

DEVELOPMENT OF HIGH-PROTEIN SNACKS USING LOCAL LEGUME INGREDIENTS

Arham Ali

BS Student, Department of English Literature, Punjab University Lahore

ABSTRACT

The increasing demand for nutritious, affordable, and convenient foods has encouraged researchers and food manufacturers to explore plant-based ingredients for the development of value-added snack products. Legumes such as chickpeas, lentils, peas, mung beans, cowpeas, and beans are locally available food resources that provide considerable amounts of protein, dietary fiber, minerals, vitamins, and bioactive compounds. The present study focuses on the development of high-protein snacks using locally available legume ingredients and evaluates their nutritional, physicochemical, and sensory characteristics. Different proportions of selected legume flours were incorporated into snack formulations to improve protein content while maintaining desirable taste, texture, aroma, color, and overall acceptability. The developed formulations were subjected to proximate analysis, including moisture, ash, fat, protein, fiber, and carbohydrate determination. Sensory evaluation was conducted using a hedonic scale involving attributes such as appearance, aroma, flavor, texture, crispness, and overall acceptability. The study is designed to identify a formulation that provides improved nutritional quality without compromising consumer acceptance. Previous research indicates that incorporation of legume ingredients can substantially improve protein and fiber levels in snack products, although excessive legume incorporation may influence texture, flavor, and appearance. Recent research has also demonstrated the potential of chickpea, lentil, pea, soybean, and other pulse ingredients for protein-rich snack development. The study therefore highlights the potential of local legumes as economical and sustainable ingredients for the production of nutritious high-protein snacks.

KEYWORDS: High-protein snacks, legumes, chickpea, lentil, pea, mung bean, plant protein, nutritional quality, sensory evaluation, snack development.

INTRODUCTION

The modern food system has experienced a significant increase in demand for convenient foods that can provide nutritional benefits while fitting into increasingly busy lifestyles. Snacks have become an important part of daily dietary patterns among children, adolescents, university students, working adults, and other population groups. However, many commercially available snack products are primarily formulated from refined cereals, starches, fats, salt, and sugars and may provide high energy but comparatively limited amounts of protein and other essential nutrients. The growing interest in healthy eating has consequently encouraged food researchers to develop snack products with improved nutritional profiles. One promising approach is the incorporation of locally available legumes into snack formulations. Legumes provide plant-based protein together with dietary fiber, vitamins, minerals, complex carbohydrates, and several bioactive compounds. Recent research describes pulses as nutrient-dense and relatively affordable protein sources with favorable environmental characteristics. Legumes are particularly important in developing and emerging food systems because they can provide relatively inexpensive sources of dietary protein. Common examples include chickpeas, lentils, peas, beans, mung beans, cowpeas, and faba beans. These ingredients can be consumed directly or processed into flours and protein-rich fractions for incorporation into different food products. Pulse proteins have received increasing attention because of their nutritional value and functional properties,

including water-holding capacity, oil-holding capacity, emulsification, gelation, and foaming. These characteristics make legumes suitable for bakery products, extruded snacks, crackers, nutritional products, and other formulated foods. A 2024 review of pulse protein ingredients emphasized that chickpeas, lentils, peas, beans, faba beans, and other pulses have considerable potential for food formulation because of their nutritional and technological functionality. Protein is one of the most important nutrients required for human growth, tissue repair, enzyme production, hormone synthesis, and maintenance of body functions. Although animal foods can provide high-quality protein, increasing attention is being given to plant proteins because of concerns related to food affordability, sustainability, dietary diversity, and environmental pressure. Legumes can contribute substantially to protein intake while also supplying fiber and micronutrients. FAO has highlighted pulses such as lentils, beans, chickpeas, and cowpeas as important and generally affordable sources of protein, particularly in populations where access to animal-source foods may be limited. Therefore, incorporating local legumes into snack foods may provide an opportunity to improve the nutritional value of commonly consumed foods while making use of locally available agricultural resources.

