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*The objects of the study are goat and camel sausage with the addition of the natural antioxidant purslane powder. Goat and camel meat are rich in protein, contains little fat and has good digestibility, which makes it an attractive product for baby food. The results showed that experimental samples of goat sausage and chicken fillet and goat sausage and camel sausage showed a moisture content of 72.7 % and 70.6 %, fat 8.1 % and 6.7 %, protein 13.41 % and 15.31 %, carbohydrates 3.0 % and 4.4 %, respectively. The moisture binding capacity of goat and chicken fillet sausage with purslane is 78.16 %, which is 1.73 % higher than the benchmark, which is 76.43 %. The moisture binding capacity of goat and camel sausage with purslane was 78.65 %, which is 2.22 % higher than in the control. High moisture-binding ability helps to preserve the freshness and taste of sausage for a long time. In the course of the work, a comparative analysis of the digestibility of proteins of experimental samples of boiled sausage products was carried out. It was found that goat sausage and chicken fillet are characterized by a lower concentration of tyrosine due to the action of proteolytic enzymes (pepsin and trypsin) – from 624.6 mcg/ml (during the first three hours of hydrolysis) to 371.3 mcg/ml (during 6 hours of hydrolysis), against sausage made from goat meat and camel meat 674.2 when digested with pepsin and 377.3 when digested with trypsin, which indicates a higher degree of digestibility of proteins of these products. Thus, the research of goat and camel sausages for school-age children can contribute to the creation of innovative products that will meet the needs of children's health and development, as well as contribute to the sustainable development of rural regions and the growth of economic activity*

*Keywords: goat meat, camel meat, purslane, fatty acid composition, school child*

# ENHANCING SAUSAGE FUNCTIONALITY PRODUCTS FOR SCHOOL-AGE CHILDREN: A STUDY ON GOAT AND CAMEL MEAT WITH NATURAL PURSLANE POWDER AS AN ANTIOXIDANT ADDITIVE

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## 1. Introduction

The problem of rational nutrition of children remains relevant and important for ensuring their health and well-being [1]. Today we are faced with an increase in cases of pathological conditions associated with intolerance to certain food components [2]. Therefore, such raw materials as goat meat, which is an excellent product with a low content of lipids, cholesterol and high-quality proteins, becomes the best product for nutrition [3]. Camel meat contains a low amount of fat and cholesterol, high moisture content and these indicators make it

ideal for inclusion in the diet [4]. Camel meat is a good source of nutrients. This raw material is very similar to beef in terms of such indicators as taste and texture, but the amino acid content is ten times higher than that of beef [5]. Thus, the development of meat products from these raw materials will contribute to the development of proper nutrition of school-age children. In this context, biologically complete products, which can only be produced on an industrial scale, play an important role in ensuring children's diet [6].

With the increasing demand for meat products every year, our country still depends on their imports [7]. Con-

sidering the prospects of camel and goat breeding, the development of industrial production of meat products from camel and goat meat is a new and promising direction in the industry [8, 9].

The global trend towards the consumption of low-fat and hypoallergenic types of meat, such as goat and camel, especially in baby food, continues to grow [10].

The oxidative process of sausages can significantly affect the quality of finished products and shelf life [5]. When the components of meat products are oxidized, unstable intermediate radicals are formed and disintegrate, and the accumulation of these products leads to irreversible organoleptic, chemical changes [11]. The addition of antioxidants to the composition of meat products can slow down or prevent oxidative processes [12].

Thus, the development of technologies for the production of meat products for children from camel and goat meat, which have high nutritional and biological value, dietary properties and a long shelf life is relevant.

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## 2. Literature review and problem statement

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Scientific studies confirm that the quality of a person's life largely depends on its general health, and health, in turn, is strongly related to nutrition. According to statistics, proper and rational nutrition can increase life expectancy by 15–20 % [13].

Goat meat, although it is a less common type of meat, deserves more attention, especially in the context of its unique nutritional characteristics. Unlike traditional types of red meat, goat meat has a rich amino acid and mineral composition, as well as a high content of unsaturated fats. It is also characterized by easy digestibility and hypoallergenic properties, which makes it a valuable component for the production of functional foods [14].

In recent years, a variety of food products based on goat and sheep meat have entered the market, including smoked, fried, dried and minced meat products [15]. In particular, minced meat products, including meatballs and sausages, are becoming increasingly popular among consumers due to their taste and convenience [16, 17].

