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Research Article

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Investigation of the Nutritional and Biological Value of Dry Meat Snacks Enriched with Dietary Fibers

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Abstract

Research aimed at developing the technology of dry meat snacks from various types of meat is becoming increasingly relevant in light of the growing interest in a healthy lifestyle as a source of protein. The purpose of the study is to investigate the effect of a dose of flaxseed flour on the nutritional and biological value of experimental samples of dry meat snacks from mutton, horse meat, and camel meat. In the course of the conducted study, it was established that the use of flaxseed flour in the production of dry meat snacks has a substantial effect on their chemical composition, leading to changes in the content of water, protein, fats, and ash, depending on the percentage of the additive. The addition of flaxseed flour also leads to a substantial increase in fiber content and changes in the vitamin and amino acid composition of the finished product. The results of microbiological analysis confirm the absence of microbial contamination in samples of finished products of dry meat snacks, which indicates their safety. The practical importance of the study lies in the possibility of optimizing the production processes of dry meat snacks with the addition of flaxseed flour, which will allow manufacturers to create products with improved nutritional characteristics that meet the needs of consumers.

Keywords

Nutritional value, Vitamins, Amino acids, Mutton, Horse meat, Camel meat

Introduction

In the 21st century, when the pace of life is rapidly increasing, and the need for nutritious and tasty products remains relevant, the research and development of dry meat snacks represent an important stage in the development of the food industry. These innovative products combine high nutritional value, long shelf life, and ease of use, which makes them attractive to a wide range of consumers. The problems of research and development of dry meat snacks include the search for new protein sources, the introduction of bioactive additives to improve food characteristics and the optimization of drying and packaging technologies.

As stated by Auyeskhan et al. [1], dry meat snacks are becoming not only a convenient snack for active people but also an important element of a rational nutrition strategy. They support the need for high-quality proteins, giving consumers the opportunity to enjoy the taste of meat at any convenient time. In addition to attention to taste aspects, research aimed at developing the technology of dry meat snacks focuses on innovative methods to improve the nutritional value of the product. The development of processes that preserve the maximum amount of nutrients in meat plays a key role in the creation of dry meat snacks. Technological solutions, such as low temperature drying or vacuum packaging, contribute to the preservation of the natural taste and aroma of meat, which is

important for creating attractive products for the consumer. Innovative methods are also aimed at reducing the fat and salt content in dry meat snacks, which corresponds to healthy eating trends [2-4].

Mendybayeva et al. [5] also believe that research in the field of dry meat snacks includes aspects of sustainability and environmental responsibility. The search for effective methods of recycling meat production waste, drying modes, and the use of sustainable packaging materials are becoming an integral part of the development of new products. According to Holman et al. [6], considering the growing interest in diverse diets and consumer preferences, the number of people following paleo- or keto-diets is increasing. This opens up new horizons for innovation in the field of alternative protein sources and the creation of products that meet diverse consumer preferences. Thus, the research and development of dry meat snacks continues to evolve in a direction that combines high quality, taste, and functional characteristics to meet the requirements of modern consumers.

According to Kuzeubayeva et al. [7], Kazakhstan, with its rich natural resources, provides unique opportunities for the use of various types of meat in the food industry. Horse meat, camel meat, and mutton are part of the traditional Kazakh cuisine and play an important role in the food industry of Kazakhstan. Horse meat, for example, is valued for its nutritional properties and is often used in traditional dishes such as beshbarmak. Camel meat is also gaining popularity due to its uniqueness and beneficial qualities, such as low-fat content. Mutton, being a more familiar meat, remains the basis of many national dishes. Thus, the use of these types of meat not only preserves the cultural legacy but also opens up new opportunities for the development of the food industry in Kazakhstan.

Despite the available research, the scientific gap in the field of research and development of dry meat snacks is a complex set of aspects that require additional examination, which include the search for new protein sources, the introduction of bioactive additives to improve nutritional characteristics, and the optimization of drying and packaging technologies. Therefore, the research and development of dry meat snacks is an urgent direction in the modern food industry, responding to the growing consumer demand for nutritious and delicious products.

