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# The study of physicochemical and technological properties of boiled sausage recommended for the older adults

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## ABSTRACT

A recipe for cooked sausages of the herodietic direction using protein hydrolysate in the amount of 3%, 5%, and 7% of the mass of raw materials is proposed. The recipe is based on "Beef Sausage". Organoleptic evaluation of the prototypes showed that when protein hydrolysate was added in an amount of 7%, a specific taste characteristic of by-products was present in the prototype. Based on the sensory evaluation results, it was decided to continue the study of samples with the addition of 3% and 5% protein hydrolysate. The results of the study of the physicochemical parameters of the prototypes with the addition of protein hydrolysate 3% and 5%, showed the values of the mass fraction of protein 16.65% and 19.29%, fat 9.85% and 12.25%, carbohydrates 2.85% and 3.07% respectively, indicating an increase in the amount of protein and a decrease in the proportion of fat compared to the control sample. A significant increase in the content of such essential amino acids as lysine and valine and interchangeable amino acids as arginine, glycine, and serine in the test samples confirms that the protein hydrolysate introduced into the prototype is rich and well-balanced in amino acid composition. To study the effect of protein hydrolysate on the quality of meat products, the moisture binding capacity was determined, which was 3% and 5% in the experimental samples with the addition of protein hydrolysate – 75.62% and 79.13%, which is 3.4% and 8.2% higher than that of the control sample, respectively. The sample with the addition of 5% hydrolysate (80.01) has the greatest moisture-retaining ability, which is 9% higher than that of the sample with 3% hydrolysate and 15.8% higher than the control indicator. The study results of the fat-holding capacity in the samples also showed positive dynamics.

**Keywords:** balanced nutrition, older person, aging, herodietic product, moisture-binding ability

## INTRODUCTION

Currently, there is a progressive aging of the population worldwide. In 2000, there were about 600 million people over the age of 60 in the world; according to WHO forecasts, in 2025, the number of older adults will increase to 1.2 billion people, and in 2050 the expected number is 2 billion people **[1]**. In the Republic of Kazakhstan, there is an increase in the share of older adults in the age structure of the country's population. At the beginning of 2019, people over the age of 60 accounted for 11.6%, over the age of 65 7.5% of the country's total population **[2]**. According to the UN classification, a society in which the proportion of people over 65 years of age from the entire population of the country is 7% or more refers to aging. In this regard, it can be argued that our country is at the initial stage of demographic aging. From 2010 to 2018, life expectancy in our country increased from 68.3 years to 73.12 years. Despite the positive growth in life expectancy, it is worth noting that it does not correspond to the country's income levels. The life expectancy of the Economic Cooperation Organization countries, such as Chile and Turkey, with similar GDPs, is 80 years **[3]**. The analysis of food products presented on the market of our country has shown that the following areas are developing dynamically: the production of baby food products, therapeutic and preventive directions. However, their market share is minimal in the range and direction of action on the human body. Herodietic products are mainly represented in products made from dairy raw materials, bakery products, and meat products in limited quantities.

A study of the nutrition of elderly people in the capital of Kazakhstan (Nursultan) shows that the diet mainly consisted of the following products: proteins and fats of animal origin and easily digestible carbohydrates. It is noted that the products had an excess of saturated fatty acids, a lack of polyunsaturated fatty acids (PUFA), a high level of consumption of simple carbohydrates, a deficiency in vitamins: D, A, B1, E, C, biotin, folic and pantothenic acids, and a lack of calcium and potassium **[4]**.

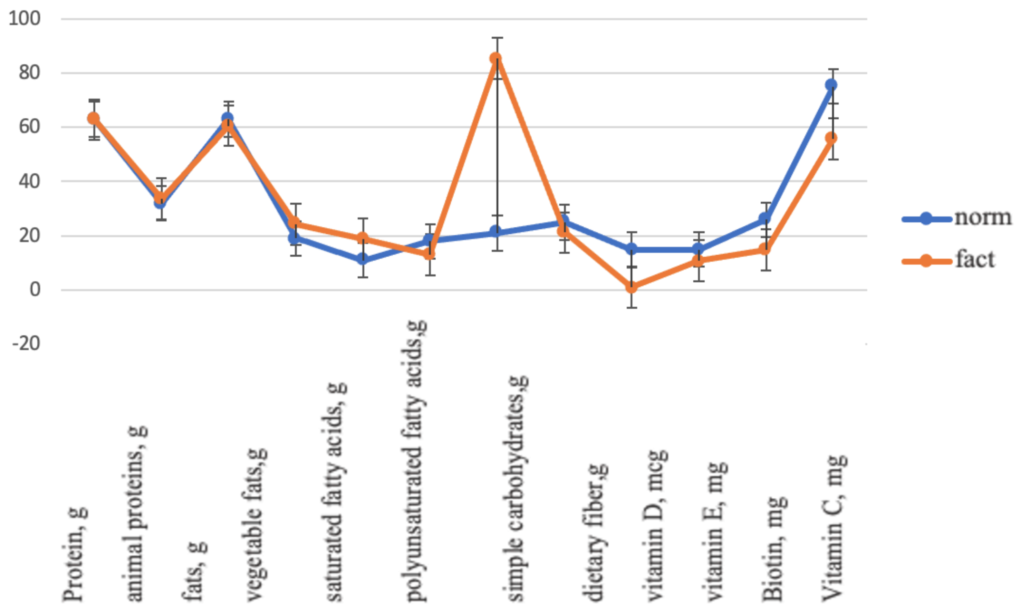


**Figure 1** Daily intake of older adults in Nur-Sultan of food substances in comparison with recommended norms **[5]**.

The study revealed that respondents consume meat and meat products daily: 55.2% of respondents, 10% once a week, and 4.3% do not consume at all. In particular, beef was consumed by 31.4%, horse meat by 29%, mutton by 8.1%, and 8.6% consumed as food.

