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ПЕРАПРАЦОЎКА І ЗАХАВАННЕ СЕЛЬСКАГАСПАДАРЧАЙ ПРАДУКЦЫІ

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Marina N. Alshevskaya[1], Dmitriy L. Alshevskiy[1], Yu. V. Mastyugin[2], Faina S. Karneeva[1], Ekaterina P. Bedo[3]

[1]Kaliningrad State Technical University, Kaliningrad, Russian Federation
[2] College of Mechatronics and Food Industry, Svetly, Russian Federation
[3] Uzbekistan State University of World Languages, Tashkent, Republic of Uzbekistan

COMPREHENSIVE ASSESSMENT OF NUTRITIONAL VALUE OF A COMMON BEAVER (*CASTOR FIBER*) INHABITING THE KALININGRAD REGION OF THE RUSSIAN FEDERATION

Abstract. In the Republic of Belarus and the Kaliningrad region, a decrease in the beaver population and use of its meat at meat processing plants is of great relevance. The aim of the present study was a comprehensive assessment of the nutritional value of beaver inhabiting the Kaliningrad region of the Russian Federation, including the study of the amino acid and fatty acid composition of proteins and lipids of muscle tissue and the lipoprotein part of the tail and the design of their mixture. Data is presented on the content of protein, fat, moisture, amino acids and fatty acids in the muscle tissue and the lipoprotein part of the beaver tail. The protein content in the muscle tissue made 20.2 %, in the lipoprotein part of the tail – 6.0 %, fat content – 5.1 and 85.1 %, respectively. The amino acid composition of the parts of the beaver carcass is represented by all essential amino acids, however, a number of indicators show an imbalance in the amino acid composition of the protein. To solve the problem of imbalance of essential amino acids, a combined mixture of muscle tissue and lipid-and-protein part of the tail was calculated with an optimal ratio of 72 to 28 %. The protein composition of this mixture is characterized by high biological value – 75 % and a special balance index – 0.87. At the same time, the content of polyunsaturated fatty acids in the combined mixture is 46.6 % of the total mass of lipids, which significantly exceeds the content of saturated (18.3 %) or monounsaturated (35.1 %) fatty acids. Also, the content of essential fatty acids linolic and linoleic is quite high and amounts to 24.0 g / 100 g of lipids and 21.3 g / 100 g of lipids. The engineered blend is a rich source of essential fatty acids. The conducted studies have resulted in actual data on the chemical composition and safety indicators of the river beaver inhabiting the Kaliningrad region, as well as in the optimal ratio of muscle tissue and the lipoprotein part of the beaver tail.

Keywords: meat products, amino acid composition, biological value, lipoprotein part, engineering

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М. Н. Альшевская[1], Д. Л. Альшевский[1], Ю. В. Мастюгин[2], Ф. С. Карнеева[1], Е. П. Бедо[3]

[1] Калининградский государственный технический университет, Калининград, Российская Федерация
[2] Колледж мехатроники и пищевой индустрии, Светлый, Российская Федерация
[3] Узбекский государственный университет мировых языков, Ташкент, Республика Узбекистан

КОМПЛЕКСНАЯ ОЦЕНКА ПИЩЕВОЙ ЦЕННОСТИ БОБРА ОБЫКНОВЕННОГО (*CASTOR FIBER*), ОБИТАЮЩЕГО В КАЛИНИНГРАДСКОМ РЕГИОНЕ РОССИЙСКОЙ ФЕДЕРАЦИИ

Аннотация. В Республике Беларусь и Калининградском регионе (Российская Федерация) актуальным является уменьшение численности популяции бобра и использование его мяса на мясоперерабатывающих предприятиях. Целью исследования являлась комплексная оценка пищевой ценности бобра, обитающего в Калининградском регионе, включающая изучение аминокислотного и жирнокислотного состава белков и липидов мышечной ткани и липидно-белковой части хвоста и проектирование их смеси. Представлены данные по содержанию белка, жира, влаги, аминокислот и жирных кислот в мышечной ткани и липидно-белковой части хвоста бобра. Содержание белка в мы-