Over the past five decades, there has been a significant increase in the number of goats in the world, by about 240 %. While populations of other livestock species remained stable or decreased. At the moment, the population of goats in the world exceeds 1 billion individuals, and more than 94 % of this population is distributed between Asia (with more than 556 million heads) and Africa (with more than 388 million heads) [18]. About 97 % of goat meat production is carried out in developing countries, with China, which produces about 38 % of the world's goat meat, in the first place [19]. In 2019, the total number of goats in Southeast Asia was about 39 million, with Indonesia taking the leading place, with almost 19 million goats [20]. Currently, there are about 2.65 million goats in Vietnam [21]. In Republic of Kazakhstan, there are more than 3 million goats. These studies demonstrate that goat production is expanding significantly and is expected to continue to grow in the coming decades [22]. This is primarily due to the development of dairy goat breeding, and as a result, the consumption of goat meat is also growing. However, currently goat meat is mainly used in home cooking, industrial processing due to the lack of technological development does not allow the full

use of goat meat for the production of meat products. Goat and camel meat are a rich source of protein, which is of significant importance for school-age children [23]. Protein is essential for the proper growth and development of children, as well as for maintaining their overall health. Studies have shown that protein fractions in this type of raw material are able to retain moisture well, which will positively affect sausages and improve organoleptic parameters. Goat and camel meat are also rich in B vitamins, which play an important role in strengthening the immune system and maintaining the nervous system [24]. These nutrients are especially important for active schoolchildren who need enough energy and nutrients for their daily activities and classes.

Chicken fillet usually contains a high amount of protein, about 20–25 g of protein per 100 g of product. Goat meat is also rich in protein and contains about 20–27 g of protein per 100 g. Camel meat contains about 17–21 g of protein per 100 g. Chicken fillet usually has a low fat content, about 1–5 g of fat per 100 g. Goat meat may contain more fat, about 5–10 g of fat per 100 g. But even these indicators are acceptable in dietary nutrition.

Camel meat is usually low in fat, approximately 1–4 g of fat per 100 g. Chicken fillet is rich in protein, but has a low content of iron and zinc [25]. Goat meat provides a good source of protein and iron, as well as vitamins of group B [26]. Camel meat contains iron, zinc and vitamin B<sub>12</sub> [27]. The choice between these types of meat will depend on your dietary preferences and nutritional needs. Chicken fillet may be the preferred choice for those who seek a low-calorie and low-fat diet. Goat meat can be a good source of protein and iron, but it is more caloric and rich in fats. Camel meat also provides some nutrients and can be an interesting choice in regions where it is available. In the Republic of Kazakhstan, these three types of meat raw materials are used in home cooking, but there is no industrial processing of goat and camel meat. For this reason, scientifically based recommendations, developments on processing of these types of raw materials are needed.

However, their introduction into the diet of children faces a number of technological and taste problems [28]. Processing of camel meat is difficult with its rigidity. If to use only camel meat in the recipe, this will lead to a worse consistency, and consumers will not use such products. Processing of goat meat is difficult due to its specific smell, therefore it is necessary to combine such types of meat raw materials to obtain the best organoleptic indicators of the finished product [29]. In this context, natural purslane powder, which has powerful antioxidant properties, not only helps to preserve the freshness of the product [30], but also contributes to its longer storage without loss of nutritional value. Children at school age need a balanced diet rich in protein, vitamins and minerals to support growth and development. Therefore, meat products for children should be enriched with the necessary nutrients, and this may require careful selection of ingredients and additives. One of the solutions to the problems is to reduce the amount of salt and fat in meat products, this will lead to a balanced composition and dietary orientation of meat products [31]. The addition of ingredients with a functional focus for the improvement and prevention of various diseases. For example, plant components that can enrich the nutrient composition of meat products, and which will contribute to the prevention of diseases [32]. Reducing salt and nitrites in sausage products will contribute to improving the health of consumers, but it

is necessary to ensure the shelf life of finished sausages. This is possible due to the addition of natural sources of natural antioxidants [33]. Children are a more vulnerable group of consumers, and products for them must meet high food safety standards [34]. It is necessary to take into account the control of microbiological purity, the absence of allergens and other factors that can have a negative impact on the health of children [35]. Optimal use of all available ingredients and additives is important to increase the nutritional value of the product and its structure. The solution to this problem can be a scientifically based combination of various types of meat raw materials, for example, a combination of goat and camel meat [36]. The use of natural sources of antioxidants to solve the problem of excessive consumption of nitrites and salts [37], purslane is a natural antioxidant that can reduce the amount of nitrite and salts used in sausages. The above methods for the use and proper combination of different types of meat cheese and the use of natural antioxidants are one of the best ways to develop sausages that have a positive effect on the human body. However, the choice and use of natural ingredients and antioxidants, as in the case of purslane powder, also create difficulties in ensuring the stability of the product. In this regard, it is advisable to conduct research to determine the effect of plant raw materials on organoleptic indicators and shelf life indicators.

**3. The aim and objectives of the study**

The aim of this study is to improve the nutritional value and technological characteristics and increase the shelf life of baby sausages through the use of goat and camel meat and purslane powder.