It was revealed that the low level of calcium, vitamin D, and potassium intake. At the same time, calcium in women is 528 mg/day, and in men, 549 mg/day with a normal requirement of 1300 mg/day. Vitamin D with a norm for women and men of 15 mcg/day; the actual intake was 0.92 and 1.15 mcg/day, respectively. Potassium at a rate of 5000 mg/day, the actual consumption was 2681 mg/day in women and 2835 mg/day in men.

Analysis of the antioxidant potential of raw materials of animal origin, the objects of the study were by-products: liver, brain, heart, aorta, and mesenteric lymph nodes of pigs. As a result, superoxide dismutase, catalase activity, antioxidant activity by the FRAP method, and the concentration of active products interacting with 2-thiobarbituric acid were determined. Liver tissues showed the greatest antioxidant activity of superoxide dismutase and catalase, which amounted to 1398.3 ±16.5 U/g of raw materials and 53.27 ±1.58 U/g of raw materials per minute. The antioxidant activity determined by the FRAP method was 4.10 ±0.16 $mmol^{-eq}$. dihydroquercetin/g of raw materials. The lowest antioxidant activity was observed in the aorta, which was 0.36 ±0.02 $mmol^{-eq}$. dihydroquercetin/g of raw materials. Scientists emphasized that by-products of the meat industry should be used as a source of biologically active components **[6]**.

The study showed a positive effect of β-alanine on the work efficiency of older adults when it is added to the diet as a dietary supplement **[7]**.

The technology of pates for the elderly with the use of raw meat with a high content of connective tissue has been developed. The technology provides for the inclusion of the following components in the recipe: beef trimmings – 35%, grade I beef – 27%, corn groats – 17.5%, oatmeal – 7.3%, carrots – 2.1%, ridge bacon – 10.2%, soybean oil – 0.9%. The above product is recommended for older adults suffering from or predisposed to cardiovascular and gastrointestinal diseases. The following recipe is recommended for older adults with impaired lipid metabolism: grade I beef – 36%, cattle head meat – 18%, buckwheat – 7.2%, carrots – 27.4%, ridge bacon – 10.5%, soybean oil – 0.9% **[8]**.

A boiled sausage for the elderly, "Zdravitsa" has been developed, including cumin, milk thistle oil, and lactulose. These biologically active food components contribute to improving digestion and removing toxins from the liver.

The use of raw meat materials for the production of products for the elderly is relevant and promising. The meat's raw materials contain biologically active substances, such as high-grade animal protein, minerals, vitamins, and fatty acids. These indicators determine the functional properties of raw materials necessary to prevent diseases of the musculoskeletal system (including osteoporosis, osteoarthritis), iron deficiency anemia.

Thus, the main components for products for the elderly that form their orientation are: connective tissue proteins, dietary fibers, vitamins, minerals, antioxidants, and phospholipids.

## Scientific hypothesis

Development of technology for producing boiled sausage using protein hydrolysate is recommended for the elderly. Processing legs with a put joint (beef, lamb, horse meat) will increase the quality indicators in the finished boiled sausage. We expect a significant effect of collagen on the consistency of the finished product.

## MATERIAL AND METHODOLOGY

### Samples

The research objects were legs with a put joint (beef, mutton, horse meat).

### Chemicals

All reagents used were of U.S.P. purity or higher. All solvents, including water, were used with the LC/MS label.

### Instruments

The MOD MARS 6 microwave sample preparation system was used for sample preparation. The amino acid composition was determined using a high-performance liquid chromatograph "Agilent-1200".

### Laboratory Methods

Laboratory studies of raw meat materials were carried out based on the NAO "S.Seifullin KATU" (Nur-Sultan, Kazakhstan). The following were investigated: the total chemical composition (moisture, fat, protein, ash) and amino acid composition **[9]**, **[10]**, **[11]**, **[12]**, **[13]**.

### Description of the Experiment

**Sample preparation:** The objects of the study were legs with a put joint (horse meat, beef, lamb). The main stage of the tests was grinding meat products into minced meat. Grinding was carried out using a meat grinder. The diameter of the grate is 2 mm. Enzyme treatment and hydrolysis process. For experimental studies, samples of beef, horse, and lamb legs with a put joint were selected. The effect of enzyme preparations on connective tissue raw materials was studied using beef, horse, and lamb legs processed according to the traditional technology of processing meat and bone by-products at meat processing enterprises. Legs with a put joint were crushed with a band saw into discs 15-20 mm wide and weighing 50-85 g. 200 ml of distilled water was added to 100 g of legs, and the suspension was heated for 40-45 minutes at 95-98 °C. The released fat was separated. The fat-free legs were placed in a fermentation tank. As is known, to carry out effective hydrolysis of protein substrates, it is necessary to choose the optimal concentration of the enzyme correctly. Therefore, in the future, three enzyme concentrations were selected for the selection of the enzyme concentration, referring to the literature data: 1%, 2%, and 3% protease solution.

A total of 18 samples were selected for the study, in which 1%, 2%, and 3% protease solution was added, and 6 samples for each type of concentration, respectively. Hydrolysis was carried out until the collagen proteins were dissolved entirely, visually observing the samples for 24 hours, with a time interval of 6 hours. An external assessment of protein hydrolysis was performed every 6 hours, which showed the dynamics of protein dissolution from small flakes in the substrate to more extensive precipitation. Hydrolysis was carried out at a temperature of 40 ±5 °C for 24 ±2 hours at pH 8.0.

