



UDC 637.524.2

THE STUDY OF A PROTEIN-ENRICHED MEAT PRODUCT EFFICIENCY AND SAFETY FOR WOMEN IN THE POSTMENOPAUSAL PERIOD WITH PRESCARCOPENIA

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Received 7 September 2021; accepted 12 October 2021; available online 27 October 2021

Abstract

The research is devoted to the development of recipes for cooked sausages and to the extension of their assortment through the use of poultry meat and by-products of meat and dairy industries in recipes. The most popular and affordable meat products among the population of Ukraine – boiled sausages – were selected for research. The main components of the recipes: red poultry meat mechanically deboned poultry meat product, semi-fat pork. In the formulations of the developed products, 10 % of raw meat was replaced by a hydrated protein-mineral-carbohydrate additive (PMCA). According to physical and chemical parameters, it was established that the protein-carbohydrate-mineral additive in the technology of cooked sausages allowed to obtain finished products with excellent quality indicators. It was found that the addition of protein-carbohydrate-mineral additive to the recipes significantly affected the physico-chemical, functional and technological parameters and biological value of hybrid meat products. The obtained experimental data showed that the moisture content in the raw mince for sausages "Viennese" was 1.7 % higher than in the control samples. The moisture binding capacity in raw minced meat of control samples is 5 % lower than in the experimental samples. In the finished product, the moisture binding capacity was 3.8 % higher than in the test samples. The study showed that the amino acid difference coefficient in the control sample of cooked sausage was 13.0 % higher than in the sample of sausages "Viennese". Developed cooked sausages with the protein-mineral-carbohydrate additive can be introduced into production as functional products with improved biological value.

Keywords: boiled sausage, sausages, protein, protein-mineral-carbohydrate additive, hybrid meat products, amino acid composition.

ВИВЧЕННЯ ЕФЕКТИВНОСТІ ТА БЕЗПЕЧНОСТІ М'ЯСНОГО ПРОДУКТУ З ПІДВИЩЕНИМ ВМІСТОМ БІЛКА У ЖІНОК У ПОСТМЕНОПАУЗАЛЬНОМУ ПЕРІОДІ З ПРЕСАРКОПЕНІЄЮ

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Анотація

Дослідження присвячено розробці рецептур варених ковбасних виробів та розширенню їхнього асортименту за рахунок використання у рецептурах м'яса птиці та вторинних продуктів переробки м'ясної та молочної галузей. Для досліджень обрано найбільш популярні серед населення України та доступні за ціною м'ясні продукти: варені ковбаси і сосиски із м'яса птиці. Основні складові рецептур: червоне м'ясо птиці, м'ясо птиці механічного обвалювання, свинина напівжирна. У рецептурах розроблених продуктів замінювали 10 % м'ясної сировини гідратованою білково-вуглеводно-мінеральною добавкою. За фізико-хімічними показниками встановлено, що білково-вуглеводно-мінеральна добавка в технології варених ковбасних виробів дозволяє отримувати готові продукти з відмінними показниками якості. Встановлено, що додавання білково-вуглеводно-мінеральної добавки до рецептур суттєво впливало на фізико-хімічні, функціонально-технологічні показники та біологічну цінність м'ясних продуктів. Розроблені варені ковбасні вироби з білково-вуглеводно-мінеральною добавкою можуть бути впроваджені у виробництво як функціональні вироби з покращеною біологічною цінністю.

Ключові слова: варена ковбаса, сосиски, білок, білково-мінерально-вуглеводна добавка, гібридні м'ясні продукти, амінокислотний склад.

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doi: 10.15421/jchemtech.v29i3.240898

ИЗУЧЕНИЕ ЭФФЕКТИВНОСТИ И БЕЗОПАСНОСТИ МЯСОПРОДУКТА С ПОВЫШЕННЫМ СОДЕРЖАНИЕМ БЕЛКА У ЖЕНЩИН В ПОСТМЕНОПАУЗАЛЬНОМ ПЕРИОДЕ С ПРЕСАРКОПЕНИЕЙ

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Аннотация

Исследование посвящено разработке рецептур вареных колбасных изделий и расширению их ассортимента за счет использования в рецептурах мяса птицы и вторичных продуктов переработки мясной и молочной отраслей. Для исследований выбраны наиболее популярные среди населения Украины и доступные по цене мясные продукты: вареные колбасы и сосиски из мяса птицы. Основные составляющие рецептур: красное мясо прицы, мясо птицы механической обвалки, свинина полужирная. В рецептурах разработанных продуктов заменяли 10 % мясного сырья гидратированной белково-углеводно-минеральной добавкой. По физико-химическим свойствам установлено, что белково-углеводно-минеральная добавка в технологии вареных колбасных изделий позволяет получать готовые продукты с отличными показателями качества. Установлено, что введение белково-углеводно-минеральной добавки в рецептуры существенно влияло на физико-химические, функционально-технологические показатели и биологическую ценность мясопродуктов. Разработанные вареные колбасные изделия с белково-углеводно-минеральной добавкой могут быть введены в производство как функциональные изделия с улучшенной биологической ценностью.