The use of local ingredients is particularly relevant to food product development because locally produced legumes may reduce dependence on expensive imported protein ingredients. In countries such as Pakistan, chickpea, lentil, mung bean, and other pulse crops are familiar components of traditional diets. Their familiarity can potentially facilitate consumer acceptance of newly developed snack products. Mnayer, D., & Joubrane, K. (2025). Explained Instead of relying entirely on highly processed commercial protein isolates, food developers can investigate the use of whole-legume flours or simple combinations of local ingredients. This approach may also support local agriculture and provide opportunities for small-scale food processing enterprises. Research on pulse crops has shown that legumes can combine nutritional density, affordability, and relatively low environmental impacts, making them relevant to sustainable food development. The nutritional potential of legumes is not limited to their protein content. Legumes also provide dietary fiber, resistant starch, minerals, vitamins, and bioactive compounds. A 2024 review of pulse consumption identified chickpeas, lentils, common beans, black-eyed peas, and split peas among the extensively studied pulses and summarized evidence concerning their potential contributions to health outcomes. In food formulations, the addition of legumes may therefore improve several aspects of nutritional quality simultaneously. However, nutritional improvement must be balanced against product quality because consumers generally expect snacks to possess desirable sensory characteristics such as crispness, pleasant flavor, attractive appearance, and acceptable aroma.

The technological properties of legumes can strongly influence the final quality of snack products. Legume flours contain proteins and fibers that interact with starch, water, lipids, and other ingredients during processing. Increasing the proportion of legume flour may increase protein and fiber content, but it can also modify dough properties, expansion, hardness, color, flavor, and crispness. Consequently, the development of a high-protein snack requires careful selection of ingredients and appropriate formulation. Recent research on extruded snacks containing soybean flour demonstrated that processing conditions such as barrel temperature and feed moisture can significantly affect physicochemical and sensory characteristics. Similarly, research using cowpea and wheat demonstrated that increasing

cowpea incorporation could increase protein and fiber, while processing conditions affected the nutritional characteristics of the final snack.

Snack development using legumes can take several forms, including baked crackers, chips, extruded products, roasted snacks, energy bites, bars, and composite-flour products. The selection of processing technology depends on the intended product and available equipment. Baking is particularly suitable for small-scale research because it is comparatively simple, economical, and easy to standardize. Bisson, G., Baggio, A., Rossi, I., Cutroneo, S., Tagliasco, M., Tedeschi, T., ... & Pellegrini, N. (2025). Explains Extrusion is another important technology because it can produce expanded and crispy snacks from cereal-legume blends. Recent research has demonstrated that cereal-legume combinations can be used to develop nutrient-rich extruded snacks with improved nutritional and physicochemical properties. Recent research also demonstrates that successful high-protein snack development requires more than simply increasing protein concentration. A 2025 study developed protein-rich snacks using soybean, pea, lentil, chickpea, and other protein ingredients. The researchers found that protein incorporation influenced texture, aroma, flavor, and appearance, while certain combinations received better sensory responses than others. Another 2025 study developed high-protein snacks based on pea and fava bean proteins and found that protein type and thermal treatment influenced sensory characteristics and protein digestibility. These findings demonstrate that formulation optimization is necessary to obtain an appropriate balance between nutritional improvement and consumer acceptability. The use of chickpea and lentil flour in snack formulations is particularly promising because these ingredients can be processed into flour relatively easily and incorporated into cereal-based products.

Another important consideration is the presence of antinutritional factors in raw legumes. Compounds such as phytates, tannins, and protease inhibitors may affect mineral bioavailability and protein utilization. Appropriate processing methods—including soaking, germination, fermentation, cooking, roasting, extrusion, or fractionation—can modify these components. Modern research has also investigated fractionation technologies for improving the protein concentration and functionality of legumes. A 2025 study of chickpea, fava bean, and red lentil reported that fractionation could produce protein-enriched ingredients with different functional characteristics. Therefore, processing should be considered an important component of high-protein snack development. From a sustainability perspective, the use of legumes offers additional advantages. Pulses can contribute to diversified agricultural systems and have environmental benefits compared with some animal protein sources. FAO emphasizes the nutritional and environmental importance of pulses and their potential contribution to sustainable food systems. Developing snacks from local legumes may therefore address several objectives simultaneously: improving nutritional quality, utilizing local agricultural resources, supporting affordable food production, and promoting plant-based food consumption.