**Number of samples analyzed:** We analyzed 18 samples.

**Number of repeated analyses:** All measurements of instrument readings were performed two times.

**Number of experiment replication:** The number of repetitions of each experiment to determine one value was two times.

**Design of the experiment:** Physicochemical analyses of the meat mince samples were conducted to standard methods: Total nitrogen content was assayed by the Kjeldahl method using devices DK6, UDK129 (VELP SCIENTIFICA, Italy), an automated incinerator, and a distillation apparatus **[14]**. Moisture was determined by drying the sample in a metal bottle at a temperature of 105°C to constant weight **[15]**. Total fat was determined via the Soxhlet method **[16]**. The ash content was determined via the dry ashing method.


**Figure 2** Samples of legs with a put joint.

## Statistical Analysis

The data were analyzed using Statistica 12.0 (STATISTICA, 2014; StatSoft Inc., Tulsa, OK, USA). The values are presented as the mean ± SEM. The differences were considered to be statistically significant at $p \leq 0.05$. The data were analyzed by One-way ANOVA using free web-based software.

## RESULTS AND DISCUSSION

Regarding the quantitative content of proteins, by-products of the II category are not inferior to meat. Consequently, producing various biologically active substances can be a valuable source of proteins.

**Table 1** The yield of offal to the mass of meat.

| The name of the indicator | Output of meat offal, % | | |
|---|---|---|---|
| | cattle | mutton | horse meat |
| meat offal, | 24.0 ±0.90 | 17.2 ±0.7 | 22.4 ±0.9 |
| including legs with a put joint | 3.37 ±0.07 | 3.6 ±0.05 | 3.59 ±0.05 |

The table shows the output of legs with a put joint from the total number of offal, which is 3.37% for cattle, 3.6% mutton, and 3.67 for horse meat. By-products with high nutritional value allow them to be used in the production of sausages, pates, canned food, and jellies.

**Table 2** Chemical composition and energy value of wool by-products of category 2.

| Title | Content | | | | Energy value, kcal |
|---|---|---|---|---|---|
| | moisture | protein | fat | ash | |
| Mutton legs with a put joint | 64.6 ±0.40 | 27.2 ±0.10 | 7.8 ±0.2 | 0.8 ±0.02 | 168.7 |
| Horse legs with a put joint | 68.3 ±0.40 | 26.7 ±0.14 | 3.8 ±0.2 | 1.2 ±0.02 | 139.4 |
| Beef legs with a putty joint | 65.7 ±0.40 | 26.7 ±0.11 | 6.5 ±0.2 | 1.2 ±0.03 | 161.3 |
| Pig's legs with a putty joint | 55.5 ±0.60 | 22.2 ±0.10 | 21.45 ±0.2 | 0.8 ±0.02 | 281.85 |

Analysis of the chemical composition of wool by-products of category 2 shows that the protein content in mutton legs with a put joint is 27.10-27.30% when both in horse and beef wool derivatives, the amount of protein is at the same level of 26.56-26.84%. This allows us to conclude that mutton, horse, and beef legs with a put joint can be used as raw materials for producing protein hydrolysates.

The fat content in raw materials is one of the important indicators in the production of protein hydrolysates since its content of more than 15-20% complicates the drying process and reduces the shelf life. The study showed that horse, lamb, and beef wool offal (legs with a put joint) have a relatively low-fat content with increased protein mass fraction. Thus, horse legs contain 3.8% fat, beef 6.5%, lamb contains 7.8%, and pork – 21.45%. It follows from this that the low-fat content in the studied samples will allow obtaining protein hydrolysate with optimal quality indicators and using it as an additive in the formulation of a herodietic product.

Data for the amino acid composition of the protein of meat raw materials and offal of category 2 are presented in Table 3.

**Table 3** Amino acid composition of protein of meat offal of category II, g/100 g of protein.

| Indicators | Mutton legs with a put joint | Horse legs with a put joint | beef legs with a putty joint |
|---|---|---|---|
| Valin | 2.1 ±0.10 | 3.2 ±0.10 | 2.0 ±0.10 |
| Leucine | 6.5 ±0.25 | 7.5 ±0.25 | 6.3 ±0.25 |
| Isoleucine | 2.3 ±0.15 | 2.2 ±0.15 | 2.3 ±0.15 |
| Lysine | 6.4 ±0.25 | 6.7 ±0.25 | 6.4 ±0.25 |
| Methionine | 1.1 ±0.18 | 0.53 ±0.18 | 1.1 ±0.18 |
| Threonine | 3.8 ±0.10 | 3.8 ±0.10 | 4.4 ±0.10 |
| Tryptophan | 1.24 ±0.02 | 0.8 ±0.02 | - |
| Phenylalanine | 3.1 ±0.15 | 2.8 ±0.15 | 3.4 ±0.15 |
| Alanin | 9.9 ±0.36 | 9.4 ±0.36 | 3.6 ±0.36 |
| Arginine | 7.9 ±0.30 | 8.2 ±0.30 | 8.7 ±0.30 |
| Aspartic acid | 9.5 ±0.20 | 6.9 ±0.20 | 7.3 ±0.20 |
| Histidine | 1.3 ±0.03 | 1.70 ±0.03 | 1.1 ±0.03 |
| Glycine | 9.5 ±0.5 | 15.2 ±0.5 | 3.5 ±0.5 |
| Glutamic acid | 15.8 ±0.70 | 17.2 ±0.70 | 14.4 ±0.70 |
| Proline | 8.1 ±0.25 | 7.8 ±0.25 | 6.8 ±0.25 |
| Serin | 4.9 ±0.25 | 6.5 ±0.25 | 6.9 ±0.25 |
| Tyrosine | 2.7 ±0.15 | 4.7 ±0.15 | 5.5 ±0.15 |

The research results show a high content of glycine, alanine, glutamic acid, serine, and proline in the by-products of category 2, i.e., those amino acids that are mainly contained in collagen.