Considering the above, the purpose of the study was to identify the qualitative and nutritional characteristics of dry meat snacks that contain flaxseed flour as an additive in various drying methods. The following tasks were set to achieve the stated goal: conduct an examination of dry meat snacks from various types of meat, including sources such as mutton, horse meat, and camel meat, to determine the best options, considering taste and nutritional qualities, investigate the introduction of a flaxseed flour bioactive additive in different proportions, increase nutritional value, and create a product promoting a healthy lifestyle.

Material and Methods

To investigate the technology of dry meat snacks from different types of meat, biomedical requirements for their development and production features, data from the state system of technical regulation of the Republic of Kazakhstan [8] were used. Samples of dry meat snacks from different types of meat were tested to determine the nutritional value of dry meat snacks: mutton, horse meat, camel meat with the addition of flaxseed flour in the amount of 10%, 20%, and 30% as a source of nutrients, while dry meat snacks without the addition of flaxseed flour were control samples. The recipe is selected according to standardized schemes of food technology.

Based on early trials aimed at striking a compromise between the nutritious increase of the dry meat snacks and the preservation of their organoleptic properties, the quantities of 10%, 20%, and 30% flaxseed flour were chosen. The purpose of selecting these particular percentages was to investigate a variety of potential increases in the amount of dietary fiber without appreciably changing the product's general acceptability by consumers or its texture or taste. The gradual rises made it possible to conduct a thorough investigation into the potential effects of different flaxseed flour concentrations on the meat snacks' sensory qualities and nutritional makeup.

The meat raw materials were first crushed to prepare dry meat snacks, while the size of the pieces was 3 - 4 mm. The formation of minced meat was conducted by mixing the components in a stirrer for 5 - 6 min. Next, the process of forming dry meat snacks is conducted in the form of bars. Drying of dry meat snacks was conducted by convective drying-by air heating at a temperature of 60 - 80 °C, at which the air circulation rate was 3 - 6 m/min in a sublimation cabinet. This process continued until the mass fraction of moisture in the product decreased from 65 - 70% to 22 - 40%. The cooling of dry meat snacks was conducted in a uniform air flow using an intensive method. The air velocity was 0.05 - 0.1 m/sec, and the relative humidity was in the range of 70 - 80% until the product temperature reached 10 - 12 °C.

The content of moisture, proteins, fats, and carbohydrates was determined by the Kjeldahl method. The analysis of the number of amino acids and water-soluble vitamins was determined using the method of high-performance liquid chromatography using the LC 3000 Eppendorf chromatograph (Division Biotronic, Germany) and the LiChrosorb RP-18 column (Phenomenex, United States of America). Isoleucine, lysine, leucine, methionine, threonine, phenylalanine, and valine were identified from the essential amino acids, and arginine, histidine, glycine, and serine were identified from the interchangeable ones. Among the vitamins, B1, B2, and B6 were identified.

The Kjeldahl method was used to analyze the protein content, and accuracy and precision were carefully considered throughout the process. To guarantee the accuracy of the nitrogen readings, the Kjeldahl apparatus was calibrated using a number of well-known standard ammonium sulfate solutions. Before every batch of analyses, this procedure was carried out again to ensure consistency in the findings. The study's protein content data was deemed credible because the standards utilized for calibration complied with the directives issued by the regulatory authorities.

The pH level was measured using a pH meter with an electrode 9625-10D (HORIBA LAQUA-PH1500-SR, Japan). The assessment of dietary fiber content was conducted according to the interstate standard GOST 34844-2022 [9]. The ash content was determined by gravimetric method, by burning the sample. Ash content, the inorganic residue left after boiling organic matter and water, is crucial in food science for determining the mineral content and safety of food items. This study examines the impact of flaxseed flour on the mineral profile of dry beef snacks by measuring its ash level [10].

A pH meter that was calibrated and had an electrode attached was used to determine the pH of the dry meat snacks (HORIBA LAQUA-PH1500-SR, Japan). Standard buffer solutions with pH values of 4.00, 7.00, and 10.00 were used for calibration, guaranteeing the accuracy of the readings throughout the relevant range. To ensure uniformity and take into consideration the possible effects of temperature on pH values, measurements were carried out at a controlled temperature of 25 °C. These parameters were kept constant for every sample to guarantee that the outcomes could be compared.