To accomplish the aim, the following tasks have been set:

- determine the chemical composition of sausages;
- determine the fatty acid composition;
- determine the lipid oxidation;
- determine the color stability of sausages;
- determine the digestibility of sausage proteins by digestive enzymes.

**4. Materials and methods**

**4. 1. Object and hypothesis of the study**

The objects of the study are the first sample – boiled goat sausage with the addition of chicken fillet and dry (1 %) purslane powder; and the second sample – boiled goat sausage with the addition of camel meat and dry (1 %) purslane powder. Raw meat chicken fillet, the back of goat and camel meat were purchased in a specialized meat store “Adal et” (Astana, Republic of Kazakhstan). Purslane “Vegetable garden” (manufacturer of Aelita).

Boiled sausages with the addition of purslane are made according to the standard technology of boiled sausages (Fig. 1). Purslane powder (in the amount of 1 % of the mass of 100 kg of minced meat) was added during the minced meat cutting. The recipe for is shown in Table 1.

The heat treatment was carried out to a temperature inside the loaf of 72 °C.

The samples were developed at the pilot production at the Kazakh Agrotechnical Research University named after Saken Seifullin.

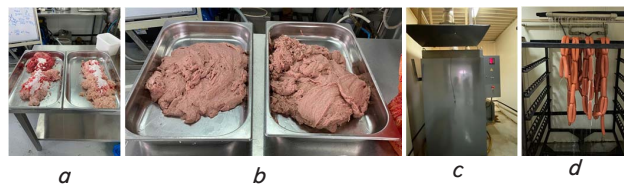


Fig. 1. The process of preparing sausages from goat meat and camel meat: *a* – primary ground meat with the addition of spices and purslane; *b* – secondarily shredded (cutting) sausage minced meat; *c* – heat treatment in a universal thermal chamber; *d* – finished products from goat and camel meat

Table 1

Sausage recipes

Name of ingredients	Goat and chicken fillet sausage with purslane	Goat and camel sausage with purslane
Goat meat, kg	45	45
Chicken fillet, kg	45	45
Raw beef fat, kg	7	7
Purslane, kg	1	1
Salt, kg	1.6	1.7
Sodium nitrite, kg	0.05	0.05
Granulated sugar, kg	0.19	0.19
Black pepper, kg	0.15	0.15
Cardamom or nutmeg, kg	0.2	0.2

It is assumed that the use of goat and camel meat in combination with purslane will improve the nutritional value of sausages, increase antioxidant properties, which will lead to an increase in the shelf life of sausages.

**4. 2. Determination of the moisture binding capacity of sausages**

The moisture binding capacity of the samples was determined by the Grau-Hamm method based on pressing the test sample. To do this, a sample weight of 0.30±0.01 g was weighed on a laboratory scale on a circle of polyethylene with a diameter of 15–20 cm. Then it was transferred to a decontaminated filter with a diameter of 9–11 cm, placed on a glass or plexiglass plate so that the suspension was under a polyethylene circle. From above, the suspension was covered with a plate of the same size as the lower one, a load weighing 1 kg was placed on it and maintained for 10 minutes. The filter with a hitch was released from the load and the lower plate. With a pencil, the contour of the spot was outlined around the compressed suspension, the contour of the wet spot was drawn by itself when the filter paper dried in the air.

The area of the spot formed by adsorption moisture was calculated from the difference between the total area of the spot and the area of the spot formed by the sample. The areas of spots formed by the compressed sample and adsorption moisture were measured with a planimeter. 1 cm<sup>2</sup> of the wet spot area of the filter corresponds to 8.4 mg of water.

### 4. 3. Digestibility of goat and camel sausage proteins by digestive enzymes

The simulation of digestion for boiled sausage product samples followed the protocol devised by Pokrovsky and Yertanov, as outlined below. To begin, 0.5 g of finely crushed sample was combined with 25 mL of freshly prepared pepsin solution (at a concentration of 1 mg/mL). This mixture was created by blending 25 mL of 0.02 N hydrochloric acid solution (with a pH of 1.2) and 25 mg of crystalline pepsin. It was thoroughly mixed and then heated to 37 °C, maintaining this temperature for a duration of 3 hours.

Following the digestion process with pepsin (25 mL), the remaining samples were neutralized by stirring in 0.65 mL of 2 N sodium hydroxide. Subsequently, 25 mL of 0.02 N sodium bicarbonate solution (with a pH of 8.2) and 25 mg of crystalline trypsin (resulting in a final enzyme concentration of 0.5 mg/mL) were added. This mixture was then incubated at 37 °C for another 3 hours.

Upon completion of the digestion process, the samples were promptly frozen at -40 °C for several hours. To measure the protein concentration, the samples were thawed and subjected to centrifugation for 20 minutes at 14,000 rpm, after which the supernatant was collected [38].