Ключевые слова: вареная колбаса, сосиски, белок, белково-минерально-углеводная добавка, гибридные мясные продукты, аминокислотный состав.

Introduction

Against the background of the aging population of Ukraine and the increasing prevalence of metabolic diseases, the proportion of people with muscle activity loss is increasing. Today, the problem of providing a balanced diet for the prevention and treatment of metabolic disorders is unresolved. The recommended protein content of 12–15 % of the energy value of the diet does not meet the needs of nutritional correction of metabolic disorders, as well as non-prevention of muscle loss with age. A promising area is the development of foods with high biological value, including increasing the protein content and improving its amino acid composition.

In the D.F. Chebotaryov State Institute of Gerontology of National Academy of Medical Sciences of Ukraine the Department of Clinical Physiology and Pathology of the Locomotor Apparatus and the Laboratory of Gerodietics conducted a clinical approbation of a meat product with high protein content, developed at the Department of Meat Technology and Meat Products of the National University of Food Technologies. The research conducted by the authors was performed in accordance with the plan of research works of the D.F. Chebotaryov State Institute of Gerontology "Development and implementation of a comprehensive system for diagnosis, treatment and prevention of systemic osteoporosis and its complications among the population of Ukraine at different levels of care" (number DR 0115U000613) and research plan of the National University of Food Technology "Scientific substantiation of technology of new

generation meat products for health and preventive nutrition" (DR number №0115U006059).

Literary review. The human body requires 20 amino acids for the construction of most proteins, which must come in clearly defined amounts and ratios.

A mismatch between the amino acid composition of dietary proteins and the "ideal protein" leads to a disruption of protein synthesis, shifting the dynamic balance of protein anabolism and catabolism toward the breakdown of the body's own proteins, including protein-enzymes. A lack of one amino acid or another limits the use of other amino acids in protein biosynthesis.

The human body, even with age, does not lose the ability to absorb protein from food - of course, if there are no chronic intestinal diseases, or the protein simply does not come in sufficient quantities with food. Instead, the synthesis of one's own proteins may slow down with age. This is primarily due to the deterioration of the endocrine system, as with age the ability to synthesize hormones - such as insulin-like growth hormone and testosterone - is lost.

These processes lead to deterioration of muscle tissue, muscle weakness, disorders of nerve fiber conduction and even damage to nerve cells. As a result - a violation of muscle recovery and coordination. This condition is called sarcopenia, a global disease that affects almost 10 % of the working population over the age of 45. Therefore, it is very necessary to develop technologies for food products enriched with substances and highly available for digestion

amino acids that prevent this disease, reduce the degree of its manifestation and carry out prevention.

The availability of certain amino acids may be reduced by the presence of digestive enzyme inhibitors in food proteins, such as legumes, or by thermal damage to proteins and amino acids, ie by cooking.

Insufficient amount of protein in food stimulates the production of alternative products with the optimal ratio of the formulation components to achieve the desired technological and physiological effect. As a result, we have developed a meat product with high protein and low fat content, enriched with leucine. Leucine plays an important role in muscle mass and is a precursor to protein synthesis in the body, increases the regulation of matrix ribonucleic acid (mRNA) translation, thereby increasing muscle protein synthesis, and is a strong secretory genotype of insulin. Leucine is important for human health because it is actively involved in the processes of protein synthesis and breakdown. Due to leucine, a nitrogenous balance is maintained in the internal environment of the body, without which metabolic reactions of sugars and proteins are impossible [1–3].

The main source of natural protein is meat products. Today, a new style of high-protein production is quite popular in the world – meat hybrids [4]. The main meaning of this term is to effect the rapid adaptation of the world's growing population, especially in underdeveloped countries and of low-wage population, to the transition from animal proteins to more promising plant sources. Hybrid plant and animal protein products focus on the sensory aspects of nutrition, as they allow to achieve a higher sensory sensitivity of plant foods, which differ from raw meat in texture and taste, but have a fairly high level of digestibility and are the most environmentally friendly and fastest growing raw materials.