The organoleptic evaluation of ready-made dry meat snacks was conducted in accordance with the interstate standard GOST 34159-2017 [11]. During the organoleptic evaluation, the main indicators for all samples were considered, namely: appearance, color, taste, smell, and texture. Microbiological analysis was conducted to determine the presence and quantity of microorganisms in dry meat snacks and to assess their hygienic condition. For this purpose, the method of surface seeding was used. The research results were processed by statistical processing methods. The significance was set at the level of $p \leq 0.05$.

Results

It was established that the addition of flaxseed flour to the meat component affects the chemical composition of dry meat snacks. Thus, there is a decrease in the water content with an increase in the addition of flaxseed flour. The fat and ash content varies heterogeneously, but in general, it increases with the addition of flaxseed flour. Perhaps this is due to the higher fat content in flaxseed flour and its mineral composition. Also, a slight decrease in pH was noted with an increase in the content of flaxseed flour, which may be due to the chemical properties of the additive (Table 1).

Based on the analysis of dry meat snacks from horse, mutton, and camel meat with the addition of flaxseed flour, the following key conclusions can be drawn. The addition of flaxseed flour reduces the water content in all three types of meat and also changes the content of protein, fat, carbohydrates, and ash. In particular, the protein content decreases in mutton and horse meat but in camel meat, it first increases and then decreases. The fat component increases in mutton and camel meat but fluctuates in horse meat. Carbohydrates increase substantially in all samples with the addition of flaxseed flour.

The addition of flaxseed flour also affects the pH level, causing a slight decrease, and contributes to an increase in the mass fraction of dietary fiber, especially in mutton and horse meat. These results highlight the potential of using flaxseed flour to improve the nutritional value of dry meat snacks, making them richer in dietary fiber and changing other key parameters. Thus, the general conclusion indicates that the addition of flaxseed flour contributes to an increase in the fiber content of meat products, although specific fluctuations may vary depending on the type of meat and the level of flaxseed flour additive. These data may be important when deciding whether to introduce such products into the diet to increase dietary fiber intake. An analysis of the vitamin and amino acid composition of dry meat snacks with the addition of flaxseed flour determined that the level of vitamin B1 decreases when flaxseed flour is added to dry meat snacks from mutton and horse meat, while in dry meat snacks from camel meat, there is an increase and subsequent decrease. The amount of vitamin B2 varies heterogeneously, but in general, it decreases with an

Table 1: Physical-chemical properties of experimental samples of dry meat products.

Samples of dry meat products	Mass fraction (%)						pH
	Moisture	Protein	Fat	Carbohydrates	Ash	Dietary fiber	
From mutton							
Control sample	5.65 ± 0.05	5.65 ± 0.05	5.65 ± 0.05	5.65 ± 0.05	5.65 ± 0.05	-	6.13
A prototype with							
10% flaxseed flour	4.81 ± 0.02	4.81 ± 0.02	4.81 ± 0.02	4.81 ± 0.02	4.81 ± 0.02	1.01 ± 0.02	6.09
20% flaxseed flour	4.22 ± 0.02	4.22 ± 0.02	4.22 ± 0.02	4.22 ± 0.02	4.22 ± 0.02	1.52 ± 0.04	6.09
30% flaxseed flour	3.5 ± 0.03	3.5 ± 0.03	3.5 ± 0.03	3.5 ± 0.03	3.5 ± 0.03	1.64 ± 0.05	6.09
From horse meat							
Control sample	4.14 ± 0.02	4.14 ± 0.02	4.14 ± 0.02	4.14 ± 0.02	4.14 ± 0.02	-	6.11
A prototype with							
10% flaxseed flour	4.10 ± 0.02	4.10 ± 0.02	4.10 ± 0.02	4.10 ± 0.02	4.10 ± 0.02	1.31 ± 0.02	6.04
20% flaxseed flour	4.23 ± 0.03	4.23 ± 0.03	4.23 ± 0.03	4.23 ± 0.03	4.23 ± 0.03	1.27 ± 0.03	6.04
30% flaxseed flour	3.24 ± 0.02	3.24 ± 0.02	3.24 ± 0.02	3.24 ± 0.02	3.24 ± 0.02	1.73 ± 0.05	6.04
From camel meat							
Control sample	6.33 ± 0.05	6.33 ± 0.05	6.33 ± 0.05	6.33 ± 0.05	6.33 ± 0.05	-	5.89
A prototype with							
10% flaxseed flour	5.35 ± 0.03	5.35 ± 0.03	5.35 ± 0.03	5.35 ± 0.03	5.35 ± 0.03	1.30 ± 0.04	5.87
20% flaxseed flour	3.67 ± 0.05	3.67 ± 0.05	3.67 ± 0.05	3.67 ± 0.05	3.67 ± 0.05	1.53 ± 0.03	5.87
30% flaxseed flour	3.80 ± 0.02	3.80 ± 0.02	3.80 ± 0.02	3.80 ± 0.02	3.80 ± 0.02	1.03 ± 0.02	5.87

