FROM FIELD TO PLATE: HIGH-PROTEIN PLANT-BASED MEAT PRODUCTION TECHNOLOGY IN UZBEKISTAN

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Abstract

The increasing demand for sustainable and nutritionally rich food sources has led to a growing interest in plant-based meat alternatives. This study explores the potential of three locally available legumes—chickpeas (Karakul variety), mung beans (Navruz variety), and soybeans (Navbahor variety)—for high-protein plant-based meat production in Uzbekistan. The primary objective of this research is to identify which of these crops can most effectively meet the nutritional, textural, and sensory demands of plant-based meat products. Using an empirical approach, the study employs four laboratory methods: protein extraction and quantification by the Kjeldahl method, Texture Profile Analysis (TPA), nutritional composition analysis via High-Performance Liquid Chromatography (HPLC), and sensory evaluation with a trained panel.

Results show that the Navbahor soybean variety provides the highest protein content (35.03%), optimal textural qualities, and the most favorable amino acid profile, making it the best candidate for plant-based meat. Mung beans, with moderate protein content (23.03%) and favorable textural properties, serve as a suitable secondary option, while chickpeas are identified for milder-flavored applications. The study contributes to the theoretical understanding of plant-based protein sources and offers practical insights for developing locally-sourced meat alternatives in Uzbekistan. These findings have practical significance for enhancing food security, supporting sustainable agriculture, and advancing the plant-based food industry in Uzbekistan. The results underline the potential for scaling up high-protein plant-based meat production, contributing to environmental sustainability and health-conscious consumer trends.

Keywords: plant-based meat, protein extraction, texture analysis, nutritional

composition, chickpeas, soybeans

Introduction

By utilizing local crops such as chickpeas, mung beans, and soybeans, the study aims to develop plant-based meat products that support Uzbekistan's agricultural strengths and provide a healthier protein alternative. As plant-based diets become more popular due to their lower environmental impact, Uzbekistan can leverage this trend by creating locally-sourced protein-rich meat substitutes.

Plant-based meat production aligns with key United Nations Sustainable Development Goals (SDGs), including Zero Hunger (SDG 2), Good Health and Well-being (SDG 3), Responsible Consumption and Production (SDG 12), and Climate Action (SDG 13). This is particularly relevant for Uzbekistan, where water scarcity and land degradation present challenges to traditional livestock farming. By adopting plant-based alternatives, the country can reduce the environmental burden of meat production while enhancing agricultural diversity and public health through reduced rates of diet-related diseases.

Uzbekistan's regulatory framework supports these goals. The 2021 Law on Food Safety ensures that plant-based meats meet national safety standards, while the Law on the Protection of Consumer Rights (1996) emphasizes accurate labeling and ingredient transparency. Additionally, the 2020 Decree on Sustainable Agricultural Development encourages crop diversification, creating space for plant-based protein sources.

This research aligns with Uzbekistan's strategic priorities by exploring the potential of chickpeas, mung beans, and soybeans for high-protein meat alternatives. Through methods such as protein extraction, texture analysis, and sensory evaluation, the study supports Uzbekistan's goal of reducing reliance on imported protein, improving food security, and positioning itself as a leader in sustainable food production in Central Asia.

RESULTS

1. Protein Extraction and Quantification by Kjeldahl Method

The protein content for each of the three plant sources (chickpeas, mung beans, and soybeans) was measured using the Kjeldahl method. Each analysis was performed in triplicate to ensure accuracy.

Table 1: Protein Content of Chickpeas, Mung Beans, and Soybeans by Kjeldahl Method

Plant Source	Run 1	Run 2	Run 3	Average (±SD)
Chickpeas (Karakul)	19,5	19,8	19,6	19.63 (±0.15)
Mung Beans (Navruz)	23,2	22,9	23	23.03 (±0.15)
Soybeans (Navbahor)	35,2	34,8	35,1	35.03 (±0.17)

Explanation: As shown in Table 1, the Navbahor soybean variety had the highest protein content, with an average of 35.03% and a standard deviation of 0.17. Mung beans, represented by the Navruz variety, had a moderate protein content, averaging 23.03%.

Chickpeas, represented by the Karakul variety, had the lowest protein content, averaging 19.63%. The consistency across each set of triplicate runs was high, as indicated by the low standard deviations.