In Pakistan, where traditional foods already include chickpeas, lentils, peas, beans, and other legumes, there is considerable potential for developing modern snack products based on familiar ingredients. Transforming these traditional ingredients into convenient, attractive, and protein-rich snack products may increase their utilization among younger consumers.

Such products can potentially be marketed as nutritious alternatives to conventional snacks. However, product development must consider local taste preferences, ingredient availability, production cost, processing methods, and sensory acceptability. The present research therefore focuses on the development of high-protein snacks using local legume ingredients. The study aims to formulate different snack treatments using selected local legumes and to evaluate their nutritional and sensory characteristics. The research will investigate whether the incorporation of legume ingredients can increase protein content while maintaining acceptable product quality. The findings may provide useful information for students, food technologists, culinary professionals, small-scale food processors, and researchers interested in developing affordable plant-based snack products.

RESEARCH OBJECTIVE

1. To develop high-protein snack products using locally available legume ingredients and evaluate their nutritional, physicochemical, and sensory characteristics in order to identify an acceptable and nutritionally improved formulation.

RESEARCH QUESTION

1. How does the incorporation of locally available legume ingredients affect the nutritional, physicochemical, and sensory characteristics of high-protein snack products?

LITERATURE REVIEW

Legumes are important plant-based sources of protein and are widely recognized for their nutritional and agricultural value. Chickpeas, lentils, peas, beans, mung beans, cowpeas, and faba beans contain substantial amounts of protein and are also sources of dietary fiber, minerals, vitamins, and bioactive compounds. Recent literature emphasizes that pulses have potential as sustainable protein ingredients because of their nutritional density, affordability, and comparatively favorable environmental profile. Drewnowski, A. (2024). Fund that Their use in food products is therefore increasingly relevant to the development of nutritious foods. Pulse proteins can also provide important technological functions in food systems. Their solubility, water-holding capacity, oil-holding capacity, emulsification, gelation, and foaming characteristics vary according to the type of legume and processing method. These properties influence how legume ingredients perform in baked, extruded, and formulated foods. Legume-based foods can provide protein together with fiber and micronutrients. The combination of protein and dietary fiber may make legume-containing products nutritionally more substantial than many conventional refined cereal snacks. A 2024 scoping review examined evidence concerning pulse consumption and health outcomes and included research on lentils, chickpeas, beans, peas, and other pulses. . One of the simplest ways of incorporating legumes into snack foods is through flour production. Legumes can be cleaned, dried, milled, and sieved to produce flour that can be blended with cereal flour or other ingredients. Legume flour can then be used in crackers, biscuits, chips, baked snacks, extruded snacks, and other products.

A recent study developing crackers from cereal and legume flours found that incorporating lentil and pea flour improved protein and amino-acid levels. The researchers also reported improvements in resistant starch and changes in starch digestibility, while acceptable sensory quality could be maintained at appropriate substitution levels. This suggests that legume flour can improve nutritional characteristics without necessarily making a product unacceptable. Chickpea is particularly suitable for snack development because of its nutritional composition, availability, mild flavor, and versatility. Chickpea flour can be used in both traditional and modern foods. Recent research on rice-chickpea snacks demonstrated that extrusion processing altered the microstructure and improved protein-related nutritional characteristics. Guo, F., Danielski, R., Santhiravel, S., & Shahidi, F. (2024). Revealed The study identified a formulation containing 20% chickpea as particularly successful because it maintained desirable expansion, crispness, nutritional quality, and consumer preference. Chickpea can therefore be considered a promising local ingredient for the development of protein-enriched snacks. Its use may also help connect traditional legume consumption with modern convenience foods. Lentils and peas are additional important ingredients for high-protein snack formulation

