Utilization of plant-based ingredients in poultry meat products to enhance competitiveness

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Abstract. This article presents the results of a study on the influence of the biological value and consumer properties of poultry patties (a cooked poultry meat product) on consumer preferences and product competitiveness. Sesame was selected for enrichment due to its high content of calcium and polyunsaturated fatty acids. Coagulated egg melange was introduced to enhance the biological value of the patties. The developed samples were evaluated based on organoleptic indicators, calcium content, and fatty acid profile. The biological effectiveness of the samples was determined through calculation. A non-enriched sample was used as a control. A positive influence of the enriching plant-based ingredient on the organoleptic properties of the patties was established: taste, aroma, and consistency were improved. A higher calcium content was noted in the samples with the addition of black sesame. A positive impact of the plant-based ingredient on the fatty acid profile of the samples was observed: the content of saturated fatty acids decreased, while the content of polyunsaturated fatty acids increased. The influence of the introduced enriching ingredients on the level of competitiveness of the samples was determined. Consumers were offered samples of patties with the enriching ingredients and patties without them. Information about the beneficial properties of the enriching ingredients was provided beforehand. The study results established that consumer preferences were in favor of the most beneficial patties containing black sesame.

1 Introduction

Sesame as an agricultural crop originated many centuries BC. Its seeds were discovered during excavations of Egyptian pharaohs' tombs. Sesame oil (sesame) was also used during the campaigns of Alexander the Great (4th century BC), as evidenced by literary sources.

Sesame (Sesamum indicum L.) is an annual plant belonging to the Pedaliaceae family and classified as an oilseed crop. Sesame holds significant agricultural importance. It is cultivated in regions of the African continent, China, America, and the Indian subcontinent. Currently, the total global sesame cultivation area is 7.0 million hectares.

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The high nutritional value of this crop is attributed to its high content of protein (27%), carbohydrates (20%), and up to 60% oil, which has a digestibility rate of 100% and surpasses olive oil in this aspect. Sesame oil has a high biological efficiency index and contains polyunsaturated fatty acids (PUFAs): 35-38% oleic acid and up to 48% linoleic acid.

Sesame seeds contain proteins, primarily composed of globulins. They also contain vitamin E, sesamol, lignans, alcohols, and phytosterols. The nutritional value varies among different sesame varieties. Specifically, black sesame has been found to possess the highest nutritional value.

Sesame seeds contain substantial amounts of minerals - calcium, sodium, magnesium, phosphorus, and potassium salts (Ca, K, Mg, P, Na). Sesame oil contains a high concentration of unsaturated fatty acids [1-4].

Meat and meat products are integral components of a complete diet and are in constant demand among the population. This is explained by the high biological value of these products. At the same time, there is a limitation of resources, especially meat raw materials and their quality, which does not always allow for the production of high nutritional value products. Therefore, in accordance with modern production requirements, it is necessary to introduce new types of raw materials and technologies that will enable the manufacture of high nutritional value products [5-8].

The modern accelerated pace of life has led to a change in dietary patterns. There is an increasing demand for quick-prep foods, in particular, semi-finished products. Expanding the range of this market segment can be achieved through the production of enriched types of semi-finished products, provided their quality is maintained. Specifically, the use of plant-based raw materials as a source of vitamins, minerals, polyunsaturated fatty acids, and dietary fiber is possible. It is also necessary to consider that products made solely from plant-based or solely from animal-derived raw materials are inferior in nutritional value to combined products. Therefore, the development of such products is a promising direction [9-11].

Diseases related to insufficient nutrient intake include osteoporosis, which is observed in old age. WHO statistics indicate that 80% of the population suffers from various musculoskeletal disorders. Some clinical research data show that supplements containing a combination of calcium and vitamin D can reduce the risk of fractures in older adults. To increase calcium levels in the diet, it is recommended to include foods high in calcium. Traditionally, these are milk and dairy products. Another source of calcium is sesame, which contains 1474 mg of calcium. Sesame has high physiological value. It contains substances that have a positive effect on the body's recovery after significant physical exertion and psychological stress. Substances contained in sesame seeds and oil have excellent effects on the cardiovascular and digestive subsystems of the human body: they regulate the increase in acid concentration in gastric juice, promote the treatment of the liver and gallbladder; reduce cholesterol levels and regulate oxygen exchange, promote cell renewal, and inhibit the aging process. A positive effect on thyroid gland activity is also noted [12, 13].