### 4. 4. Determination of color characteristics

Color characteristics of the samples were assessed utilizing a Konica Minolta CM-2300d spectrophotometer, which had been calibrated using standard black-and-white calibration plates. The color parameters were represented as follows:  $L$  (lightness),  $a$  (redness), and  $b$  (yellowness).

For the evaluation of color stability under light exposure, the criterion employed was denoted as  $Y$ . Color stability was calculated using the following formula:

$$Y = \left( 1 - \left( \frac{L_1 - L_2}{3 * L_1} + \frac{a_1 - a_2}{3 * a_1} + \frac{b_1 - b_2}{3 * b_1} \right) \right) * 100\% \quad (1)$$

where  $L_1$  and  $L_2$  – the values of the light index before and after exposure to light;

$a_1$  and  $a_2$  – the values of the redness index before and after exposure to light;

$b_1$  and  $b_2$  – the values of the yellowness index before and after exposure to light.

In the assessment of color stability to light, the sample was positioned beneath an artificial light source, specifically an incandescent fluorescent lamp with a minimum power rating of 40 watts. Color attribute changes were measured instrumentally after 1 hour from the commencement of the experiment.

These investigations were conducted with a five-fold repetition for each sample. Data analysis was performed using Microsoft Excel version 16.76, in conjunction with the XLSTAT program [38].

### 4. 5. Measurement of the peroxide number

This method relies on the reaction involving the initial products of fat oxidation, primarily peroxides and hydroperoxides, in the presence of potassium iodide under acidic conditions. Subsequently, titration is carried out using a sodium thiosulfate solution, enabling the quantitative determination of the liberated iodine.

### 4. 6. Determination of the ultimate shear stress

The limiting shear stress of the samples was determined on the Geppler consistometer according to the formula, Pa:

$$\theta_0 = K\alpha * (M/h^2), \quad (2)$$

where  $\theta_0$  – the limiting shear stress, Pa;

$K\alpha$  – the constant of the cone, depending on the angle  $\alpha$  at its vertex;

$M$  – the mass of the load acting on the cone, kg;

$h$  – the immersion depth of the cone, m.

### 4. 7. Determination of carbonyl content

Carbonyls reacted with 2,4-dinitrophenylhydrazine, and the products were detected by measuring absorption at 370 nm. Protein concentrations were calculated by measuring absorption at 280 nm using bovine whey protein as the standard. The carbonyl content was calculated using an extinction coefficient equal to 22,0000 M<sup>-1</sup>cm<sup>-1</sup>.

### 4. 8. Analysis of methyl esters of fatty acids

The analysis of methyl esters of fatty acids was conducted using an Agilent 7890 gas chromatograph, manufactured by Agilent Technologies (Santa Clara, CA, USA). The system was equipped with a flame ionization detector and a capillary column (HP-Innowax, dimensions: 60 m×0.32 mm×0.5 μm), operated with a nitrogen flow. The temperature gradient ranged from 100 to 260 °C at a rate of 10 °C/min. A 1 μL injection was made, and gas flow was mixed at a ratio of 1:100. The detector temperature was maintained between 250 and 300 °C, respectively. The analysis utilized a standard mixture of methyl esters of fatty acids (Supelco No. 47885U) for comparison, and data on the content of C6 to C24 fatty acids were automatically calculated. Quantitative determination of fatty acid content was performed using the internal normalization method.

Statistical analysis of the results followed standard methodologies, in accordance with the specified metrological characteristics of the methods. In cases where such characteristics were lacking, principles outlined in paragraph 5.5 of RMG 76-2014 were applied, assuming a critical significance level ( $p$ ) of 0.05 [39].

## 5. Results of the study of the functional parameters of sausages

### 5. 1. Results of the study of the chemical composition of sausages

When assessing the chemical composition of experimental samples of boiled meat products from goat and camel meat, a difference was noted from the sample made from goat meat, but with the addition of poultry meat (Table 2).

One of the most important functional and technological indicators of sausages are moisture-binding capacity.

The results of the study of sausages obtained from local raw materials, the moisture binding capacity of the prototypes exceeds the control samples (Table 3).

The data obtained show that the addition of purslane, especially in combination with camel meat (78.65±0.23), increases the moisture-binding ability of sausages. This is a positive quality because it helps to retain moisture, which can help improve the overall taste and shelf life of these meat products.