increase in flaxseed flour in dry meat snacks made from mutton and camel meat. Vitamin B6 levels show variations but generally decrease with an increase in the addition of flaxseed flour to dry meat snacks from mutton and horse meat.

Regarding amino acids, lysine, in most cases, increases with an increase in the content of flaxseed flour in dry meat snacks from mutton, horse meat, and camel meat. Leucine and isoleucine decrease with an increase in flaxseed flour in dry mutton and horse meat snacks, while there is an increase in dry camel meat snacks. The level of methionine and threonine decreases when flaxseed flour is added to dry meat snacks from all types of meat. Phenylalanine and valine mainly decrease with an increase in the content of flaxseed flour in dry meat snacks from mutton, horse meat, and camel meat. Arginine decreases with an increase in flaxseed flour in dry mutton and horse meat snacks, but this trend is less pronounced in dry camel meat snacks. The indicators of histidine and glycine show variability, but it is difficult to identify general trends. Serine, in general, decreases with an increase in the content of flaxseed flour in dry meat snacks from mutton, horse meat, and camel meat (Table 2, table 3 and table 4).

An organoleptic analysis of ready-made dry meat snacks, including an assessment of appearance, color, taste, smell, and texture, was conducted to identify characteristics that may affect the consumer's perception of products. Visually, all samples of dry meat snacks retain a high degree of attractiveness. During the color assessment, it was established that the control variants have a pink color, and dry meat snacks with the addition of flaxseed flour have a lighter shade. Samples of dry meat snacks with flaxseed flour have a delicate structure and a slightly sweet taste, which gives them unique characteristics. The smell of both types of dry meat snacks is preserved without substantial differences. The texture of all dry meat snacks is finely ground, homogeneous, dry surface, and dense consistency, providing a pleasant feeling when consumed.

Thus, the results of the organoleptic analysis confirm the high quality of all variants of dry meat snacks, and the addition of flaxseed flour gives the product additional positive characteristics, making it more interesting for consumers. Consequently, organoleptically, dry meat snacks from different types of meat show similarities, despite differences in raw materials (mutton, horse meat, and camel meat), and the overall results

Table 2: Vitamin and amino acid composition of dry meat snacks from mutton.

Component	Control (mutton)	Mutton + 10% flaxseed flour	Mutton + 20% flaxseed flour	Mutton + 30% flaxseed flour
Vitamins (mg/100 g)				
B1	1.134 ± 0.227	0.913 ± 0.183	0.861 ± 0.172	0.683 ± 0.137
B2	0.146 ± 0.061	0.066 ± 0.028	0.112 ± 0.047	0.107 ± 0.045
B6	0.189 ± 0.038	0.127 ± 0.025	0.112 ± 0.022	0.107 ± 0.021
Amino acids (%)				
Lysine	4.554 ± 1.184	5.296 ± 1.801	4.558 ± 1.55	3.997 ± 1.359
Leucine and isoleucine	7.97 ± 2.71	3.641 ± 0.947	3.226 ± 0.839	2.831 ± 0.736
Methionine	2.77 ± 0.942	1.721 ± 0.585	1.367 ± 0.465	1.299 ± 0.442
Threonine	3.795 ± 1.518	2.516 ± 1.006	2.314 ± 0.926	2.099 ± 0.839
Phenylalanine	3.795 ± 1.139	3.244 ± 0.973	2.91 ± 0.873	2.798 ± 0.839
Valin	3.302 ± 1.321	2.516 ± 1.006	2.209 ± 0.884	1.999 ± 0.799
Arginine	7.970 ± 3.188	10.262 ± 4.105	9.467 ± 3.787	7.995 ± 3.198
Histidine	1.898 ± 0.949	1.49 ± 0.745	1.403 ± 0.701	1.166 ± 0.583
Glycine	4.175 ± 1.419	3.31 ± 1.125	3.436 ± 1.168	3.131 ± 1.065
Serin	2.467 ± 0.641	1.787 ± 0.465	1.964 ± 0.511	1.732 ± 0.45