Thus, the conducted studies indicate a high potential for the possibility of using these raw materials and have all the prerequisites for producing meat products of the herodietic direction from them.

As a result of the analysis of existing technologies of herodietic meat products, the use of collagen-containing raw materials requires the pretreatment of wool offal. One of the processing options is the hydrolysis of meat and bone raw materials. In the hydrolysis of meat and bone raw materials, fat content is one of the main criteria. With the amount of 15-20% of lipids in the fetal joints, obtaining protein hydrolysates is difficult. In this regard, it is required to pre-degrease meat and bone raw materials.

Heat treatment is one of the widely used methods of extracting fat from bones. The heating of raw materials leads to the denaturation of proteins, which contributes to fat extraction from the bone. Under the influence of high temperatures, fat becomes fluid and less viscous.

When conducting experimental studies, horse, beef, and lamb legs with a put joint are stored at a temperature of 0-6 °C. They are transferred to degreasing no later than 8 hours after deboning. If necessary, these by-products can be stored at a temperature of -18 °C for no more than two months.

Taking into account the peculiarities of the preparation of components, the technological process was worked out, and a technological scheme for producing protein hydrolysate was proposed.

Samples of beef, horse, and sheep legs with a put joint were selected for experimental studies. Based on the research results and for more complete use of all the resources of meat raw materials, in the production of cooked sausages of the herodietic direction, it is proposed to use protein hydrolysate obtained from beef, horse, and lamb legs with a put joint.

The formulations of the control and experimental samples are presented in Table 4.

**Table 4** Formulations of control and experimental samples.

| Name of ingredients | Samples | | | |
|---|---|---|---|---|
| | Control "Beef Sausage" | Experience 1 | Experience 2 | Experience 3 |
| Veneered beef of the first grade, kg | 70 | 70 | 70 | 70 |
| Fat veined beef, kg | 15 | 12 | 11 | 10 |
| Raw beef fat | 12 | 10 | 10 | 10 |
| Protein hydrolysate, kg | - | 3 | 5 | 7 |
| Dry purslane extract, kg | - | 1 | 1 | 1 |
| Table salt, kg | 2.1 | 2.1 | 2.1 | 2.1 |
| Sodium nitrite, kg | 0.05 | 0.05 | 0.05 | 0.05 |
| Granulated sugar, kg | 0.19 | 0.19 | 0.19 | 0.19 |
| Black pepper, kg | 0.15 | 0.15 | 0.15 | 0.15 |
| Cardamom or nutmeg, kg | 0.2 | 0.2 | 0.2 | 0.2 |

The proposed ratio of ingredients provides the required structure, nutritional and biological value, and high functional and technological properties in the finished product.

An organoleptic evaluation of the prototypes was carried out (Figure 3).

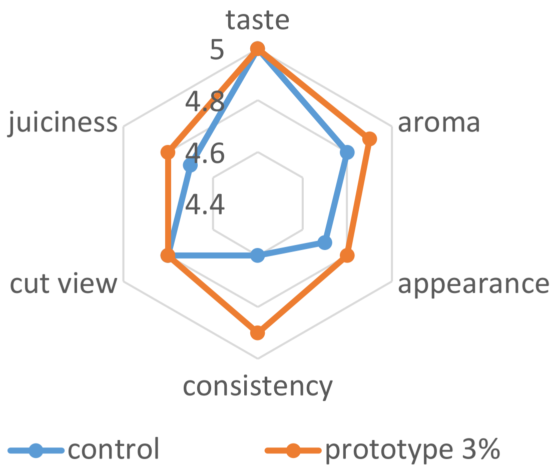


**Figure 3** Sensory evaluation of finished products.

Organoleptic evaluation of the prototypes showed that the optimal amount of protein hydrolysate addition is 3% and 5%. Both samples had a good appearance, consistency, taste, and smell. When protein hydrolysate was added in 7%, a specific taste characteristic of by-products was present in the test sample. Based on the sensory evaluation results, it was decided to continue the study of samples with the addition of 3% and 5% protein hydrolysate.

The results of the study of the chemical composition of control and experimental samples are presented in table 5.

**Table 5** Physico-chemical parameters of control and experimental samples.

| Name of samples | Mass fraction, % | | | |
|---|---|---|---|---|
| | protein | fat | carbohydrates | moisture |
| "Beef sausage" (control sample) | 18.93 | 14.90 | 3.07 | 56.86 |
| Experiment 1 (with the addition of purslane 1%, protein hydrolysate 3%) | 16.65 | 9.85 | 2.85 | 51.31 |
| Experiment 2 (with the addition of purslane 1%, protein hydrolysate 5%) | 19.29 | 12.25 | 3.07 | 51.10 |

In conditions of insufficient protein content in the body, the proteins contained in the tissues begin to hydrolyze. For this reason, it is very important to follow the recommended protein intake standards **[2]**. According to the WHO FAO recommendations, the protein intake rate is 65-100 g per day or 10-15% of the amount of protein consumed in food.

Taking into account the formalized requirements for the composition of herodietic products, the mass fraction of protein of a specialized product should be at least 10%.