The poultry industry produces eggs as one of its primary products. Over the past 50 years, significant changes have occurred in the egg processing industry. Currently, in European countries and the United States, more than 30% of total egg consumption consists of processed egg products, with the remainder sold in-shell. In Russia, only 10% of eggs are used in processed forms: frozen and pasteurized products such as melange, egg white, egg yolk, egg powder, and omelets.

Eggs are considered a healthy food, well-suited for high-protein, low-carbohydrate diets. The egg is regarded as nature's most perfect food, containing protein with high biological value while having a moderate calorie content (approximately 150 kcal/100 g). Eggs exhibit a high ratio of unsaturated fatty acids to saturated fatty acids. They also contain minerals and vitamins. The polyfunctionality of eggs makes them a preferred ingredient in many food formulations; they can be used not only in the confectionery, meat, and processing industries but also be marketed as a ready-to-eat dish. Consequently, eggs possess high nutritional and biological value, along with high culinary versatility [14].

2 Materials and Methods

This study produced chopped semi-finished products in accordance with GOST 32951 "Meat and Meat-Containing Semi-Finished Products. General Technical Conditions" – chicken broiler meat patties with the addition of 8% coagulated egg melange, 5% black sesame, and 5% white sesame. For comparison, a control sample of patties without sesame was produced. No preliminary processing of the sesame was conducted. The melange was additionally ground after production to achieve a paste-like consistency and ensure better distribution within the mince. The mince was produced from chicken broiler breasts. Grinding was performed using a plate with a hole diameter of 2-3 mm.

* Sample 1 – with the addition of black sesame;
* Sample 2 – with the addition of white sesame;
* Sample 3 – control (without sesame addition).

The resulting semi-finished products were evaluated based on organoleptic indicators (GOST 31470-2012). The following descriptors were selected: irregular shape, atypical taste, plant-derived aftertaste, meat aroma, egg aroma, sesame aftertaste, juiciness, tenderness.

The calcium level in the samples was determined according to GOST 31470-2012, and the fatty acid composition of the semi-finished products was established using a chromatographic method.

The fatty acid score indices of the samples and the indicator of the biological effectiveness of the fat components were calculated. The biological effectiveness of lipids, which is determined by the internal structure of fatty acids, their proportion relative to each other, and other food components, is a comprehensive indicator that assesses their impact on the human body.

Per 100 g of lipids required daily by a person, the portion for saturated fatty acids (SFA) F_{01} should be 20 g, for polyunsaturated fatty acids (PUFA) F_{02} – 6 g, and for oleic acid F_{03} – 35 g.

The reference "ideal" lipid is a theoretical product containing PUFAs, SFAs, and oleic acid in proportions where the biological effectiveness coefficient equals 1.

To determine the biological effectiveness coefficient of lipids, the following steps are necessary:

- The content of fractions - F_{ij} - SFA (F11), PUFA (F_{12}), oleic acid (F_{13}) - is determined from the results of the empirical assessment of the fatty acid composition of the semi-finished product samples, calculated in grams per 100 g of fat;

- Scores for the fractions (SFA, PUFA, and oleic acid) - C_{ij} (C_{11}, C_{12}, C_{13}) - are calculated;

- The biological effectiveness coefficient of the product's lipids is calculated, assuming the following equality: $C_{ik} = C_{13}$.

A study was conducted to determine the competitiveness of the developed semi-finished products. In the first stage, a tasting of the developed samples was carried out by students and faculty of the Smolensk State Agricultural Academy, and the consumer properties of the semi-finished products were determined. Commercially produced chicken semi-finished products without enriching ingredients were selected as the control sample. Tasters were provided with data on the enrichment of the semi-finished products with plant-based raw materials, and the biological value of the enriched samples and characteristics of the enriching raw materials were explained. In the second stage of the study, an assessment of the economic indicators of the samples, considering the inclusion of enriching raw materials, was determined. At the final stage, the integral indicator of competitiveness was assessed as the ratio of consumer properties to the economic indicator.

3 Results and Discussion

The introduction of new types of plant-based raw materials can influence organoleptic properties. Changes in these properties may negatively impact the demand for new product types. Therefore, the first stage of the research involved an evaluation of organoleptic indicators.

The developed semi-finished products had the correct form, with a good, even surface free of cracks and breaks. The taste of each enriched semi-finished product possessed a specific, pronounced taste and aroma of the enriching raw material. A uniform distribution of sesame seeds and melange was observed in the cross-section of the experimental patty samples. A profilogram based on the selected descriptors was developed and is presented in Figure 1.