Table 3: Vitamin and amino acid composition of dry meat snacks from horse meat.

Component	Control (horse meat)	Horse meat + 10% flaxseed flour	Horse meat + 20% flaxseed flour	Horsemeat + 30% flaxseed flour
Vitamins (mg/100 g)				
B1	1.661 ± 0.332	0.827 ± 0.165	1.181 ± 0.236	0.988 ± 0.198
B2	0.166 ± 0.07	0.105 ± 0.044	0.135 ± 0.057	0.099 ± 0.041
B6	0.114 ± 0.023	0.127 ± 0.025	0.152 ± 0.03	0.082 ± 0.016
Amino acids (%)				
Lysine	9.549 ± 3.247	8.529 ± 2.9	7.303 ± 2.483	5.971 ± 2.03
Leucine and isoleucine	5.927 ± 1.541	8.5 ± 0.03	5.951 ± 1.547	5.118 ± 1.331
Methionine	3.622 ± 1.231	2.62 ± 0.891	2.651 ± 0.901	2.09 ± 0.711
Threonine	5.268 ± 2.107	4.264 ± 1.706	4.869 ± 1.948	3.839 ± 1.536
Phenylalanine	4.939 ± 1.482	4.264 ± 1.279	3.516 ± 1.055	3.412 ± 1.024
Valin	4.281 ± 1.712	3.655 ± 1.462	4.057 ± 1.623	3.412 ± 1.365
Arginine	7.244 ± 2.898	7.31 ± 2.924	5.41 ± 2.164	5.332 ± 2.133
Histidine	3.951 ± 1.976	3.96 ± 1.98	3.516 ± 1.758	2.986 ± 1.493
Glycine	5.598 ± 1.903	5.483 ± 1.864	5.41 ± 1.839	5.332 ± 1.813
Serin	4.610 ± 1.199	4.264 ± 1.109	4.328 ± 1.125	4.265 ± 1.109

Table 4: Vitamin and amino acid composition of dry meat snacks from camel meat.

Component	Control (camel meat)	Camel meat + 10% flaxseed flour	Camel meat + 20% flaxseed flour	Camel meat + 30% flaxseed flour
Vitamins (mg/100 g)				
B1	0.642 ± 0.128	1.408 ± 0.282	0.882 ± 0.176	0.697 ± 0.139
B2	0.093 ± 0.039	0.518 ± 0.218	0.208 ± 0.088	0.172 ± 0.072
B6	0.105 ± 0.021	0.237 ± 0.047	0.070 ± 0.014	0.080 ± 0.016
Amino acids (%)				
Lysine	7.419 ± 2.523	7.192 ± 2.445	5.168 ± 1.757	4.751 ± 1.615
Leucine and isoleucine	5.806 ± 1.510	4.690 ± 1.220	3.230 ± 0.840	3.251 ± 0.845
Methionine	2.677 ± 0.910	2.439 ± 0.829	1.712 ± 0.582	1.475 ± 0.502
Threonine	3.548 ± 1.419	4.378 ± 1.751	2.972 ± 1.189	3.001 ± 1.200
Phenylalanine	4.194 ± 1.258	3.096 ± 0.929	3.004 ± 0.901	3.001 ± 0.900
Valin	5.484 ± 2.194	3.440 ± 1.376	3.101 ± 1.240	3.501 ± 1.400
Arginine	7.419 ± 2.968	5.629 ± 2.251	5.168 ± 2.067	5.501 ± 2.201
Histidine	2.484 ± 1.242	2.064 ± 1.032	1.809 ± 0.904	1 475 ± 0.738
Glycine	5.161 ± 1.755	5.941 ± 2.020	3.230 ± 1.098	4.001 ± 1.360
Serin	2.806 ± 0.730	3.440 ± 0.894	2.713 ± 0.705	3.251 ± 0.845

indicate that all variants have fairly high ratings in appearance, color, smell, taste, and texture (Figure 1).