**Table 2**  
Physico-chemical parameters of the studied samples of boiled sausage products with the addition of purslane and a variation of meat raw materials

Name of the Indicators to Be Determined	Unit of Measurement	Test Results	
		Goat and chicken fillet sausage with purslane	Goat and camel sausage with purslane
Mass fraction of moisture	%	72.7±7.3	70.6±7.1
Mass fraction of fat	%	8.1±1.2	6.7±1.0
Mass fraction of protein	%	13.41±2.01	15.31±2.30
Carbohydrates	%	3.0	4.4
Energy Value	kcal	139	139.5
Water-soluble proteins	%	2.94	3.08
Salt-soluble proteins	%	0.52	0.58
Alkali-soluble proteins	%	9.68	11.48
Cutoff voltage	kPa	31.4±0.13	37.6±0.11
Limiting shear stress	Pa	463±0.15	760±0.21

**Table 3**

Moisture binding capacity of sausages

Title	Control Sausage for child food GOST 31498-2012	Goat and chicken fillet sausage with purslane	Goat and camel sausage with purslane
Moisture binding capacity	76.43±0.22	78.16±0.21	78.65±0.23

**5. 2. Results of determination of fatty acid composition and lipid oxidation**

Table 4 shows the main content of the fatty acid composition of the studied samples.

**Table 4**

Fatty acid composition of sausages

Name of the Indicator	Unit of Measurement	Goat and chicken fillet sausage with purslane	Goat and camel sausage with purslane
Myristic C14:0	%	0.5±0.4	1.8±0.4
Myristolein C14:1	%	less than 0.1	0.1±0.4
Pentadecane C15:0	%	0.1±0.4	0.1±0.4
Palmitic C16:0	%	16.6±2.1	20.4±2.1
Palmitoleic C16:1	%	2.6±0.4	2.9±0.4
Margarine With 17:0	%	0.3±0.4	0.5±0.4
Heptadecene C17:1	%	0.2±0.4	0.1±0.4
Stearic C18:0	%	5.8±2.1	7.2±2.1
Oleic C18:1	%	29.7±2.1	30.1±2.1
Linoleic C18:2ω6	%	41.6±2.1	34.3±2.1
Linolenic C18:3ω3	%	1.7±0.4	1.6±0.4
Arachin C20:0	%	0.1±0.4	0.2±0.4
Eicosadienoic acid C20:2ω6	%	0.3±0.4	0.3±0.4
Tricosan C23:0	%	0.4±0.4	0.3±0.4

In summary, the goat and camel sausage generally contains higher percentages of some fatty acids, while the goat and chicken fillet sausage have a higher percentage of Linoleic acid (C18:2ω6). These variations can influence the flavor, texture, and nutritional characteristics of the sausages.

**5. 3. Results of determination of lipid oxidation**

The objective of this research was to assess how purslane extract can protect lipids and proteins from oxidation during a 7-day period of refrigerated storage (Table 5).

**Table 5**

Dynamics of fat oxidation and protein oxidation (background) in sausages during storage

Name of the Indicators to Be Determined	Unit of Measurement	Goat and chicken fillet sausage with purslane	Goat and camel sausage with purslane
Peroxide number (1 day)	meq/kg	1.8±0.2	1.6±0.2
Peroxide number (2 days)	meq/kg	2.2±0.2	2.1±0.2
Peroxide number (3 days)	meq/kg	2.6±0.3	2.5±0.3
Peroxide number (4 days)	meq/kg	2.8±0.3	2.9±0.3
Peroxide number (5 days)	meq/kg	3.5±0.3	3.6±0.4
Peroxide number (6 days)	meq/kg	4.0±0.4	4.2±0.4
Peroxide number (7 days)	meq/kg	4.6±0.5	5.4±0.5
Carbonyl compounds	nmol/mg of protein	96.5	94.8

The carbonyl compound levels in both sausage products are very close, with “Goat and Camel Sausage with Purslane” having a slightly lower value (94.8 nmol/mg of protein) compared to “Goat and Chicken Fillet Sausage with Purslane” (96.5 nmol/mg of protein). The lower levels of carbonyl compounds indicate less oxidative damage to the proteins in the sausage products, suggesting that protein quality is well-preserved.

**5. 4. Results of Color stability**

In the investigation of color stability, both before and after exposure to light, various key color attributes of the cooked sausages were assessed. These attributes include *L* (lightness), *a* (redness), and *b* (yellowness). The corresponding data is detailed in Table 6 for reference.

The results of the determination of color stability showed that both sausage products demonstrate good color stability after exposure to light, with a slight decrease in lightness and an increase in yellowness. The “Goat and Chicken Fillet Sausage with Purslane” exhibits slightly better color stability than the “Goat and Camel Sausage with Purslane,” with a higher percentage (93.89 % vs. 91.69 %). This indicates a fairly stable color formation in the product. Oxidation of meat pigments occurs as a result of a reaction between oxygen and meat proteins. This is a process that occurs during the preparation of meat, as well as during storage and transportation. Oxidation of pigments can lead to a change in the color of meat and a decrease in its quality. To prevent oxidation, an additive of purslane was added, which has an antioxidant effect that helps slow down the oxidation process. The stabilization of meat pigments is also an important aspect of its processing. Stabilization allows to preserve the color of meat after cooking and prevent its discoloration during storage.