In the food industry, a large group of substances is used, which is united by the general term food additives. They are of both natural and synthetic origin and serve to improve the technology of special purpose products (dietary, medicinal), preserve the necessary properties, increase stability and improve the organoleptic properties of food products [5]. It is due to food additives that the taste and texture in meat hybrids can be improved in comparison with products based on natural raw materials without any significant changes in the technological process. In addition, there is an improvement in

the digestibility of finished products due to the fact that the use of vegetable raw materials in meat hybrids eliminates the need to introduce large amounts of fat and connective tissue in order to reduce costs and increase binding function. Meat hybrids are high in bioflavonoids, biologically active substances that are unique to plants, which in turn will allow in the future to create such hybrid products that will prevent diseases associated with aging and more.

Due to the shortage of domestic protein-containing raw materials, and in particular raw materials of animal origin, the food industry is a sector, which is currently experiencing a decline in production and consumption, but there is a process of constant expansion and renewal of the range of finished products, available raw materials, improvement and intensification of technological processes. The problem is exacerbated by the unfavorable conditions in livestock industry due to domestic changes in economic and political life, which has negatively affected the production of meat and meat products in Ukraine in general. Despite this, the new types of food and functional-technological protein-containing additives are being introduced, a new ideology of healthy food production is being formed and implemented in practice, traditional principles of raw material processing and biological food safety are being revised. The modern market of food ingredients is characterized by import dependence, associated with the dominance of foreign products. The main reason is the state's lack of interest in supporting domestic producers of food ingredients and the high risks of organizing a full production cycle.

On the market, there are mainly protein preparations in the form of soy protein isolates with high functional and technological properties. Currently, there is an increase in the use in the production of meat products of animal proteins isolated from collagen-containing raw materials (pork and beef skins). High functional and technological properties of such drugs, especially moisture-binding and gelling properties can significantly improve the rheological properties of food products - consistency, as well as organoleptic characteristics, to enrich meat products with dietary fiber. Recent years studies in have shown that connective tissue collagen plays the role of dietary fiber in human diets, stimulating the secretion and peristalsis of the intestine, having a beneficial effect on the beneficial microflora. Connective tissue elements (collagen, glucosamines, mucopolysaccharides), like plant dietary fibers, have

cation exchange properties, promote the excretion of various toxins, including toxic metabolites and anthropogenic contamination of raw materials, participate in the regulation of cholesterol metabolism. Given the amino acid deficiency of collagen, as well as the instability of gels based on it after repeated heat treatment, the combination of animal collagen proteins with milk proteins and polysaccharides will compensate for these shortcomings, ensure the rational use of raw meat, reduce costs and improve quality. [6–8].

One of the reserves in solving the problem of animal protein deficiency is the maximum involvement of secondary products of animal origin raw materials processing on the basis of evaluation and creation of new food forms of protein. Collagen-containing raw materials, according to tryptophan content, cystine and cysteine, can not be an adequate replacement for muscle tissue, but in modern conditions it is possible to select such variants of recipes that increase the amino acid composition of finished products, approximated to the quantitative ratio of amino acids to amino acids to the requirement FAO WHO. In many EU countries, such proteins are considered "meat" and do not even indicate in the mandatory formula of the composition [9; 10].

Over the past thirty years, the leading scientists in the meat and dairy industries Lipatov MM, Zhuravskaya NA, Khrantsov AG, Chagarovsky OP, have developed the technologies of milk protein-carbohydrate concentrates based on whey and skim milk, which allow to recommend them for use in the technology of meat hybrids as an alternative to soy preparations [11].

Alginate, carrageenans, fiber, starch, pectin, gums, protein textures, soy isolates and concentrates are widely used in industry to stabilize the quality and structure of meat hybrids. Special attention for the Chinese market is given to the development of sausages with high content of mushroom raw materials [12]. A modern solution in terms of stabilization and improvement of structural and mechanical parameters is chitosan [13–17].

