance, while also being associated with cardiovascular and metabolic health benefits [15,16].

However, despite their effectiveness, commercial supplements present several limitations. First, they are often expensive and therefore inaccessible to individuals in resource-limited settings. Second, many products contain additives, preservatives, and artificial flavors, which may be undesirable for health-conscious consumers. Third, the environmental footprint associated with large-scale production, packaging, and transportation of commercial supplements is increasingly a concern [17,18].

Table 2: Amino Acid Profile of Key Ingredients

Ingredient	Limiting Amino Acid	Complementary Ingredient	Complete Protein?	References
Chickpeas	Methionine	Rice, Quinoa	Yes	[23,24]
Lentils	Methionine	Oats, Barley	Yes	[23]
Soybeans	None (complete)	-	Yes	[10,22]
Almonds	Lysine	Legumes	Yes	[16,18]
Quinoa	None (complete)	-	Yes	[14,15]

These challenges have sparked growing interest in developing homemade protein supplements using locally avail-

able natural ingredients [8,9]. Homemade formulations offer a cost-effective, culturally acceptable, and nutritionally .

Utilizing ingredients such as legumes, cereals, seeds, nuts, and dairy allows for the creation of protein-rich supplements that can meet essential amino acid requirements while also providing additional micronutrients and bioactive compounds [19–21].

Table 3: Processing Methods for Enhancing Protein Quality

Processing Method	Description	Impact on Protein & Nutrients	References
Soaking	Seeds/legumes soaked in water	Reduces phytates & tannins, improves digestibility	[25]
Sprouting/Germination	Seeds or legumes sprouted 2–5 days	Increases amino acid availability, enzymatic activity	[26,33]
Roasting	Dry heat applied to nuts/legumes	Improves flavor, reduces anti-nutrients	[27]
Fermentation	Natural or starter culture fermentation	Enhances digestibility, introduces probiotics	[28,35]
Grinding & Blending	Powdering ingredients and mixing	Improves homogeneity and bioavailability	[29,31]

Legumes such as chickpeas, lentils, soybeans, and black beans are excellent sources of plant-based protein, containing significant levels of lysine and other essential amino acids [10,22]. They are also rich in fiber, vitamins, minerals, and phytochemicals, which provide antioxidant, anti-inflammatory, and cardioprotective effects. However, legume proteins are typically low in sulfur-containing amino acids, such as methionine and cysteine, which ne-

cessitates complementation with cereals or seeds to achieve a balanced amino acid profile [23].

Cereals like rice, oats, and quinoa complement legumes by providing the limiting amino acids, particularly methionine, thereby enhancing the overall protein quality of the supplement [14,24]. Quinoa is particularly notable, as it contains all nine essential amino acids and is considered a complete plant-based protein source. Seeds and nuts, including pumpkin seeds, almonds, sesame, and flaxseed, not only provide protein but also healthy fats, fiber, vitamins, and minerals, contributing to the functional properties of the supplement [15–18]. Dairy products, such as milk, yogurt, and cheese, offer highly bioavailable proteins (casein and whey), calcium, and probiotics, further enhancing the nutritional and functional profile of homemade protein formulations [19,20].

The preparation of homemade protein supplements also allows for processing strategies that improve digestibility, safety, and sensory qualities. Techniques such as soaking, sprouting, roasting, and fermentation reduce anti-nutritional factors like phytates, tannins, and trypsin inhibitors while increasing protein availability [25–28]. Flavoring with natural ingredients like cocoa, vanilla, or dried fruits can improve palatability, while blending complementary protein sources ensures a complete amino acid profile, making the supplement suitable for all age groups [29–31].

Additionally, homemade protein supplements align with sustainable nutrition practices, as they reduce dependency on imported commercial products, support local agri-

culture, and minimize environmental impact related to packaging and transportation [32,33]. From a public health perspective, they represent a practical intervention to combat malnutrition, particularly in children, elderly populations, and low-income communities, where affordable, protein-rich foods are critical [34,35].