Color characteristics of sausages

Samples	Color Characteristics Before Exposure to Light			Color Characteristics after Exposure to Light			Color Stability, %
	<i>L</i>	<i>a</i>	<i>b</i>	<i>L</i>	<i>a</i>	<i>b</i>	
Goat and chicken fillet sausage with purslane	70.27±0.35	20.01±0.38	10.86±0.32	69.14±0.34	20.07±0.33	12.53±0.35	93.89±1.67
Goat and camel sausage with purslane	62.89±0.32	17.27±0.40	12.08±0.26	59.57±0.74	17.57±0.44	14.25±0.11	91.69±1.06

**5. 5. Results of determination of the digestibility of sausages by food enzymes**

In vitro digestion models are synthetic systems designed to replicate natural digestion processes without the involvement of living organisms. These models serve as valuable tools for investigating diverse aspects of protein compound functionality, including their digestion, absorption, and metabolic processes. For instance, in vitro digestion models play a crucial role in identifying the ideal conditions for producing and delivering proteins to the human body. They also contribute to the development of novel therapies for diseases linked to digestive ailments. When studying the digestibility of boiled sausage products, the following values were obtained, presented in Table 7.

Table 7

Results of the evaluation of the digestibility of sausages

Title	C, mcg/ml	
	Goat and chicken fillet sausage with purslane	Goat and camel sausage with purslane
Stage 1 hydrolysis (pepsin)	624.6±35.4	674.2±33.3
Stage 2 hydrolysis (trypsin)	371.3±11.4	377.3±12.5

The results indicate that the “Goat and Camel Sausage with Purslane” contains a higher initial concentration of tyrosine and retains more tyrosine after both stages of hydrolysis compared to the “Goat and Chicken Fillet Sausage with Purslane.” This may suggest a higher degree of protein digestibility in the former product, as more tyrosine remains in the hydrolysate, indicating less degradation of protein during digestion.

**6. Discussion of experimental results of the study of the chemical composition and functional parameters of sausages**

The data in table 1 show a higher protein content and a lower fat content in sausages. Thus, with the generally accepted technology of production of this type of product, the fat content ranges up to 8,1 % absolute units, and protein in the range of 13–15 %. Moreover, the low-fat content was determined, because, as it is known, camel meat contains more fat than chicken breast. The investigation into the dynamics of changes in protein fraction composition, as inferred from comparative studies of sarcoplasmic protein ratios, involved the extraction of sarcoplasmic proteins from muscle tissue using a low ionic strength buffer solution. Sub-

sequently, fractions of water-soluble, salt-soluble, and alkali-soluble proteins were obtained, and their quantities were determined using the Kjeldahl method. The results are presented in Table 2. It was observed that in the test sample containing camel meat, the highest quantity of protein fractions was found in the alkali-soluble fraction, while the salt-soluble fraction had the lowest amount.

Cutoff voltage and Limiting shear stress are indicators used to characterize certain properties of

the tested materials [40]. Cutoff Voltage measures the maximum voltage or pressure at which the material or sample undergoes a specific change or reaches a certain limit [41]. For the “Goat sausage and chicken fillet with purslane,” the cutoff voltage is approximately 31.4 kPa, while for “Goat and camel sausage with purslane,” it’s approximately 37.6 kPa. Limiting shear stress refers to the maximum amount of shear stress a material can withstand before undergoing deformation or failure [42]. For “Goat sausage and chicken fillet with purslane,” the limiting shear stress is approximately 463 Pa, while for “Goat and camel sausage with purslane,” it’s approximately 760 Pa. These indicators help in assessing the mechanical properties of materials and can be crucial in food technology, for understanding how materials respond to loads and pressures is essential for quality control and product development [43]. The data obtained show excellent strength characteristics of sausage products. The results reflect how good the consistency of the resulting sausages is. Which in turn confirms the juiciness of goat and camel sausages.

The results obtained show that sausages made of goat meat and chicken fillet with purslane, and sausages made of goat meat and camel meat with purslane have high indicators of moisture binding ability. This is due to the good technological properties and high moisture-binding capacity of goat meat [44]. The moisture binding capacity of goat and chicken fillet sausage with purslane is 78.16 %, which is 1.73 higher than the benchmark, which is 76.43 %. The moisture binding capacity of Goat and camel sausage with purslane was 78.65 %, which is 2.22 % higher than the control. High moisture-binding ability helps to preserve the freshness and taste of sausage for a long time [45]. This allows to increase the shelf life of the product, which is important for manufacturers and consumers [46]. Loss of moisture can make the sausage stiff and dry, which negatively affects its texture and taste [47]. High moisture binding capacity can contribute to the uniform distribution of flavor and aromatic components throughout the sausage, which improves its taste and aroma [48].