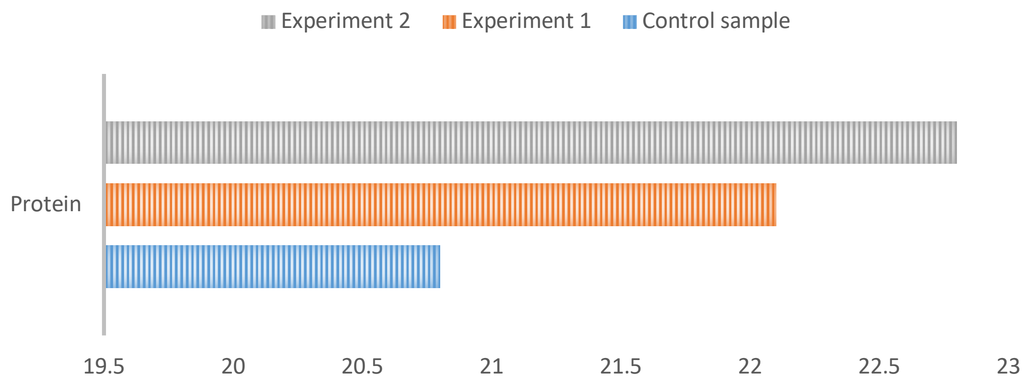


**Figure 4** Effect of protein hydrolysate on protein indicators in finished products.

One of the main indicators of food quality is the biological value, reflecting the degree of compliance with the amino acid balance of the body's needs, necessary for the course of physiological processes in the body (Table 6).

**Table 6** Amino acid composition of boiled sausages with the addition of protein hydrolysate.

| Name of amino acids | "Beef sausage" (control sample), % | Experiment 1 (with the addition of purslane 1%, protein hydrolysate 3%) | Experiment 2 (with the addition of purslane 1%, protein hydrolysate 5%), % |
|---|---|---|---|
| | Mass fraction of amino acids, % | | |
| Arginine | 1.477 ±0.591 | 1.780 ±0.712 | 2.058 ±0.823 |
| Lysine | 2.685 ±0.913 | 2.671 ±0.908 | 2.743 ±0.933 |
| Tyrosine | 1.193 ±0.358 | 1.142 ±0.343 | 1.183 ±0.355 |
| Phenylalanine | 1.402 ±0.421 | 1.365 ±0.409 | 1.320 ±0.396 |
| Histidine | 0.895 ±0.448 | 0.801 ±0.401 | 0.617 ±0.309 |
| Leucine+isoleucine | 2.238 ±0.582 | 2.077 ±0.540 | 2.058 ±0.535 |
| Methionine | 0.925 ±0.314 | 0.861 ±0.293 | 0.857 ±0.291 |
| Valine | 1.939 ±0.776 | 2.077 ±0.831 | 2.572 ±1.029 |
| Proline | 2.089 ±0.543 | 2.522 ±0.656 | 2.058 ±0.535 |
| Threonine | 1.387 ±0.555 | 1.484 ±0.593 | 1.543 ±0.617 |
| Serine | 1.298 ±0.337 | 1.484 ±0.386 | 1.423 ±0.370 |
| Alanine | 2.238 ±0.582 | 2.671 ±0.694 | 2.229 ±0.580 |
| Glycine | 2.387 ±0.812 | 3.412 ±1.160 | 2.401 ±0.816 |

A significant increase in the content of essential amino acids such as lysine and valine and interchangeable amino acids such as arginine, glycine, and serine in the test samples confirms that the protein hydrolysate introduced into the prototype is rich and well-balanced in amino acid composition.

The most important functional properties of proteins include solubility; stabilizing dispersed systems (emulsions, foams, suspensions) and forming gels; adhesive and rheological properties (viscosity, elasticity); water-binding, fat-binding, texturing, and film-forming ability.

To study the effect of protein hydrolysate on the quality indicators of meat products, moisture-binding, moisture-retaining, and fat-retaining abilities were determined.

**Table 7** Basic functional and technological properties of boiled sausages with the addition of protein hydrolysate.

| Name of samples | Indicators, % | | | |
|---|---|---|---|---|
| | moisture binding capacity, % | moisture-holding capacity, % | fat-holding capacity, % | The yield of finished products, % |
| "Beef sausage" (control sample) | 73.12 ±0.36 | 69.12 ±0.72 | 57.18 ±0.51 | 107 |
| Experiment 1 (with the addition of purslane 1%, protein hydrolysate 3%) | 75.62 ±0.84 | 73.37 ±0.91 | 59.13 ±0.83 | 110 |
| Experiment 2 (with the addition of purslane 1%, protein hydrolysate 5%) | 79.13 ±0.62 | 80.01 ±0.65 | 60.05 ±1.01 | 114 |

Protein hydrolysates of animal origin, in comparison with popular soy protein isolates, are characterized by an increased (two to three times) moisture-retaining ability, comparable fat-retaining ability, and significantly greater (4-8 times) strength of water-fat emulsion and can be used in sausage recipes instead of soy proteins.