It was noted that the samples had a pleasant taste. The experimental samples exhibited a plant-derived aftertaste, which was particularly pronounced in Sample 1. The most distinct meat aroma was found in Sample 3 (the control). An egg aroma was noted in Sample 2 and Sample 3. A plant-derived aroma was noted in Sample 1, while a more meaty aroma was noted in Sample 3. The highest levels of juiciness and tenderness were observed in Sample 2.

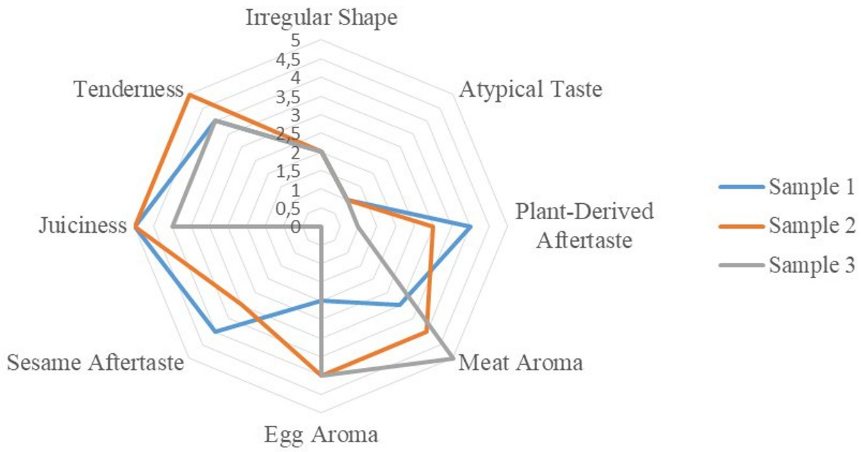

Fig. 1. Organoleptic Profile of Patty Samples

The calcium content was determined in the produced samples.

Table 1. Calcium Content in Experimental Samples

Functional Food Ingredient	Sample 1	Degree of Daily Requirement Satisfaction, %	Sample 2	Degree of Daily Requirement Satisfaction, %
Calcium, mg/100 g	130.6	13.1	43.5	4.4

The higher calcium content in the sample with added sesame allows it to be recommended as an additive for food enrichment. White sesame contributes an insignificant amount of calcium.

The fatty acid composition of the patties was determined. The results are presented graphically in Figure 2.

A positive influence of the plant-based raw material on the fatty acid composition of the semi-finished products was noted, manifested in a reduction of saturated fatty acids from 33.03% in Sample 3 (the control sample) to 31.51% in Sample 2 (with added white sesame). An increase in the quantity of polyunsaturated fatty acids was observed in Sample 1 (with added black sesame).

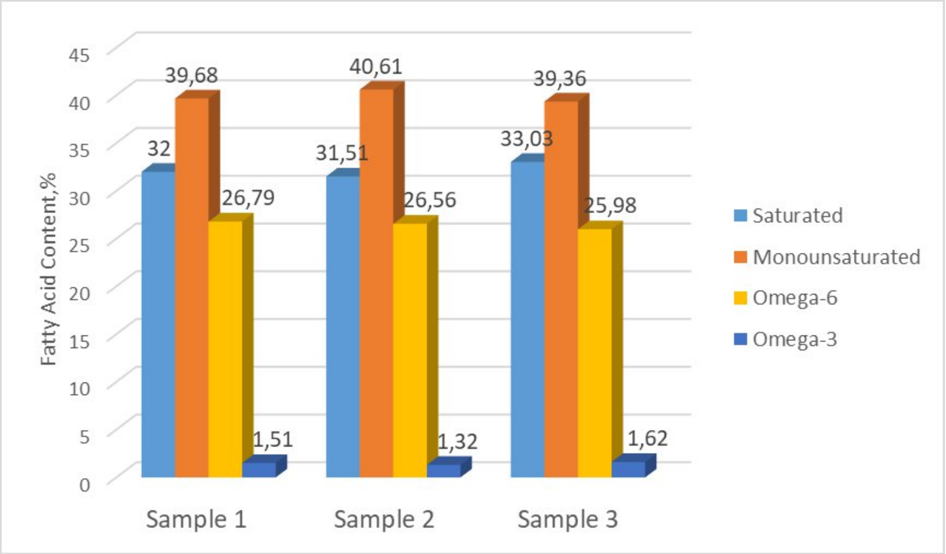

Fig. 2. Fatty Acid Content in Patties

The biological effectiveness of the patty samples was determined.