Microbiological examination is an important step in assessing and ensuring the safety of dry meat snacks as a food product. This type of analysis involves checking the presence and quantity of various microorganisms such as bacteria, mold, and yeast. Production and storage processes can create conditions for the reproduction of microorganisms, which can become a source of contamination of products or lead to their decomposition. This poses potential health risks, and microbiological analysis helps to monitor the quality and safety of dry meat snacks. The results of the microbiological analysis indicate that no microbial pathogens or other harmful microorganisms were identified in the samples of dry meat snacks. The absence of microbial contamination in the dry meat snacks under study emphasizes their safety for consumption and maintains the high quality and nutritional value of the product.

Thus, several key conclusions can be identified after examining the nutritional value of dry meat snacks made from different types of meat with the addition of flaxseed flour. Firstly, the addition of flaxseed flour leads to a decrease in the water content in dry meat snacks from mutton, horse meat, and camel meat, giving the product a denser structure. Secondly, changes in protein, fats, and carbohydrates indicate that flaxseed flour has an effect on nutritional value, making dry meat snacks more balanced in terms of these components. Additionally, the analysis of vitamin and amino acid composition showed that the addition of flaxseed flour can affect the content of vitamins B1, B2, and B6 and the level of amino acids. These changes highlight the potential benefits of flaxseed flour products for consumers, such as increased dietary fiber, balanced composition, and changes in nutritional value, which may be important when developing products for a healthy diet.

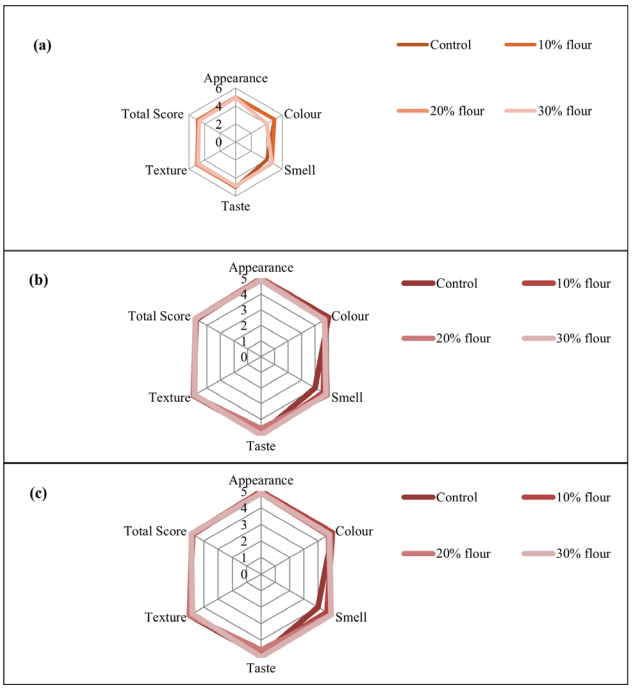

Figure 1: Organoleptic analysis of samples of dry meat snacks from different types of meat: **(a)** mutton; **(b)** horse meat; and **(c)** camel meat.

Discussion

In modern society, where the rhythm of life is becoming more and more active, the importance of a healthy diet and convenient snacks is steadily increasing. In this context, dry meat snacks occupy a special place as a source of protein and energy to maintain physical activity and overall well-being. The development of technologies and research in the field of the production of dry meat snacks play a key role in the creation of innovative products that combine excellent taste and high nutritional value. Dehydrated meat products have become an integral part of the modern consumer market, providing customers with convenient options for meat products. The growing interest in this category is due to its convenience in storage, long shelf life, and ease of transportation. However, the variety of dehydrated meat products on the market creates certain difficulties for consumers when choosing a product that meets their individual needs [12].