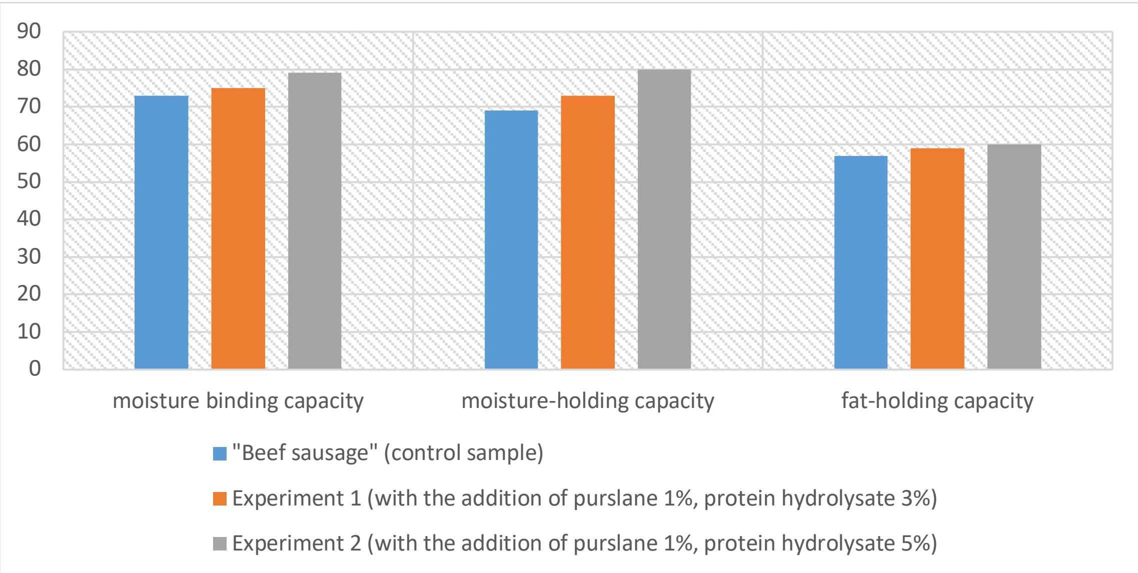


**Figure 5** Functional and technological properties of the studied samples.

The addition of protein hydrolysate leads to an increase in the water-binding capacity in the test samples and thereby provides a high yield of products. The presented data indicate that the yield increases in experimental samples with the addition of protein hydrolysate in an amount of 5%. This is explained by the fact that protein hydrolysate binds a large proportion of moisture, having such important properties of natural meat additives as solubility, emulsifying and gelling abilities, and provides an increased yield of finished products.