As a result of the study of the fatty acid composition (Table 4), it was found that significant concentrations of only 14 of the 36 fatty acids were detected. To improve sensory evaluation, meat needs to achieve a minimum amount of IMF and ensure a large deposition of oleic acid and CLA [49]. As a result of the conducted studies, the content of linoleic acid in samples of boiled goat sausage products with the addition of poultry meat was determined to be 30 % higher than in the product of goat and camel meat. However, the content of oleic acid is within the margin of error in equal proportions.

Therefore, it is not entirely reliable to assume the sensory lability of the consumer on the above basis. It is also worth

noting that the W3 content in both products is at the same level of LCD concentration.

Phospholipids are plastic components of cell membranes and in ruminants contain a much larger proportion of PUFA than triacylglycerols. Thus, dilution of phospholipids with triacylglycerols in itself explains why lean meat contains more PUFA. Our results confirm that the composition of fat in goat muscles corresponds to the general scheme [50] described for beef and lamb.

Portulaca (*Portulaca oleracea* L.) is a plant that contains vitamin C and antioxidants. Adding purslane to meat products can help protect fat from oxidation. Vitamin C and antioxidants can slow down the oxidation process, which can extend the shelf life of the product. However, it should be borne in mind that the addition of purslane can change the taste and aroma of the product, so the dose of its use in the products in question was used in moderation, no more than 1 %.

Peroxides accumulate in meat during storage, especially at high temperature and humidity. They are formed as a result of the oxidation of fats and proteins. Peroxides can cause changes in the taste, smell and color of meat, as well as worsen its quality. To avoid the accumulation of peroxides, meat needs to be stabilized using both natural and synthetic stabilizers and antioxidants. It is possible to use antioxidants that slow down the oxidation process, as it is suggested, which includes purslane. This is due to the plant's ability to remove free radicals and neutralize oxidation products, both fats and protein.

In the assessment of the obtained findings (Table 5), it can be deduced that the peroxide number accumulates gradually, with peroxides exhibiting the capacity for initial accumulation followed by subsequent reduction during the storage period. In essence, once the threshold of 10.0 meq/kg is surpassed, the meat is deemed incapable of reestablishing its biochemical equilibrium, thereby rendering it unsuitable for practical utilization in the context of food production.

Purslane is a plant that has a number of useful properties, including antioxidant ability [32]. The antioxidant properties of purslane may be related to its ability to protect cells from damage by free radicals, which are one of the main causes of aging and many diseases. Free radicals can cause cell damage, which leads to various diseases such as cancer, cardiovascular diseases, diabetes and others. Purslane contains antioxidants such as flavonoids, carotenoids and vitamin C, which can help protect cells from free radicals. Studies have shown that the introduction of even 1 % into the formulation of the product has a protective mechanism in the process of fat spoilage.

Boiled sausages have certain color characteristics that depend on the ingredients used and the production technology. For example, the color of boiled sausage can be from pink to red, depending on the type of meat and spices used in the cooking process.

The color stability of cooked sausages also depends on many factors, such as the quality of ingredients, production technology, storage and transportation conditions. If sausage products are stored in the right conditions (for example, at low temperature and humidity), they can retain their color for a long time.

However, if sausage products are exposed to high temperatures or light, they can lose their color and become faded. This can happen, for example, when cooking on the grill or when stored in the sun.

In general, the color stability of cooked sausages is an important factor that affects their quality and attractiveness to consumers. Therefore, manufacturers should monitor the storage and transportation conditions in order to preserve the color and quality of their products.

Hence, during the assessment of meat product color stability under varying temperature conditions (specifically, heating to a temperature range of 70–72 °C), considering the impact of added chemical additives (following standard recipes), and investigating color stability during storage, an examination of color attributes was conducted, resulting in the determination of color stability (Table 6). The observed changes in lightness and redness were relatively minor, with decreases of approximately 1.5 % and 5 % in samples containing poultry and goat meat with added purslane. Moreover, there was practically no change in redness for both sets of samples. Conversely, yellowness exhibited higher values (an increase of 15 % and 18 %) after exposure to light compared to its initial values. This suggests the presence of a reasonably stable color formation in the product. The oxidation of meat pigments primarily occurs due to the reaction between oxygen and meat proteins. This is a process that occurs during the preparation of meat, as well as during storage and transportation. Oxidation of pigments can lead to a change in the color of meat and a decrease in its quality. To prevent oxidation, an additive of purslane was added, which has an antioxidant effect that helps slow down the oxidation process. The stabilization of meat pigments is also an important aspect of its processing. Stabilization allows to preserve the color of meat after cooking and prevent its discoloration during storage.