The process of producing dehydrated meat products involves removing water from raw meat by drying or freezing [13]. This process can be implemented mechanically or in a natural way. Dry meat snacks are products usually obtained by dehydration and preservation of meat, often by air or solar drying. This process removes moisture from the meat, which helps to preserve it and gives the product a long shelf life without the need for chemical preservatives. Dried meat snacks are usually high in protein and are a convenient snack or addition to main dishes [14-16]. Along with this, Zhu et al. [17] and Xiaolei et al. [18] prove that different drying methods can have different effects on the quality of dry meat snacks. Air heating ensures quick drying and can change the texture of the product, making it crispier, however, loss of nutrients may occur. Vacuum drying, on the contrary, allows preserving the taste, aroma, and nutrients of meat due to lower temperatures and a more uniform drying process, which is also presented in the study. Both methods have their advantages and disadvantages, and the choice between them depends on the production goals and requirements for the final product.

Xu et al. [19] and Botinestean et al. [20] note that the preservation of fresh foods, such as meat, plays an important role in overcoming global food shortages. Meat drying, a traditional method of canning, has found wide application in various cultures around the world. The dried meat products market is a dynamic segment of the food industry with increased demand from consumers [21, 22]. A variety of meat types, innovative technologies, and the use of healthy ingredients contribute to the diversity of the market supply. The growing interest in healthy eating and increased protein intake contributes to the sustainable development of this segment. Globally, the market is showing growth, and organic and natural products without artificial additives are gaining additional popularity among demanding consumers [23, 24]. Overall, the results of the study suggest that adding flaxseed flour can be an effective way to improve the nutritional value of dry meat snacks, making them more balanced and richer in dietary fiber. This can be important for developing healthy food products and meeting the growing demand for functional products.

The ash content is changing, but the overall trend is ambiguous. When flaxseed flour is added, the samples' pH level decreases. An increase in the content of flaxseed flour is accompanied by an increase in the mass fraction of dietary fiber: mutton gradually increases from 1.01% to 1.64%, some fluctuations are observed in horse meat, with a maximum at 30% (1.73%), and in dry meat snacks from camel meat, changes occur with an increase to 20% and a subsequent decrease at 30% of the addition of flaxseed flour. These findings highlight the potential of flaxseed flour products as a source of dietary fiber and may be important when deciding whether to introduce such products into the diet to increase dietary fiber intake. The results of the organoleptic analysis of the finished products indicate the high quality of all product variants, but dry meat snacks dried by vacuum have differences in color, aroma, texture, and taste compared to chips dried by air heating. Therewith, the choice of drying method may depend on consumers: personal preferences regarding taste, aroma, texture, and other characteristics of the product may influence the choice of drying method. The results of microbiological analysis confirm the absence of microbial contamination in the samples of dry meat snacks, which emphasizes their safety and high quality [25, 26].

In this study, it was determined that the addition of flaxseed flour to meat components affects the chemical composition of dry meat snacks. This result is consistent with other studies that have also shown that the addition of flaxseed flour can affect the chemical composition of meat products. Thus, in the study conducted by Núñez-Gómez et al. [27], it was established that adding flaxseed flour to meat products leads to an increase in protein and fat content, and a decrease in water content. This study also determined that the addition of flaxseed flour decreases the water content in dry meat snacks made from mutton, horse, and camel meat, giving the product a denser structure. This result is also consistent with other studies, in particular, by Cholakkal et al. [28], Mediani et al. [29], Aykin-Dinçer et al. [30], which showed that adding flaxseed flour can improve the texture of meat products. In addition, the results obtained by Burris et al. [31] and Fraeye et al. [32] show that adding flaxseed flour to meat products not only increases their shelf life but also enriches their taste and texture. This is due to the high content of nutrients, such as unsaturated fatty acids, vitamins and minerals, which contribute not only to maintaining freshness but also to increasing the nutritional value of the product, which is also demonstrated by the study. In this regard, the addition of flaxseed flour may be attractive to consumers who are looking for healthy and delicious alternatives in their diet. In addition, in this study, it was established that the addition of flaxseed flour can affect the content of vitamins B1, B2, B6 and the level of amino acids. This result is also consistent with other studies that have shown that adding flaxseed flour can improve the nutritional value of meat products.