The global population is becoming older, and this cohort still considers red meat (beef and sheep meat) an important staple in their diet. It is understood that the requirements from these red meats will vary as a person ages, often because of associated physiological changes, nutrition and health concerns, and reduced sensorial capacities. This creates an imperative to develop red meat products that appeal to and satisfy the demands of older adults. Based on these studies, it was apparent that these specifications may be delivered using available knowledge of intrinsic and extrinsic influences on red meat if considered within the context of elderly customers. That is, to deliver upon older adults' requirements for conventional red meat products, which are inexpensive, of consistent and perceivable high quality, and quell any associated health concerns for the consumer **[17]**. Red meat has a tougher texture compared with many other food products. Therefore consumption is often reduced among older adults. Acidic treatments had a positive effect on WBSF values (reduced the WBSF values from 23.35 N for control to 14.83 N), and texture parameters and a combination with apple fibre and rice starch may improve the health profile of a meat product with benefits for consumers, particularly for the older population. This study optimized and successfully validated a novel meat product with a softer texture (apple fibre 0.15%, rice starch 0.30%, and citric acid 0.16 M). The results obtained for the objective measurements of tenderness were confirmed by consumers' tenderness results ($p$ <0.05); moreover, texture-optimized beef samples were found to be more acceptable by older consumers compared with the control **[18]**. Meat processors have a role to play in enhancing the availability of appropriate foodstuffs for older people through developing targeted products that will meet this cohort's specialized nutritional and chemosensory needs. Meat intakes in the older population are commonly reduced because the relatively tough texture of the meat can impair mastication. In this study, beef steaks tenderized with papain and papain: bromelain (50:50) were demonstrated to produce more tender meat products, with a lower cook loss compared with tenderization with bromelain alone, which has relevance to the development of texture-optimized meat products that appeal to older adults with difficulty in mastication. This information could help meat processors develop strategies for optimizing texture-modified beef products within their businesses **[19]**. Among diverse and numerous food energy sources, beef is a valuable dietary source of high-quality bioavailable protein and is very suitable for the diet of the elderly population **[20]**. There is a need to develop softer-textured beef products for older consumers with masticatory issues, which might contribute to offsetting the decline in meat intake. The effect of citric acid on meat tenderness has been studied by several authors and was reported to have a beneficial effect on meat tenderness, contributing to the partial denaturation of proteins which might make it accessible for the absorption of different added ingredients **[21]**, **[22]**. On the other hand, it has been reported that dietary fibres, including fruit fibres and rice starch, could be used as functional ingredients in meat products **[23]**. It has been suggested that apple pulp represents a typical source of dietary fibre due to its high concentration of flavonoids and carotenes with superior quality compared with other fibres **[24]**. Meat and meat products are a good sources of bioactive compounds with positive effects on human health, such as vitamins, minerals, peptides, or fatty acids. Growing food consumer awareness and intensified global meat producers' competition put pressure on creating new healthier meat products. To meet these expectations, producers use supplements with functional properties for animal diets and as direct additives for meat products. In the presented work seven groups of key functional constituents were chosen: (i) fatty acids; (ii) minerals; (iii) vitamins; (iv) plant antioxidants; (v) dietary fibers; (vi) probiotics and (vii) bioactive peptides. Each of them is discussed in terms of their impact on human health and some quality attributes of the final products **[25]**. In 2 experiments, dark-cutting (DC) beef strip loins were used to test the effects of citric acid-enhancement pH on the visual and instrumental color of fresh and cooked steaks. In Exp. 1 and 2, each DC (mean pH = 6.57 and 6.65, respectively) and normal-pH, low USDA Choice (CH; mean pH = 5.48 and 5.51, respectively) strip loin was cut into 2 equal-length sections, and DC sections were injected to 111% of raw section weight with pH 3.5 to 5.0 (Exp. 1) or pH 2.0 to 3.5 (Exp. 2) solutions made by mixing citric acid in either 0.05% orthophosphate (PO) solution or tap water (HO) base solutions (Exp. 1) and 0.5% PO or 0.5% tripolyphosphate solution base solutions (Exp. 2) **[26]**. Rice starch (RS) and fructooligosaccharides (FOS) were studied as substitutes for phosphates (STPP) and dextrose (Dex) in cooked hams using response surface methodology (RSM). RS, STPP, Dex, and FOS were combined in 25 runs and applied to the Biceps femoris (BF) and Semimembranosus (SM) muscles. Muscles were injected (120% green weight), tumbled, netted, and steam cooked. Cook loss and yield were affected by STPP. Colour was predominantly affected by muscle type, and the ingredients studied, whereas texture was principally affected by STPP and RS. NMR and expressible moisture data showed higher free water retention in samples containing RS. This was visualized by light microscopy as starch gel pockets. Despite some reductions in yield, it is feasible to substitute STPP with RS and obtain a satisfactory quality product. However, higher levels of added FOS would be required to warrant a health claim **[27]**. Chicken breast dipped with citric acid (CA) was treated by sous vide processing and stored in a refrigerated state for 0, 3, 6, 9, and 14 d. A non-dipped control group (CON) and three groups dipped in different concentrations of citric acid concentration were analyzed (0.5%, 0.5CIT; 2.0%, 2CIT and 5.0%, 5CIT; w/v). Cooking yield and moisture content increased due to the citric acid. While the redness of the juice and meat in all groups showed a significant increase during storage, the redness of the citric acid groups was reduced compared to the control group ($p$ <0.05). The findings indicated positive effects in sous vide chicken breast's physicochemical properties and storage ability at 2% and 5% citric acid concentrations **[28]**. Sensory characteristics and visual acceptability of cooked hams with rice starch (RS) and fructooligosaccharides (FOS) as substitutes for, respectively, sodium tripolyphosphate (STPP) and dextrose (De) were evaluated. Replacement of STPP with RS is associated with hams being less juicy, salty, and springy, but more adhesive and could negatively affect appearance. Still, replacement of Dex by FOS had minimal sensory influence. The relative importance of product appearance, pack labels, and price information cues in simulated purchasing decisions was also investigated. Consumer purchase choices were more influenced by product appearance than pack labels referring to additives or price. Including labelling information regarding the reduction or exclusion of phosphates may be more important than labels regarding a salt reduction. For the Irish consumers studied here, using phosphates in cooked hams sounds artificial, unhealthy, and unknown, whereas dietary fibre was perceived as healthy, natural, and improving the eating quality **[29]**. The effects of fat substitution (≤15%) with commercial encapsulated and unencapsulated fish oils on the technological and eating quality of beef burgers over storage [modified atmosphere packs (80% $O_2$:20% $CO_2$); constantly illuminated retail display at 4 °C; for 15days] were studied using design of experiment (DOE). Burger formulations comprised beef shin (59.5%), salt (0.5%), and vitamin E (0.015%) combined with varying levels of beef-fat/fish oils depending on the treatment. Increasing amounts of encapsulated and unencapsulated fish oils in burgers increased polyunsaturated fatty acid content ($p$ <0.001). Storage decreased ($p$ <0.001) a* values, which agreed with oxymyoglobin data. Panellists scored the optimised burger formulation ($p$ <0.05) lower than controls for overall acceptability **[30]**. Although Texture Profile Analysis (TPA) is useful for most solid foods, the misuse of TPA parameters for liquid foods has led to misunderstandings and confusion. Here, we warn of the risk of misuse of TPA parameters for liquid foods **[31]**. There is a rapid