Our previously obtained results of studies of the composition and functional and technological properties of protein-carbohydrate-mineral supplement (PMCA) "Record-75" [18], as well as model minced meat using it, show that PMCA "Record-75" is an effective fat emulsifier, which introduction into the composition of meat hybrids in the amount of 1–3 % in dry form or 10 ÷ 20 % in the hydrated state has a positive effect on both the functional and technological properties (FTP) and organoleptic characteristics of minced meat. The Record-75 additive is an effective gelling agent. Its introduction in the form of a gel in an amount of up

to 20 % (hydromodule 1 : 7) can improve the structural and mechanical characteristics of minced meat [19]. Prophylactic properties of chitosan and calcium chloride, which are a part of the protein-carbohydrate-mineral supplement, have the ability to delay the absorption of radioactive strontium in the human intestine, play the role of immunostimulants, enterosorbents, onco- and hepatoprotectors, show the ability to reduce blood [20–23] cause high biological value and prophylactic properties of hybrid meat products. Thus, the set of functional-technological and medical-biological positive characteristics determines the possibility of using PMCA "Record-75" in the technology of meat products in order to regulate the technological properties and obtain products with high biological value.

Boiled sausages are one of the types of hybrid meat products that are quite widespread in Ukraine, but when it comes to grilled sausages and hot dogs, the information marketing environment extends to Western and Eastern Europe, North America and Canada. A large number of the world's population, who are inclined to American cuisine and fast food in general, choose boiled sausages.

The basis of advertising in this segment are messages to the consumer audience that the products are inexpensive, highly safe, high in protein, well digested, quickly prepared and consumed for breakfast, lunch, dinner, party and more. In addition, during price fluctuations in the market of natural meat, cooked sausages always have a lower and more stable price, and improved views of the vegetable component, make this segment even more popular and popular. Technologists from the world's leading countries are trying to diversify the taste and enrich the composition of cooked sausages and hot dogs, because they understand that these hybrid meat products replace natural products and increasingly (especially during a pandemic) become complete meals, so add components that have health-improving properties.

The proposed object of study - food protein-mineral-carbohydrate supplement (PMCA) contains animal protein from natural pork, whey protein, chitosan and calcium chloride, serves as an emulsifier and reliably binding external moisture agent in the composition minced meat for cooked sausages.

The purpose and objectives of the study. The aim of this study was to establish the efficacy and safety of consumption of hybrid meat product with high protein content in postmenopausal women with presarcopenia.

The development of foods with high protein content and improved amino acid composition is

a promising area in the production of foods with high biological value of the hereditary direction.

To achieve the main goal of the work it is necessary to solve a number of separate tasks, namely:

1. Experimentally confirm the feasibility of using protein-mineral carbohydrate additives in the recipes of sausages, as an alternative to raw meat;
2. Investigate the physico-chemical, qualitative and nutritional properties of new types of cooked sausages;
3. Investigate the biological value of the developed cooked sausages.

Materials and methods of research

10 women aged 50–77 years were examined (mean age 66 ± 2.8 years), mean body mass index (BMI) was 26.2 ± 0.6 .

Actual nutrition was evaluated according to the method of questionnaire-weight method according to seven-day food diaries. The nutrient composition was calculated using tables of chemical composition and nutritional value of products using the computer program "Nutrition Test TRP-D02", developed by STC "Viria" [24]. Nutrition assessment was performed twice – before consumption of the developed product and during its consumption.

The arithmetic mean of the values of the indicators (M) and the errors of the mean values (m) were calculated. The statistical significance of the differences between the groups was assessed

using the Kramer-Welch t-test (modification of the Student's t-test for samples with different variance). The level of statistical significance is taken to be $p < 0.05$.

Results and their preliminary discussion

The scientific approach to the development of recipes for new types of products, in our time, should be based primarily on medical and biological principles of human nutrition. Therefore, the creation of new types of meat products with increased nutritional and biological value must fully meet or approach physiological needs. For protein products, such as meat products, the biological value is an important criterion in the development of amino acid-balanced protein systems.

A fuller nutritional value of the protein is given by the aminoacids contained, which allows to detect in the protein product essential amino acids that are limiting, by comparing the content of amino acids in the test product with their content in the conditional "ideal" protein according to FAO / WHO.

To determine the biological value of sausages "Viennese" with PMCA enriched with leucine, the amino acid composition and protein content were determined (Table 1). The relative biological value and digestibility of protein-enriched products are given in table 2 and in figure respectively.