Also, a number of researchers, in particular, Siddiqui et al. [33], Elmas et al. [34], Burcu and Serdaroğlu [35], emphasize that it is important to pay attention to the safety and quality of raw materials in the production of dry meat snacks. Control over the meat processing process and the correct application of conservation technologies help to ensure the safety and security of products. Research in the field of bacteriology and food safety plays an important role in this aspect, ensuring high standards of product quality. In addition, it is important to consider the sources of raw materials and the environmental sustainability of production since, in the modern world, consumers are increasingly attentive to the origin of products and their impact on the environment. The use of natural and organic ingredients and adherence to the principles of sustainable production can be key factors in attracting consumers and ensuring long-term market success.

The study by Bal-Prylypko et al. [36] analyzed the antioxidant properties of flaxseed flour and their impact on shelf life. The rich antioxidant content of flaxseed flour, which includes lignans and alpha-linolenic acid, can significantly extend the shelf life of food products by preventing oxidative degradation [37]. The inclusion of flaxseed flour in the dry meat snacks could potentially enhance their shelf life by reducing lipid

oxidation, which is a common cause of quality deterioration in meat products. This not only contributes to a longer shelf life but also helps in maintaining the nutritional value of the snacks over time. Further research could explore the specific impact of these antioxidant properties on the longevity and stability of meat products.

The study used flaxseed flour from a certified organic supplier but acknowledged challenges like nutrient composition variations due to growing conditions and processing methods. These could affect the nutritional content of meat snack products and potentially affect the consistency of the flour, causing variability in the results. Also, this research admits that biases may have been introduced into the data by factors including the type of meat chosen and differences in processing procedures. Mutton, horse meat, and camel meat were chosen for the dish because of its nutritional value in traditional Kazakh cuisine and increasing popularity in modern diets. However, because of the inherent variations in meat composition and customer familiarity, these choices might increase variability. Variations in processing parameters, such as drying times and temperatures, may also have an impact on the end product's nutritional value and chemical makeup. Even though these requirements have been as uniformly applied as feasible, bias may still arise from them. Even though these requirements have been as uniformly applied as feasible, bias may still arise from them. By addressing these problems, a stronger framework for evaluating the results and realizing how broadly applicable they are is provided.

Thus, developing all aspects of the production of dry meat snacks plays an important role in creating competitive products that meet the requirements of modern consumers and contribute to the sustainable development of the food industry.

Conclusions

The conducted study allows drawing several important conclusions about the effect of the addition of flaxseed flour on the chemical composition and nutritional value of dry meat snacks. Firstly, the addition of flaxseed flour leads to a change in the content of water, fats, proteins, carbohydrates, ash, and dietary fiber in dry meat products. This may be due to the higher fat and mineral content in flaxseed flour.

In addition, the results of the analysis of the vitamin and amino acid composition of dry meat snacks with the addition of flaxseed flour indicate that the addition of flaxseed flour can affect the content of vitamins B1, B2, B6 and the level of amino acids. These changes can be important when developing products for a healthy diet. The organoleptic analysis also confirmed the high quality of all variants of dry meat snacks, and the addition of flaxseed flour gives the product additional positive characteristics, such as a delicate structure and slightly sweet taste. The microbiological analysis did not identify microbial pathogens or other harmful microorganisms in the samples of dry meat snacks, which emphasizes the safety of the product for consumption.

The practical importance of the study lies in the possibility of optimizing the production processes of dry meat snacks from meat with the addition of flaxseed flour. This will allow manufacturers to create products with higher nutritional value and improved characteristics, which contributes to meeting the needs of a healthy lifestyle among consumers. The prospect of further research is to analyze variations in the composition and properties of dry meat snacks with the addition of flaxseed flour, depending on various factors such as production and storage conditions. This will allow gaining a deeper understanding of the mechanisms of interaction of components and optimizing production processes considering specific conditions and market requirements.

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Conflict of Interest

None.

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