. Both can be processed into flour or protein-rich ingredients and incorporated into baked or extruded foods. Recent research on protein-rich snacks found that combinations involving pea, soybean, lentil, and chickpea could produce products with acceptable texture and sensory characteristics. Research on high-protein snacks based on pea and fava bean proteins further demonstrated that the protein source influenced taste and overall acceptability, while processing affected texture, odor, and protein digestibility. These findings emphasize that the selection and concentration of legume ingredients should be carefully controlled. Extrusion is widely used for the manufacture of expanded snack products because it combines mixing, heating, cooking, shaping, and texturization in a single process. Mnayer, D., & Joubrane, K. (2025). Elaborated on The addition of legumes can improve the nutritional value of cereal-based extruded snacks. However, processing conditions such as temperature, moisture, screw speed, and ingredient ratio can affect expansion, density, hardness, color, and nutritional quality. A 2024 study using finger millet, sweet potato, and soybean flour demonstrated that barrel temperature and feed moisture significantly affected physicochemical and sensory properties. The research showed that optimizing processing conditions can improve the overall quality of legume-containing extruded snacks. Similarly, research using cowpea and wheat found that increasing cowpea incorporation increased protein and fiber, while the interaction between ingredient ratio and extrusion conditions influenced the final nutritional characteristics.

Sensory acceptability is a critical component of food product development. Consumers generally judge snacks according to appearance, color, aroma, flavor, texture, crispness, and overall acceptability. A nutritionally excellent snack may have limited commercial potential if consumers dislike its taste or texture. Recent research confirms that increasing protein concentration can affect sensory properties. A 2025 study of protein-rich potato snacks found that protein ingredients influenced texture, aroma, flavor, and appearance. Some combinations involving pea, soybean, chickpea, and lentil were particularly acceptable to panelists. Therefore, the present research will not evaluate protein content alone. Sensory evaluation will be conducted to determine whether the developed products are acceptable to

potential consumers. The development of high-protein snacks requires a balance between nutritional improvement and technological quality. Increasing the proportion of legume flour can increase protein and fiber but may also produce undesirable characteristics such as darker color, stronger legume flavor, greater hardness, or reduced expansion. Consequently, an optimum formulation must be identified. Recent cracker research demonstrated that legume flour incorporation could increase protein and amino-acid content while maintaining positive sensory characteristics at appropriate substitution levels. This supports the principle that moderate incorporation of legume ingredients may provide a useful balance between nutritional and sensory quality. Processing can affect the nutritional value of legumes. Heating can modify proteins and starches and may reduce some antinutritional factors. However, excessive thermal treatment may negatively affect some nutritional characteristics.

Although considerable research has examined pulse proteins, protein concentrates, and legume-based food products, there remains a need for simple, affordable snack formulations based on locally available whole-legume ingredients. Much research focuses on specialized protein isolates or industrial processing technologies. There is comparatively greater practical value in investigating formulations that can be produced using locally available legumes and relatively accessible food-processing methods. The present study addresses this gap by developing high-protein snacks using local legume ingredients and evaluating both nutritional and sensory characteristics. The research emphasizes a balance between protein enhancement, product quality, consumer acceptability, and practical feasibility.

METHODOLOGY

The study will employ a quantitative experimental research approach to develop high-protein snacks using locally available legume ingredients. Selected legumes such as chickpeas, lentils, mung beans, peas, or cowpeas will be obtained from local markets and carefully inspected to remove damaged seeds, stones, and other foreign materials. The legumes will be washed, dried, and milled into fine flour using a suitable grinder and then passed through a sieve to obtain uniform particle size. Different formulations of the snack will be prepared by incorporating varying levels of legume flour into a standardized base formulation. For example, a control treatment may contain 0% legume flour, while experimental treatments may contain 10%, 20%, and 30% legume flour. Other ingredients such as cereal flour, vegetable oil, salt, spices, and water will be kept constant as far as possible. The ingredients will be thoroughly mixed, shaped into uniform snack pieces, and baked or processed under standardized temperature and time conditions. After processing, the snacks will be cooled and stored in airtight food-grade containers before analysis.

The developed snack samples will be evaluated for their nutritional, physicochemical, and sensory characteristics. Proximate analysis will be conducted to determine moisture, ash, fat, protein, fiber, and carbohydrate contents using standard laboratory procedures. Particular attention will be given to protein content to determine the effectiveness of legume incorporation in increasing the nutritional value of the snack. Physical characteristics such as weight, thickness, color, texture, and crispness may also be recorded. Sensory evaluation will be conducted with approximately 20–30 panelists using a 9-point hedonic scale, ranging from 1 = dislike extremely to 9 = like extremely. The panelists will evaluate appearance, color,

aroma, taste, texture, crispness, and overall acceptability. Samples will be coded and presented in randomized order to reduce bias. The collected data will be analyzed using descriptive statistics, including mean and standard deviation, while analysis of variance (ANOVA) will be applied to determine significant differences among the formulations. A significance level of $p < 0.05$ will be used. The formulation demonstrating a favorable combination of high protein content and sensory acceptability will be identified as the most suitable product for further development. Available next action: Create a downloadable DOCX file here in this chat containing the editable prose above.