Table 1

Name of the amino acid	FAO / WHO mg / 100 g protein (2011)	Viennese sausages	
		Aj, mg/100 g proteine	Cj,%
Protein content,%		18.1	
Valine	40	39.9	99.75
Isoleucine	30	52.3	174.3
Leucine	61	89.1	146.0
Lysine	48	69.1	143.9
Threonine	25	53.4	213.5
Phenylalanine + tyrosine	41	43.5	106.2
Meteonin + Cystine	23	45.4	197.2
The sum of essential amino acids		392.7	
Potential biological value of protein,%		89.7	
The coefficient of difference of amino acid rate (KRAS),%		10.3	
Coefficient of utilization of amino acid composition of protein (U)		0.84	
The indicator of "comparable redundancy" - σ (PPN) g / 100 g of protein standard		1.46	
Index of essential amino acids (IEAA)		1.48	
Name of the first limiting amino acid		Valine	
The score of the first limiting amino acid, %		99.75	

* The research was conducted on the basis of the State Institution "Institute of Food Resources" UAAS.

Determination of the relative biological value and safety of the developed products was

performed on microorganisms *Tetrahymena pyriformis* (ciliated infusoria), which has a

double cycle of digestion – acidic and alkaline, which corresponds to the pepsin and trypsin stages of digestion of higher animals and humans. Its enzyme systems are adequate to the enzyme systems of higher animals, and all essential amino acids are required for its growth. The rapid growth under favorable conditions and the microscopic size of *Tetrahymena pyriformis* allow to obtain in large quantities in a short time

statistically significant data that coincide with the experimental data of studies performed on higher animals.

The results of determining the relative biological value of sausages "Viennese" and varieties enriched with food additive PMCA using test organisms *Tetrahymena pyriformis* are shown in table 2.

Table 2

Indicator	The relative biological value of control and experimental samples of cooked products**	
	control	Sausages "Viennese"
Number of individuals, in 1 cm ³	0.59x10 ³	0.93x10 ³
Relative biological value,%	100	157.94

** The research was conducted on the basis of the State Institution "Institute of Gerontology named by D.F. Chebotaryov National Academy of Medical Sciences of Ukraine.

An important indicator of meat products is their digestibility, as it is directly related to the absorption of nutrients that are part of it. To determine the digestibility of proteins by the enzymes pepsin and trypsin in vitro, the most adapted for the above objects Pokrovsky – Ertanov method in the modification of Lipatov was used [25].

Indicators of digestibility of control samples (sausages "For breakfast") and sausages "Viennese" in vitro are shown in Fig. 1. From the obtained data it is seen that the value of digestibility of the studied samples is 85.41 % and 92.98 %. The tyrosine content is 8.5 % and 7.6 % higher than the control samples, which can be explained by the presence of milk proteins in the PMCA, which are better digested. The results of the study indicate the feasibility of using PMCA in recipes for cooked sausages.

The content of basic nutrients in the diet and energy consumption are presented in table. 3. It is noteworthy that against the background of daily consumption of the developed product in the diet significantly increased the amount of protein. The increase in the proportion of protein, and in particular animal, was due to the enrichment of sausages with the amino acid leucine (Table 4). This amino acid is important for the functioning of muscle tissue. This property of leucine is used in its use to treat and prevent muscle loss with age. Thus, protein intake in the women we examined increased from 0.99 g / kg body weight to 1.22 g / kg body weight (p = 0.03). The increase in the amount of protein was accompanied by a decrease in the proportion of carbohydrates, which is also a positive factor (table 3).