шечной ткани составило 20,2 %, в липидно-белковой части хвоста – 6,0 %, жира – 5,1 и 85,1 % соответственно. Аминокислотный состав частей тушки бобра представлен всеми незаменимыми аминокислотами, однако ряд показателей указывают на несбалансированность аминокислотного состава белка. Для решения задачи несбалансированности незаменимых аминокислот была рассчитана комбинированная смесь мышечной ткани и липидно-белковой части хвоста с оптимальным соотношением 72 к 28 %. Белковый состав данной смеси характеризуется высокими значениями показателя биологической ценности – 75 % и частного индекса сбалансированности – 0,87. При этом содержание полиненасыщенных жирных кислот в комбинированной смеси – 46,6 % от общей массы липидов, что значительно превышает содержание насыщенных (18,3 %) или мононенасыщенных (35,1 %) жирных кислот. Также содержание незаменимых жирных кислот линолевой и линоленовой довольно высоко и составляет 24,0 г / 100 г липидов и 21,3 г / 100 г липидов. Спроектированная смесь является богатым источником незаменимых жирных кислот. В результате проведенных исследований получены актуальные данные по химическому составу и показателям безопасности бобра речного, обитающего в Калининградском регионе, а также оптимальное соотношение мышечной ткани и липидно-белковой части хвоста бобра.

Ключевые слова: регулирование популяции бобра, мясная продукция, аминокислотный состав, биологическая ценность, липидно-белковая часть, проектирование

Для цитирования: Комплексная оценка пищевой ценности бобра обыкновенного (*Castor fiber*), обитающего в Калининградском регионе Российской Федерации / М. Н. Альшевская, Д. Л. Альшевский, Ю. В. Мастюгин [и др.] // Весці Нацыянальнай акадэміі навук Беларусі. Серыя аграрных навук. – 2025. – Т. 63, № 3. – С. 243–252. https://doi.org/10.29235/1817-7204-2025-63-3-243-252

Introduction. Scientists from the laboratory of population ecology of terrestrial vertebrates and bioresource management of the State Scientific and Production Association “Scientific and Practical Center of the National Academy of Sciences of Belarus for Bioresources” strongly believe that the number of beavers in Belarus is two times higher than the permissible norm. Population of beavers counted up to 75 thousand in certain years in Belarus, which doubles the permissible norm. According to the National Academy of Sciences of Belarus, the number of these animals must be reduced in half. To reduce the number of beavers, the Ministry of Natural Resources and Environmental Protection of the Republic of Belarus annually develops plans stipulating number of animals allowed to be taken away. However, these plans are not implemented in full [1].

Over the past few years, population of beaver (*Castor fiber* Linnaeus, 1758) in the Kaliningrad region has been rapidly increasing. According to the monitoring data as of April 1, 2016, the number of beavers in the region at the rate of 1–2 thousand was about 6 thousand specimens. Due to their biological peculiarities, rodents build their huts and dams, changing the state of water bodies located in their habitat, which leads to flooding of territories [2]. Beavers have few natural enemies, and hunting (shooting) remains the only way to minimize the harm caused by these animals. The difficulty of catching, low prices for fur, low demand for the paired endocrine glands of the beaver (which are used for medicinal purposes) have led to a significant decrease in the attention to it as a commercial animal.

A number of problems are known that hinder widespread distribution of beaver meat in the meat processing industry. The main ones are ensuring microbiological and sanitary and hygienic safety of meat, preventing contamination at the stages of extraction and transportation to the enterprise for further processing; lack of up-to-date data on the characteristics of beaver meat produced in the Kaliningrad region and technologies for its complex processing.

The physical and chemical parameters of beaver meat are significantly influenced by their habitat and, based on this, the diet. These rodents are herbivorous, which has a positive effect on the nutritional value of meat and its organoleptic characteristics. At this point in time, studies of the biochemical composition of beaver meat are presented by Lithuanian, Polish and Belarusian researchers. However, there are no data on the study of the chemical composition, microbiological, sanitary and hygienic indicators of this animal living in the Kaliningrad region.

The concept of the nutritional value of a meat product includes a set of indicators, including a set of physical and chemical indicators (mass fraction of protein, lipids and moisture), medical and biological requirements, biological value of proteins, lipids, etc. According to literary sources, the nutritional value of beaver meat is characterized by a high level of protein and low fat content [3]. But at the same time, its amino acid composition is not balanced, and the fatty acid composition is characterized by a low content of monounsaturated fatty acids [4]. The possible solution to this problem is the design of a multicomponent meat product capable of providing a high level of adequacy of the biological value of protein and lipids

in accordance with the rated values presented in Methodical guidelines 2.3.1.0253-21 Norms of physiological needs for energy and nutrients for various groups of population of the Russian Federation.

Researchers from the Russian Federation, Belarus, Poland, Latvia, and the Czech Republic addressed the issue of processing beaver meat (*Castor fiber* Linnaeus, 1758).