RESEARCH DESIGN

A laboratory-based experimental design will be used. Selected local legumes, such as chickpea, lentil, pea, mung bean, or another locally available pulse, will be cleaned, dried, milled, and converted into flour. The flour will be incorporated into snack formulations at different levels. For example, four treatments may be developed. The remaining ingredients will be kept constant as far as possible. The formulations will be mixed, shaped, and baked or processed using a standardized procedure. Each treatment will be produced in repeated batches to improve experimental reliability. The selected legumes will first be inspected to remove damaged seeds, stones, foreign materials, and other impurities. The legumes will then be washed and dried. Where necessary, soaking or roasting may be used before milling. The dried legumes will be ground using a suitable grinder and passed through a sieve to obtain relatively uniform flour. The prepared flour will be stored in clean, airtight containers until formulation. A basic snack formulation will be prepared using legume flour, cereal flour where required, vegetable oil, salt, spices, water, and other standardized ingredients. Different quantities of legume flour will be incorporated into the formulations. The dough will be mixed thoroughly and shaped into uniform snack pieces. The products will then be baked or processed under controlled temperature and time conditions. After processing, the snacks will be cooled and packed in airtight food-grade containers until analysis. The nutritional results will be expressed as percentages per 100 g of sample. Increasing protein content across treatments will be compared with the control to determine whether legume incorporation produces the intended nutritional improvement.

DATA ANALYSIS

The collected data will be entered into Microsoft Excel and/or SPSS. Descriptive statistics including mean and standard deviation will be calculated for each treatment. Analysis of variance (ANOVA) will be used to determine whether differences among formulations are statistically significant. Where significant differences are identified, an appropriate post-hoc test such as Tukey's test may be applied. The nutritional results will be compared across treatments to identify changes associated with increased legume incorporation. Sensory scores will also be compared to determine which formulation achieves the best balance between nutritional improvement and consumer acceptability. Statistical significance will be considered at $p < 0.05$.

FINDINGS

The expected findings of the study indicate that incorporation of local legume flour will improve the protein content of the developed snack products compared with the control formulation. Treatments containing higher proportions of chickpea, lentil, pea, mung bean, or other selected legumes are expected to show increased protein and dietary fiber levels. This expectation is consistent with recent research demonstrating that legume incorporation can improve the nutritional characteristics of crackers and extruded snack products. The sensory findings are expected to demonstrate that moderate legume incorporation produces better overall acceptability than very high levels. A moderate formulation may provide an appropriate balance between protein improvement, flavor, aroma, texture, color, and crispness. Excessive legume incorporation may produce a stronger characteristic legume flavor or modify texture and appearance. Similar effects have been reported in recent high-protein snack studies, where protein source and concentration influenced sensory characteristics. It is expected that the optimized formulation will achieve significantly higher protein content than the control while maintaining acceptable sensory scores. The results may therefore demonstrate that locally available legumes can be successfully transformed into convenient high-protein snack products. The findings could support the use of chickpea, lentil, pea, mung bean, and related legumes as practical ingredients for nutritious snack development.

CONCLUSION

The study concludes that locally available legume ingredients have strong potential for the development of high-protein snack products. Legumes provide protein, dietary fiber, minerals, vitamins, and other beneficial components and can therefore improve the nutritional value of conventional snack formulations. Recent research supports the incorporation of pulse ingredients into crackers, baked snacks, extruded products, and other food formulations. The development of legume-based snacks can also contribute to the utilization of local agricultural resources and the production of relatively affordable plant-based foods. However, successful product development requires careful control of ingredient proportions and processing conditions because excessive incorporation of legumes may influence flavor, color, texture, and overall acceptability. The most suitable formulation should therefore be selected on the basis of both nutritional and sensory results. Overall, the research demonstrates the potential of local legumes to serve as valuable ingredients for nutritious, sustainable, and consumer-acceptable high-protein snack products.

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