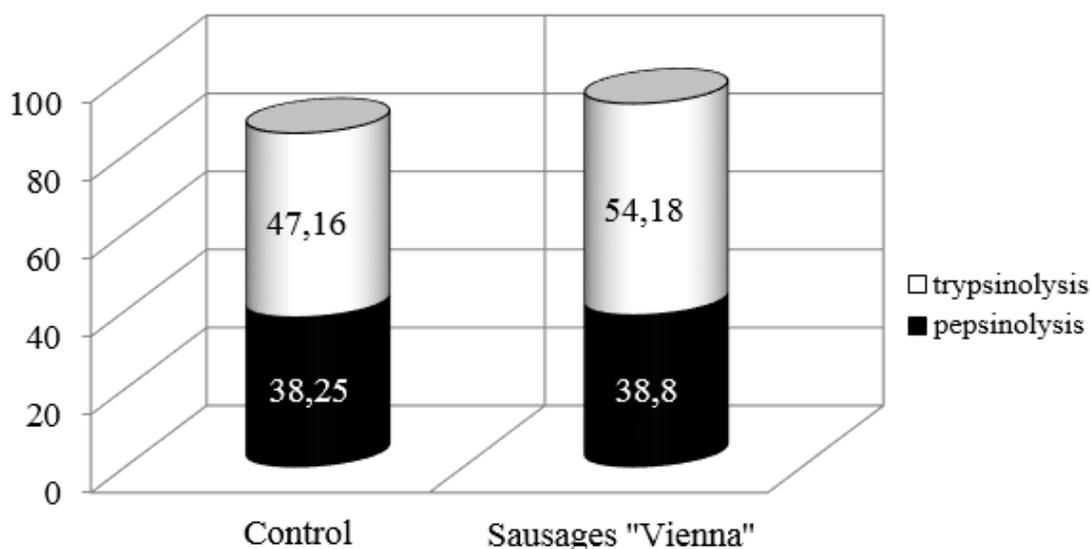


Figure. The degree of digestibility in vitro samples of control (sausages "Before breakfast") and test samples (sausages "Viennese")

Table 3

The percentage of essential nutrients in the daily diet of the surveide and energy-intensive diet

Indicator	Before consuming the product	Against the background of product consumption
Proteins, %	14.5 ± 1,2	16.44 ± 0.9
Fat, %	38.9 ± 2,3	45.3 ± 2.3
Carbohydrates, %	46.6 ± 3,3	39.1 ± 2.8
Energy consumption of the diet, kcal	1806 ± 151	1971 ± 135

Table 4

The content of protein and leucine in the daily diet of the subjects (g / day)

Nutrient	Before consuming the product	Against the background of product consumption
Total protein	63.1 ± 3.8	80.1 ± 5.5
Animal protein	35.5 ± 4.3	50.7 ± 5.5
Vegetable protein	27.6 ± 4.3	25.5 ± 2.3
Leucine	4.6 ± 0.3	6.9 ± 0.4

At the same time, the increase in the amount of fat and sodium in the diet attracts attention. Thus, the amount of sodium in the daily diet before the study was 1.37 g (excluding salting). Against the background of adding the developed product to the diet, the amount of sodium increased to 2.1 g ($p = 0.009$). It should be noted that the increase in the proportion of fat and sodium in the diet is typical in the case of consumption of industrially processed meat products, as it is associated with the recipe and technology of their production. However, these moments can negatively affect the health of people, especially older age groups. In order to prevent adverse events, the introduction of potassium salts, such as potassium citrate, should be considered in the PMCA, which will regulate the ratio of potassium to sodium in products of hereditary orientation and will be a precaution against edema and cardiovascular disease.

It should be noted that the indicators of laboratory tests (general blood test, lipid profile, ALT, AST, blood glucose, creatinine, uric acid, albumin, total calcium and ionized) were within normal limits. The same values were observed in the re-examination after consumption of the developed product for a month.

Skeletal muscle strength was assessed using a wrist spring dynamometer before and after one month of use. The figures were stable. Of the indicators that characterize the functional ability of muscle tissue, the women we examined in the postmenopausal period significantly decreased the distance of 15 m ("15-meter" test) from 19.2 ± 0.7 s to 17.2 ± 0.6 s ($p = 0.03$), which indicates an improvement in muscle function. There is a tendency to reduce the value of the test "sit-stand" from 12.2 ± 1.2 s to 9.7 ± 0.7 s ($p = 0.05$),

which indicates an improvement in muscle function, as well as reducing the risk of falls.

Approbation of research results. The developed technology for the production of cooked sausages has been tested at the production facilities of "Meat Delicacies" LLC (Kyiv), conducted at the D.F. Chebotaryov State Institute of Gerontology of NAMS of Ukraine (Department of Clinical Physiology and Pathology of the Locomotor Apparatus) clinical studies on the use of protein-mineral-carbohydrate additive "RECORD-75" and leucine in herodietic products to improve protein supply of older people, proven technological and economic feasibility of technology.

Conclusions

The developed hybrid meat product - "Sausages" Viennese" with high protein content is safe for consumption by older people, as evidenced by the results of laboratory tests. Consumption of the product in the diet significantly increases the amount of protein and amino acids of leucine, improves the functional ability of muscle tissue, which is confirmed by the result of the "15-meter" test, and the tendency to reduce the risk of falls according to the "sit-stand" test. The developed product enriched with protein-mineral-carbohydrate supplement (PMCA) is promising for maintaining and increasing muscle mass in older women with presarcopenia. However, the production technology and formulation of this product need to be improved to take into account the recommendations for reducing the amount of fat and sodium for older people or adding to the composition of potassium salts in a physiological ratio with sodium 1 : 1.

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