2. Texture Profile Analysis (TPA) Using a Texture Analyzer

The TPA results for hardness, cohesiveness, chewiness, and springiness were recorded for each plant-based meat sample created from chickpeas, mung beans, and soybeans. Each sample was analyzed three times.

Table 2: Texture Profile Analysis (TPA) of Plant-Based Meat Samples

Plant Source	Hardness (N)	Cohesiveness	Chewiness (N)	Springiness	Average (±SD)
Chickpeas (Karakul)	13.2, 13.4, 13.3	0.78, 0.79, 0.78	9.0, 9.2, 9.1	0.76, 0.77, 0.76	13.3 (±0.1), 0.78 (±0.01), 9.1 (±0.1), 0.76 (±0.01)
Mung Beans (Navruz)	16.2, 15.8, 16.0	0.82, 0.84, 0.83	10.5, 10.3, 10.4	0.79, 0.78, 0.80	16.0 (±0.2), 0.83 (±0.01), 10.4 (±0.1), 0.79 (±0.01)
Soybeans (Navbahor)	18.5, 18.7, 18.6	0.86, 0.87, 0.86	13.2, 13.3, 13.4	0.82, 0.81, 0.82	18.6 (±0.1), 0.86 (±0.01), 13.3 (±0.1), 0.82 (±0.01)

Explanation: Table 2 presents the TPA results. The Navbahor soybean variety exhibited the highest hardness, chewiness, and springiness values, with an average hardness of 18.6 N (SD ±0.1) and chewiness of 13.3 N (SD ±0.1). Mung beans showed intermediate texture properties, while chickpeas had the lowest hardness and chewiness, making them more suitable for softer textures. Consistent results across runs indicated reliable texture properties for each sample type.

3. Nutritional Composition Analysis via High-Performance Liquid Chromatography (HPLC)

The amino acid profile for each plant source was determined via HPLC, with each sample analyzed in triplicate.

Table 3: Essential Amino Acid Composition of Plant-Based Meat Samples by HPLC (mg/g)

Plant Source	Lysine	Methionine	Leucine	Valine
Chickpeas (Karakul)	4.8, 5.0, 4.9	1.9, 2.0, 1.8	5.5, 5.6, 5.4	4.7, 4.8, 4.6
Mung Beans (Navruz)	5.3, 5.2, 5.1	2.2, 2.3, 2.1	6.7, 6.5, 6.8	5.9, 5.8, 5.9
Soybeans (Navbahor)	6.2, 6.3, 6.1	2.7, 2.6, 2.8	7.9, 8.0, 7.8	6.5, 6.4, 6.6
Average (±SD)	5.4 (±0.55)	2.1 (±0.35)	6.7 (±1.25)	5.7 (±0.75)

Explanation: Table 3 displays the amino acid composition for each sample type, averaged over three runs. Soybeans consistently showed the highest levels of lysine, methionine, leucine, and valine. Chickpeas contained lower levels of these essential amino acids, while mung beans had moderate concentrations. The Navbahor soybeans showed minimal variability, reinforcing their suitability for protein-rich dietary applications.

4. Sensory Evaluation Using a Trained Panel

Sensory evaluation results for each plant-based meat sample were averaged across three runs. The trained panel evaluated appearance, texture, flavor, and overall acceptability, using a standardized scoring system from 1 to 10.

Table 4: Sensory Evaluation Scores for Plant-Based Meat Samples

Plant Source	Appearance	Texture	Flavor	Overall Acceptability	Average (±SD)
Chickpeas (Karakul)	8.1, 8.3, 8.2	7.7, 7.8, 7.9	8.4, 8.5, 8.3	8.2, 8.1, 8.3	8.2 (±0.15), 7.8 (±0.10), 8.4 (±0.10), 8.2 (±0.10)
Mung Beans (Navruz)	8.2, 8.0, 8.1	7.9, 8.0, 8.0	8.6, 8.4, 8.3	8.3, 8.2, 8.3	8.1 (±0.10), 8.0 (±0.10), 8.4 (±0.15), 8.3 (±0.05)
Soybeans (Navbahor)	8.4, 8.5, 8.3	8.1, 8.0, 8.2	8.6, 8.7, 8.5	8.5, 8.4, 8.6	8.4 (±0.10), 8.1 (±0.10), 8.6 (±0.10), 8.5 (±0.10)

Explanation: Table 4 summarizes the sensory evaluation results. Soybeans received the highest scores across all sensory attributes, with an overall acceptability score of 8.5 (SD ±0.10), followed closely by mung beans with 8.3 (SD ±0.05). Chickpeas, though slightly lower in overall sensory ratings, achieved an acceptable score, making them suitable for applications targeting milder flavors. Panelist consistency was reflected in the low standard deviations, indicating reliable and replicable sensory characteristics for each sample type.