Based on the results:

The fat fraction content in the samples was determined by calculation:

Sample 1: SFA (F_{11}) = 32 g, PUFA (F_{12}) = 28.3 g, Oleic Acid (F_{13}) = 34.61 g;

Scores for fractions: $C_{11} = 1.6$; $C_{12} = 4.7$; $C_{13} = 0.98$;

Sum of scores: $\Sigma C = 7.28$.

Sample 2: SFA (F_{11}) = 31.51 g, PUFA (F_{12}) = 27.88 g, Oleic Acid (F_{13}) = 35.56 g;

Scores for fractions: $C_{11} = 1.6$; $C_{12} = 4.6$; $C_{13} = 1.0$;

Sum of scores: $\Sigma C = 7.20$.

Sample 3: SFA (F_{11}) = 33.03 g, PUFA (F_{12}) = 27.6 g, Oleic Acid (F_{13}) = 33.83 g;

Scores for fractions: $C_{11} = 1.7$; $C_{12} = 4.6$; $C_{13} = 0.97$;

Sum of scores: $\Sigma C = 7.27$.

Based on the minimum level of any fraction, the biological effectiveness coefficient of the patty lipids was calculated, assuming that $C_{ik} = C_{13}$.

The results are: $\varphi_1 = 0.40$; $\varphi_2 = 0.42$; $\varphi_3 = 0.40$.

Thus, it can be noted that the introduction of 5% black sesame and 5% white sesame did not affect the biological effectiveness of the samples. However, an improvement in the fatty acid composition was observed, characterized by an increase in polyunsaturated fatty acids and a decrease in the level of saturated fatty acids.

The competitiveness of the patties was assessed. The consumer properties of the patties were determined. The results are presented in Table 2.

Table 2. Results of the Assessment of Consumer Properties of Patty Samples

Parameter Name	Patty Samples			Weight Coefficient
	Under Comparison		Basic	
	Patties with White Sesame Addition	Patties with Black Sesame Addition	Chicken Patty	
1. Appearance	5	5	5	0.1
2. Taste	5	5	4	0.3
3. Smell	5	5	4	0.2
4. Color	5	5	5	0.1
5. Biological Value	4	5	3	0.3
Total	22	25	21	1

Determination of Economic Indicators for Patties. The results are presented in Table 3.

Table 3. Evaluation of Economic Indicators for Patties

Parameter Name	Patty Sample		
	Under Comparison		Basic
	Patties with White Sesame Addition	Patties with Black Sesame Addition	Chicken Patty
Price, RUB/kg	370	380	350

The results of the competitiveness assessment for the patty samples are presented in Table 4.

Table 4. Results of the Competitiveness Assessment for Samples

Parameter	Patty Sample		
	Under Comparison		Basic
	Patties with White Sesame Addition	Patties with Black Sesame Addition	Chicken Patty
1. Overall Competitiveness Indicator for All Consumer Properties	0.9	1.0	0.8
2. Overall Economic Indicator	1.05	1.08	1.0
3. Integral Competitiveness Indicator	0.86	0.92	0.80

The table shows that the enriched patty samples possess the highest competitiveness indicator.

4 Discussion

Today, nutrition is emerging as one of the most important factors in forming and maintaining health. Many consumers prefer products of natural origin, as well as products with added enriching ingredients that supplement the food with nutrients lacking in the human diet.

Conducted research has shown that when assessing and choosing food products, particularly meat patties, the indicator of biological value—the balanced content of biologically active substances in their composition: essential amino acids, polyunsaturated fatty acids, vitamins, and minerals—plays an important role. Since sesame seeds contain a large amount of calcium and polyunsaturated fatty acids, their incorporation into poultry meat patties positively influenced the composition and nutritional value.

5 Conclusions

In conclusion of the presented research on the enrichment of meat products with sesame as a source of calcium and dietary fiber, the prospects for its use in the production of combined products can be noted. An improvement in the organoleptic properties of the combined products was observed. Plant-based raw materials are a source of calcium, dietary fiber, and polyunsaturated fatty acids. The inclusion of black and white sesame in meat products makes it possible to increase the content of these components in the products and improve the fatty acid composition.

To increase the calcium level to 15% of the daily requirement in the samples, it is possible to increase the content of black sesame. However, it is necessary to consider the taste of the resulting patties, as a high content of black sesame may leave a slightly bitter aftertaste.

The conducted assessment of the competitiveness of the developed patties demonstrated the competitive advantages of the developed enriched samples. This is associated with a slight increase in the cost of the samples alongside a significant increase in consumer properties and physiological effectiveness.

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