During the study, a comparative analysis of protein digestibility was conducted on experimental sausage samples (Table 7). It was observed that sausages made from poultry and goat meat exhibited lower tyrosine concentrations due to the activity of proteolytic enzymes (pepsin and trypsin). The tyrosine concentration ranged from 624.6 mcg/ml (during the initial three hours of hydrolysis) to 371.3 mcg/ml (after 6 hours of hydrolysis). In contrast, sausages made from goat and camel meat showed higher tyrosine concentrations, measuring 674.2 when digested with pepsin and 377.3 when digested with trypsin. This indicates a greater degree of protein digestibility in the latter products. Protein digestibility can vary depending on factors such as their composition, structure, and preparation method. For instance, proteins rich in branched-chain amino acids may exhibit higher digestibility than those with fewer such amino acids. Additionally, the cooking method, such as frying or baking, can influence protein digestibility and lead to the loss of amino acids and other nutrients.

Thus, the results obtained allow to conclude that the developed sausages are dietary, have a high moisture content, which indicates their delicate consistency. A low amount of fat and a high amount of protein will be useful for middle and senior school students. This technology can be used at meat processing plants, and does not require additional installation of equipment. That is, this technology is also economically advantageous, since the manufacturer does not need to purchase new equipment. Processing of goat and camel meat will give a boost to farmers engaged in the cultivation of these animals. Since the demand for these raw materials will grow.

The limitations of this study may be related to the provision of industrial enterprises with a sufficient amount of

meat raw materials. However, currently there is an active development of dairy camel and goat breeding. Farms are increasing their livestock every year, and this has a positive effect on the development of the meat sector. Since after processing and culling of livestock, it is more profitable to sell processed meat. The research perspective is to develop recipes for functional meat products using natural antioxidants to increase shelf life.

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## 7. Conclusion

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1. The study of chemical parameters of experimental samples of sausage products proved the effectiveness of using goat meat, camel meat, chicken fillet with the addition of purslane powder. The composition of protein fractions of sausage products positively affects the moisture binding capacity of goat sausage and chicken fillet, as well as goat sausage and camel sausage by 78.16 % and 78.65 %, respectively. The cut-off voltage in the sausages of 31.4 kPa and 37.6 kPa justified the delicate consistency required for this type of sausage. Sausage “Goat and chicken fillet sausage with purslane” has, moisture – 72.7 %; fat – 8.1 %; proteins – 13.41 %; carbohydrates – 3 %; Energy value 139 kcal. Sausage “Goat and camel sausage with purslane” has, moisture – 70.6 %; fat – 6.7 %; protein – 15.31 %; carbohydrates – 4.4 %; energy value 139.5 kcal.

2. Both sausages contain significant amounts of Linoleic acid (C18:2 $\omega$ 6), which is an essential polyunsaturated fatty acid known to be beneficial for heart health and overall well-being. Linolenic acid (C18:3 $\omega$ 3), another essential polyunsaturated fatty acid, is present in both sausages, although in slightly lower quantities. These fatty acids are part of the omega-3 and omega-6 families and play a crucial role in maintaining a balanced and healthy diet.

3. The results showed a balanced fatty acid composition of the studied sausages, which has a positive effect on the growing body of schoolchildren. Oxidation of lipids in sausages for 7 days showed that the addition of purslane powder to the sausage composition slows down the oxidation process (1.8 meq/kg on day 1 to 5.4 meq/kg on day 7). According to GOST 31498-2012, the shelf life is 3 days, thus, based on the results obtained, the shelf life increased by 1 day and amounted to 4 days.

4. The “Goat and Chicken Fillet Sausage with Purslane” exhibits slightly better color stability 93.89 % than the “Goat and Camel Sausage with Purslane,” with a higher percentage 91.69 %. 93.89 % vs. 91.69 %). This indicates a fairly stable color formation in the product.

5. The tyrosine concentration ranged from 624.6 mcg/ml (during the first three hours of hydrolysis)

to 371.3 mcg/ml (after 6 hours of hydrolysis). On the contrary, in sausages made from goat and camel meat, the concentration of tyrosine was higher: 674.2 when digested with pepsin and 377.3 when digested with trypsin. This indicates a greater degree of protein digestibility in recent products.

Goat meat as the main ingredient of sausages has high nutritional values and has a high moisture binding capacity. This has a positive effect on the finished sausages. The addition of purslane powder 1 % by weight of minced meat has an antioxidant effect, which increases the shelf life of cooked sausage, thereby reducing the amount of sodium nitrite in the sausage. The data obtained allow to recommend these sausages for the diet of school-age children.

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## Conflict of interest

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The authors declare that they have no conflict of interest in relation to this research, whether financial, personal, authorship or otherwise, that could affect the research and its results presented in this paper.

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## Data availability

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Data will be made available on reasonable request

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## Use of artificial intelligence

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The authors confirm that they did not use artificial intelligence technologies when creating the current work.

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