DISCUSSION

This study evaluated three local plant sources—chickpeas (Karakul), mung beans (Navruz), and soybeans (Navbahor)—for high-protein plant-based meat production in Uzbekistan. Using four methods—Kjeldahl protein quantification, Texture Profile Analysis (TPA), High-Performance Liquid Chromatography (HPLC), and sensory evaluation—the research assessed each crop's suitability based on protein content, texture, nutritional profile, and sensory appeal.

Protein Content: Navbahor soybeans led with a protein content of 35.03%, ideal for high-protein foods. Mung beans followed with 23.03%, and chickpeas had 19.63%. These values align with studies recognizing soybeans as a superior plant protein source, often preferred in meat substitutes due to their complete amino acid profile.

Texture Profile: TPA showed soybeans with the most meat-like texture due to high hardness and chewiness. Mung beans offered moderate texture versatility, while chickpeas had a softer texture, fitting for products requiring less chewiness. This supports similar findings where soybeans are modified to mimic meat textures effectively, though achieving perfect texture remains a challenge across legume-based alternatives.

Nutritional Composition: HPLC analysis revealed that soybeans have the highest essential amino acids, averaging 23.3 mg/g, similar to animal proteins. While mung beans and chickpeas offer lower levels, they contribute additional nutrients like fiber and vitamins, making them valuable in diversified plant-based diets. These findings reflect the nutritional strengths and limitations of each crop.

Sensory Evaluation: Soybeans scored highest for appearance, flavor, and overall acceptability, with an average score of 8.5. Mung beans performed well at 8.3, suitable for moderate flavor profiles, while chickpeas, though slightly lower, are valuable in applications favoring milder flavors. These results align with consumer studies, confirming that soy-based products tend to excel in sensory attributes.

Comparison with Other Studies and Future Directions: Consistent with global research, soybeans emerged as the most suitable for plant-based meat, but challenges like allergenicity and environmental concerns exist. Although chickpeas and mung beans have a lower protein and amino acid profile, they are sustainable alternatives, especially for mixed-protein products. Advanced processing methods, like extrusion for mung beans, could enhance their texture, while chickpeas may benefit from blending with high-protein crops to create well-rounded plant-based meats.

CONCLUSION

This research aimed to develop high-protein, plant-based meat alternatives in Uzbekistan using locally sourced chickpeas, mung beans, and soybeans. Given the increasing demand for sustainable foods, this study analyzed these crops' suitability using four methods: Protein Quantification via Kjeldahl, Texture Profile Analysis (TPA), Nutritional Profiling via HPLC, and Sensory Evaluation.

The findings support soybeans as the best option, meeting nutritional, textural, and sensory demands. Key results include:

Protein Content: Soybeans averaged the highest protein at 35.03%, followed by mung beans (23.03%) and chickpeas (19.63%), indicating soybeans’ superior protein potential for meat alternatives.

Texture Analysis: TPA results showed soybeans with the most meat-like hardness and chewiness. Mung beans offered moderate texture versatility, while chickpeas were softer, suiting products requiring less chewiness.

Nutritional Composition: HPLC results highlighted soybeans’ high essential amino acid content (23.3 mg/g), aligning with the study’s goal of identifying a nutritionally rich ingredient.

Sensory Evaluation: Soybeans received top scores for appearance, flavor, and overall acceptability, with mung beans also performing well. Chickpeas scored lower but offer value in products targeting milder flavors.

In conclusion, soybeans' high protein, robust texture, and favorable sensory qualities make them ideal for Uzbekistan's plant-based meat production, supporting food security, health, and environmental sustainability goals. Mung beans and chickpeas are viable complementary ingredients, enriching the range of local, sustainable food options.

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