Table 4: Formulation Strategies for Homemade Protein Supplements

Formulation Approach	Ingredients Used	Rationale	References
Legume + Cereal Blend	Chickpeas + Rice	Complements limiting amino acids	[23,24]
Seed-Enriched	Almonds + Flaxseed	Adds protein, healthy fats, and micronutrients	[15-18]
Dairy-Based	Milk + Yogurt	High-quality casein/whey, probiotics	[19,20]
Flavor Enhancement	Cocoa, Vanilla, Dried Fruits	Improves sensory acceptability	[29]
Fortification	Vitamins & Minerals	Addresses micronutrient deficiencies	[50]

In summary, the development of homemade protein supplements using locally available natural ingredients offers an innovative, sustainable, and nutritionally effective solution to meet the growing demand for high-quality protein. By leveraging the synergistic combination of legumes, cereals, seeds, nuts, and dairy, it is possible to formulate functional supplements that not only provide essential macronutrients but also promote overall health and well-being. This approach has the potential to address nutritional gaps, enhance food security, and support culturally relevant dietary practices, making it highly relevant in both developed and developing contexts [8,36].

1.1 Sources of Natural Ingredients

High-protein legumes (e.g., chickpeas, lentils, soybeans, black beans) are rich in essential amino acids, fiber, and bioactive compounds that enhance health benefits [10-12]. Cereals such as oats, rice, and quinoa provide complementary proteins and carbohydrates that improve the amino acid profile of the supplement [13,14]. Seeds and nuts including pumpkin seeds, almonds, sesame seeds, and flaxseeds contribute high levels of protein, healthy fats, and micronutrients such as magnesium, zinc, and vitamin E [15-18]. Dairy products, such as milk and yo-gurt, add bioavailable proteins (casein and whey), calcium, and probiotics [19,20].

The combination of these ingredients can yield a complete amino acid profile, improving protein quality and digestibility [21].

Table 5: Functional Properties of Protein Supplements

Property	Importance	Measurement Method	References
Water Absorption Capacity	Affects texture in shakes/porridge	Gravimetric method	[42]
Oil-Holding Capacity	Influences mouthfeel and satiety	Oil retention assay	[42]
Emulsification	Important for beverages & smoothies	Emulsifying index	[34]
Foaming Ability	Relevant for protein bars & drinks	Foam expansion test	[35]
Gelation Capacity	For pudding or custard-type products	Gel formation assay	[42]
Sensory Acceptability	Consumer compliance	9-point hedonic scale	[36]

Protein digestibility-corrected amino acid score (PDCAAS) and digestible indispensable amino acid score (DIAAS) are widely used methods for evaluating the biological value of

protein in both isolated and mixed food formulations [22,23].

1.2 Formulation Strategies

The formulation of a homemade protein supplement requires careful ingredient selection, proportion optimization, and processing techniques [24]. Grinding, roasting, sprouting, and fermentation of legumes and seeds can improve protein digestibility and reduce anti-nutritional factors such as phytates, tannins, and trypsin inhibitors [25–28]. Blending complementary proteins (e.g., legumes and cereals) can address limiting amino acids, such as lysine and methionine, enhancing overall protein quality [29]. Addition of flavouring agents (e.g., cocoa, vanilla, or dried fruits) can improve palatability and consumer acceptability [30].

1.3 Evaluation of Protein Supplements

After formulation, homemade protein supplements are evaluated for proximate composition (protein, fat, carbohydrate, moisture), micronutrient content (minerals and vitamins), amino acid profile, and antinutritional factors [31–33]. Functional properties, such as water absorption, oil-holding capacity, emulsification, and foaming ability, influence the application of the supplement in beverages, shakes, and meal replacements [34,35]. Sensory evaluation, including taste, aroma, texture, and overall acceptability, is crucial for ensuring consumer adherence [36].

1.4 Health Benefits and Applications

Homemade protein supplements can support muscle building, weight management, immune function, and recovery from illness or surgery [37,38]. Additionally, they

can serve as nutritional interventions in populations at risk of malnutrition, such as children, the elderly, and athletes [39–41]. The inclusion of functional ingredients, such as omega-3-rich seeds, antioxidant-containing nuts, and probiotic dairy, can further enhance health benefits, providing bioactive compounds that promote cardiovascular, digestive, and metabolic health [42–44].

1.5 Sustainability and Accessibility

Using locally available ingredients reduces reliance on imported commercial supplements, promotes food sovereignty, and supports local agriculture [45–47]. Homemade formulations also reduce environmental impact by minimizing packaging and transportation-related emissions [48].