change in our overall lifestyle due to the impact of globalization. Every day hasty life has forced consumers to be dependent upon fast foods, which contain the meagre amount of dietary fibre. Non-starch polysaccharides, resistant oligosaccharides, lignin, substances associated with NSP and lignin complex in plants, other analogous carbohydrates, such as resistant starch and dextrins, and synthesized carbohydrate compounds, like polydextrose are categorized as dietary fibre. They are mostly concentrated in cereals, pulses, fruits and vegetables. It has been proclaimed that daily dietary fibre intake helps in the prevention of many nutritional disorders like gut-related problems, cardiovascular diseases, type 2 diabetes, certain types of cancer, and obesity **[32]**. Beef semitendinosus (ST) muscle was marinated for 24 h in 2% NaCl solution and 1.5% lactic, acetic, and citric acid solutions individually and in mixed marinades for the combination of NaCl and three kinds of weak organic acids, respectively. The effectiveness of marinades on beef ST muscle was investigated. Changes in denaturation characteristics of connective tissue collagen were examined using differential scanning calorimetry; microstructural changes of collagenous fibers were observed with scanning electron microscopy; textural properties of meat were studied by texture profile analysis **[21]**. Acidification of meat can improve texture; however it also increases susceptibility to lipid oxidation. The effect of injection and marination of citric acid to acidify and sodium carbonate or sodium tri-polyphosphate to increase the pH of beef on tenderness, microstructure, and oxidative stability was determined. The water-holding capacity and tenderness of beef semitendinosus muscle increased significantly at pH 3.52 upon adding citric acid. They returned to the level of an untreated sample after the pH was increased (pH ~5.26) by sodium tri-polyphosphate **[22]**. Ingredients in Meat Products presents the most up-to-date information regarding the utilization of non-meat ingredients in the manufacturing of processed meat products in a wcomprehensive and practical way Emphasis has been placed on helping the reader attain a fundamental understanding of (i) the basic chemical and physical properties of each of these groups of ingredients, as we understand them today; (ii) how these properties affect their functionality in meat systems; and (iii) how to take advantage of the ingredients' functional properties to maximize their application in real-life situations **[23]**. This paper overviews the biophysical methods developed to access meat structure information. The meat industry needs reliable meat quality information throughout the production process to guarantee high-quality meat products for consumers. Fast and non-invasive sensors will shortly be deployed, based on the development of biophysical methods for assessing meat structure. Reliable meat quality information (tenderness, flavour, juiciness, colour) can be provided by many different meat structure assessments either by means of mechanical (i.e., Warner-Bratzler shear force), optical (colour measurements, fluorescence) electrical probing or using ultrasonic measurements, electromagnetic waves, NMR, NIR, and so on **[33]**. An excellent source of high biological value protein, vitamin B12, niacin, vitamin B6, iron, zinc, and phosphorus. A source of long-chain omega-3 polyunsaturated fats, riboflavin, pantothenic acid, selenium, and possibly also vitamin D. Mostly low in fat and sodium. Sources of a range of endogenous antioxidants and other bioactive substances include taurine, carnitine, carnosine, ubiquinone, glutathione, and creatine **[20]**. Longissimus muscle obtained from beef carcasses was used in this research. Initially, 0.596, 1.0%, and 1.5% lactic and citric acid solutions were prepared. The meat was marinated in these solutions (1:4 w/v) in polyethylene bags at 4 °C for 72 h. Bound water, pH, weight gain, cooking loss, and Warner Bratzler shear (WBS) were evaluated. Differential Scanning Calorimetry (DSC) was used to determine the bound water content in meat samples. The latent heat of melting (ΔHm) and bound water were found to be functions of the moisture content of marinated meat. There was a significant decrease in pH due to marination. The samples marinated with citric acid held less water than lactic acid. The WS values in control samples were higher than in marinated samples. Cooking loss was lower in samples marinated with lactic acid than citric acid maacid-marinateds **[34]**. The citric acid (CIT, 0.3%) was assessed for its ability to reduce the pink color defect in the ground, cooked (80 °C) turkey breast associated with nicotinamide hemochrome (NICHEME) and nitrosyl hemochrome (NITHEME). CIT incorporation in nicotinamide-treated (NIC, 1.0%) samples (CIT plus NIC) reduced ($p$ <0.05) redness by 51% compared to the control and 63% compared to the NIC-only treatment. CIT addition in sodium nitrite-treated (NIT, 10 ppm) samples (CIT plus NIT) was similar ($p$ >0.05) in redness to the control and reduced ($p$ <0.05) the redness by 43% compared to the NIT- only treatment **[35]**. Confocal laser scanning microscopy (CLSM) and low field nuclear magnetic resonance (LFNMR) relaxometry were combined to characterize microstructural changes and water distribution in fresh and cooked pork for 14 days. On day 1 (24 h postmortem) a few muscle fibres, which appeared swollen, were observed in both fresh and cooked meat. An identical microstructure was still apparent after 14 days. However, the number of muscle fibres showing distinguished characteristics increased throughout the aging period. Hence, it was apparent that during aging, the individual fibres swell and disintegrate at different rates **[36]**. Acetic, citric, and lactic acid were incorporated into restructured beef steaks to determine their effect on collagen. These steaks were analyzed for collagen solubility, total collagen content, shear force behavior, sarcoplasmic and myofibrillar protein extractability, thermal stability, and color. These results were compared to those obtained from control samples containing high and low collagen. Results indicate that these acids increased collagen solubility, total collagen content, and shear force values compared to the control samples. No differences ($p$ >0.05) were found in sarcoplasmic protein extractability, although myofibrillar protein extractability declined. Acid treatment decreased the thermal stability of collagen. The Hunter Color values of the uncooked and cooked acid-treated steaks differed ($p$ <0.05) from the controls **[37]**. Meat products manufactured from low-value cuts may be unacceptably tough because of the high connective tissue content of meats used in their manufacture. The effects of shin beef treated with lactic acid at two concentrations (0.5 mol/l and 0.05 mol/l) and citric acid (0.05 mol/l) on cook loss, colour, textural and sensory characteristics of frankfurters were investigated. The results were compared to two controls containing high and low-value beef. Results indicate that the acids had little or no effect on cook loss and, at the low concentrations, had no apparent tenderising effect compared to the control shin beef. However, a significant effect on tenderness ($p$ <0.05) was observed for lactic acid at a higher concentration, but to the detriment of flavour and acceptability. The sensory attribute of juiciness increased due to the addition of the acids, while lactic acid at the lower concentration improved overall texture and acceptability. Instrumental texture analysis indicated that lactic acid had a tenderising effect particularly at higher concentrations. These results demonstrate that adding lactic acid can potentially improve the functionality of meat products for use in value-added meat products **[38]**.

## CONCLUSION

The formulation of experimental samples of boiled sausage for herodietic purposes with the addition of protein hydrolysate has been developed. Organoleptic evaluation of experimental samples with the addition of protein hydrolysate 3%, 5%, 7% was carried out. The results of the study showed that when protein hydrolysate was added in an amount of more than 5%, a specific taste characteristic of offal was present in the experimental samples. Based on the sensory evaluation results, it was decided to continue the study of samples with the addition of 3% and 5% protein hydrolysate. The study of the amino acid composition of control and experimental samples showed a significant increase in the content of essential amino acids such as lysine by 2.1%, valine by 32.6%, and interchangeable amino acids such as arginine by 39.3%, glycine 0.5% and serine by 9.6%.

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