Polish authors B. Jankowska, T. Tomijewski, A. Kwiatkowska, W. Korzeniowski conducted a study of the meat composition of ten female and seven male mature European beavers, determined the meat yield during cutting, the percentage of certain elements and the chemical composition of the meat. They found that the beaver thigh is the largest and most valuable element, accounting for 33.4 % of the carcass weight and containing 66.7 % of meat, and the muscle tissue is characterized by a high concentration of protein (20.9–21.8 % of the raw weight) and mineral substances (1.27–1.31 %) [5].

Latvian authors V. Strazdina, V. Stena, A. Jemeljanova published data on the biochemical composition of beaver meat (*Castor fiber* L.) caught in Latvia. It was concluded that the protein content in the beaver meat samples made 20.07–22.68 %, and the fat content made 3.31–5.27 %. At the same time, the content of polyunsaturated fatty acids in beaver meat samples (42.54 %) was significantly higher than the content of saturated (26.80 %) or monounsaturated (27.42 %) fatty acids. The ratio of polyunsaturated fatty acids n-6 : n-3 in beaver meat samples made 1.26 [6].

The analysis of the biochemical composition and determination of the value of beaver river meat, microbiological safety indicators of chilled meat at various stages of storage were carried out by researchers from Belarus A. M. Mitrenkov, O. L. Buzo [3].

A group of Czech authors V. Razmaite, R. Šveistiene, G. J. Švirmickas studied not only the chemical composition of European beaver meat, but also its suitability for sausage production. The researchers found the optimal beaver meat content of 20–40 %, which had the most positive effect on the texture and taste of sausage products [4].

Another group of researchers from Poland, K. Zalewski, D. Martysiak-Żurowska, M. Chylińska-Ptak, B. Nitkiewicz, separated and analyzed fatty acids from lipids of muscle and adipose tissue of the European beaver. The study showed that the fat content in the muscle tissue was very low in both male and female beavers. The lipids of the beaver's adipose tissue contained fatty acids with a chain length of 12 to 22 carbon atoms, and polyunsaturated fatty acids had the highest proportion of the total fatty acid content in the beaver's adipose tissue.

According to the available data, the beaver tail is often underutilized in the production of meat products. Comprehensive processing of beaver carcasses and the use of the lipid-and-protein part of the tail, which is 10 % of the total mass of the carcass, can solve the problem of optimizing the protein composition by designing their ratio in the mixture.

The aim of this work is a comprehensive assessment of the nutritional value of the beaver inhabiting the Kaliningrad region of the Russian Federation, including the study of the amino acid and fatty acid composition of proteins and lipids of muscle tissue and the lipoprotein part of the tail and the design of their mixture, determination of sanitary-and-hygienic and microbiological safety indicators of beaver meat.

To pursue this goal, the following tasks have been set:

1) to determine sanitary-and-hygienic and microbiological indicators of the beaver meat safety;

2) to establish chemical composition of the beaver carcass parts (muscle tissue of the back of the carcass and lipoprotein part of the tail);

3) to assess amino acid composition of muscle tissue proteins and the lipoprotein part of the beaver tail and draw a conclusion about their balance;

4) to design and optimize amino acid composition of the complex mixture of muscle tissue and lipoprotein part of the tail;

5) to assess fatty acid composition of beaver carcass parts.

Materials and Methods. For laboratory studies, specimens of the river beaver were used (*Castor fiber* Linnaeus, 1758), caught in fall during the established hunting season (8.08.2020–15.11.2020) in the Gvardeisk district in the Kaliningrad region of the Russian Federation. The animals were approximately two years old; the specimens' weight was (21 ± 1) kg. The back of the carcass and tail were taken for analysis. The lipoprotein part of the tail was examined before and after heat treatment (boiling at 95 °C for 45 minutes).

Laboratory studies have been carried out in the Atlantic branch of the Federal State Scientific Institution "All-Russian Research Institute of Fisheries and Oceanography" ("AtlantNIRO") in the Russian Federation in accordance with the methods presented in Table 1.