1.6 Challenges and Future Directions

Protein is a fundamental macronutrient necessary for virtually every biological process in the human body. It is composed of amino acids, the building blocks that support muscle growth, tissue repair, enzyme synthesis, hormone production, and immune defence [1,2]. Adequate protein intake is critical not only for maintaining health in healthy adults but also during periods of increased physiological demand, such as pregnancy, lactation, growth in children, ageing, and intensive physical activity [3]. Protein also plays a vital role in satiety regulation, body composition management, and metabolic health, making it a key nutrient in both preventative and therapeutic nutrition [10].

The recommended dietary allowance (RDA) for protein varies according to age, sex, activity level, and health status. For a healthy adult, the RDA is generally 0.8 g of pro-

tein per kilogram of body weight per day; however, athletes and individuals engaged in resistance training often require between 1.2 and 2.0 g/kg/day to optimize muscle protein synthesis [3,11]. Pregnant and lactating women have increased protein requirements to support fetal growth and milk production, while older adults may need higher intakes to counteract sarcopenia—the age-related loss of muscle mass and function [12,13].

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However, despite their effectiveness, commercial supplements present several limitations. First, they are often expensive and therefore inaccessible to individuals in resource-limited settings. Second, many products contain additives, preservatives, and artificial flavors, which may be undesirable for health-conscious consumers. Third, the environmental footprint associated with large-scale production, packaging, and transportation of commercial supplements is increasingly a concern [17,18].

These challenges have sparked growing interest in developing homemade protein supplements using locally available natural ingredients [8,9]. Homemade formulations offer a cost-effective, culturally acceptable, and nutritionally robust alternative, particularly for populations with limited access to commercial products. Utilizing ingredients such as legumes, cereals, seeds, nuts, and dairy allows for the creation of protein-rich supplements that can meet essential amino acid requirements while also providing additional micronutrients and bioactive compounds [19–21].

Legumes such as chickpeas, lentils, soybeans, and black beans are excellent sources of plant-based protein, containing significant levels of lysine and other essential amino acids [10,22]. They are also rich in fiber, vitamins, minerals, and phytochemicals, which provide antioxidant, anti-inflammatory, and cardioprotective effects. However, legume proteins are typically low in sulfur-containing amino acids, such as methionine and cysteine, which necessitates complementation with cereals or seeds to achieve a balanced amino acid profile [23].

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The preparation of homemade protein supplements also allows for processing strategies that improve digestibility, safety, and sensory qualities. Techniques such as soaking, sprouting, roasting, and fermentation reduce anti-nutritional factors like phytates, tannins, and trypsin inhibitors while increasing protein availability [25–28]. Flavoring with natural ingredients like cocoa, vanilla, or dried fruits can improve palatability, while blending complementary protein sources ensures a complete amino acid profile, making the supplement suitable for all age groups [29–31].

Additionally, homemade protein supplements align with sustainable nutrition practices, as they reduce dependency on imported commercial products, support local agriculture, and minimize environmental impact related to packaging and transportation [32,33].

Table 6: Evaluation Metrics for Homemade Protein Supplements

Parameter	Purpose	Recommended Method	References
Proximate Composition	Protein, fat, carbohydrate, moisture	AOAC standard methods [31]	[31]
Amino Acid Profile	Completeness of protein	HPLC / Amino acid analyzer	[40,41]
Mineral & Vitamin Content	Micronutrient sufficiency	ICP-MS, UV-vis spectrophotometry	[40,41]
Anti-Nutritional Factors	Phytates, tannins, trypsin inhibitors	Spectrophotometric / Enzymatic assays	[25–28]
Microbial Safety	Shelf-life and safety	Total plate count, yeast/mold, coliform	[49]
Functional Properties	Water/oil absorption, foaming, emulsification	Standard food science protocols	[34,35,42]

From a public health perspective, they represent a practical intervention to combat malnutrition, particularly in children, elderly populations, and low-income communities, where affordable, protein-rich foods are critical [34,35].

In summary, the development of homemade protein supplements using locally available natural ingredients offers an innovative, sustainable, and nutritionally effective solution to meet the growing demand for high-quality protein. By leveraging the synergistic combination of legumes, cereals, seeds, nuts, and dairy, it is possible to formulate functional supplements that not only provide essential macronutrients but also promote overall health and well-being. This approach has the potential to address nutritional gaps, enhance food security, and support culturally relevant dietary practices, making it highly relevant in both developed and developing contexts [8,36].

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