Table 1. **Methods for determining sanitary and hygienic indicators of the beaver meat**

Name of the indicator to be determined	Regulatory documentation for the test procedure
Cadmium	National state standard 30178-96
Arsenicum	National state standard 31707-2012
Mercury	Methodological guidelines 4.1.1472-03
Lead	National state standard 30178-96
Hexachlorocyclohexane (alpha-, beta-, gamma-isomers)	Methodological guidelines 2142-80
DDT and its metabolites	Methodological guidelines 2142-80
Coliform bacteria	National state standard P 54354-2011
QMAFAnM	National state standard P 54354-2011
L. monocytogenes	National state standard P 54354-2011
Pathogenic microorganisms, including salmonella	National state standard P 54354-2011
Protein	National state standard 25011-2017
Fat	National state standard 23042-2015
Moisture	National state standard 33319-2015
Amino acid composition	Methodological guidelines 04-38-2009
Fatty acid composition	National state standard P 55483-2013

Calculations of biological value indicators have been carried out according to the methods of N. N. Lipatov and A. B. Lisitsyn [7–12]. The amino acid rate (Protein Digestibility Corrected Amino Acid Score (PDCAAS)) of the muscle tissue protein and lipoprotein part of the tail has been calculated relative to the ideal protein according to the 2011 FAO / WHO scale, as well as the coefficient of difference in amino acid composition (KRAS), the overall utility coefficient of (U), index of comparable redundancy (PSI), index of amino acid composition balance (ISAS) and balance of fatty acid composition.

Results and Discussion. Safety performance of beaver meat is influenced by many factors. Among them, the most important are habitat, shooting time, transportation of carcasses from the place of slaughter to the procurement and meat processing enterprises. These factors increase the risk of exceeding the microbial contamination of meat, whereas the content of toxic elements and pesticides in muscle tissue depends on the animal diet and its habitat.

Sanitary-and-hygienic and microbiological requirements for beaver meat in accordance with TR CU 021/2011 and the results of laboratory tests of samples are presented in Table 2.

Table 2. **Sanitary-and-hygienic and microbiological indicators of the beaver meat**

Name of the indicator to be determined	Permissible levels	Test results
Sanitary-and-hygienic indicators		
Toxic elements		
Lead	Not more than 0.50 mg/kg	0.110 mg/kg
Mercury	Not more than 0.03 mg/kg	0.006 mg/kg
Arsenicum	Not more than 0.10 mg/kg	0.050 mg/kg
Cadmium	Not more than 0.05 mg/kg	0.017 mg/kg
Pesticides		
Hexachlorocyclohexane (alpha-, beta-, gamma-isomers)	Not more than 0.10 mg/kg	Less than 0.005 mg/kg
DDT and its metabolites	Not more than 0.10 mg/kg	Less than 0.005 mg/kg
Microbiological indicators		
Coliform bacteria	Not allowed in 0.01 g of a product	Not found in 0.01
QMAFAnM	Not more than 1×10^4 CFU/g	3.2×10^3 CFU/g
L. monocytogenes	Not allowed in 25 g of a product	Not found in 25 g
Pathogenic microorganisms, including salmonella	Not allowed in 25 g of a product	Not found in 25 g

As can be seen from Table 2, microbiological indicators, toxic elements, heavy metals and pesticides do not exceed the permissible levels established by the regulatory documents, which indicates beaver meat safety and its suitability for technological processing.

Chemical composition of the hinder part of the beaver carcass and the lipoprotein part of the tail before and after heat treatment is shown in Table 3.

Table 3. **Chemical composition of the beaver carcass parts**

Carcass part	Composition, %			Energy value, kcal
	Protein	Fat	Moisture	
Hinder part (muscle tissue)	20.2 ± 0.8	5.1 ± 0.2	74.7 ± 3.3	126.7
Lipoprotein part of the tail without heat processing	6.1 ± 0.3	85.1 ± 4.3	8.9 ± 0.4	790.3
Lipoprotein part of the tail with heat processing	6.0 ± 0.3	85.1 ± 4.3	8.8 ± 0.4	789.9

Table 3 shows that the beaver muscle tissue has high protein content (20.2 %), while the fat content is low (5.1 %). The lipoprotein part of the beaver tail is mainly represented by fat tissue (85.1 %), the protein content is low and amounts to 6.0–6.1 % of the total mass.

The obtained data on the protein content in beaver muscle tissue correlate with the data presented for similar research facilities in the nearby regions of Poland, the Czech Republic, Latvia and Belarus [3–6, 13]. Analyzing the chemical composition, the researchers noted a high protein content in beaver muscle tissue of 21.44 % in a Polish study [13], in the range of 20.07–22.68 % in a study by Latvian authors [6], 21.44 % in an article by Czech authors [11] and 19.7–20.6 % in an article by authors from Belarus [3]. The results of the lipid content in beaver meat, presented by Czech authors – 5.08 % [4] and Latvian authors – 3.31–5.27 % [6], do not differ much and the deviation of the values in the obtained indicators is insignificant and is due to the difference in the habitat of animals and the time of extraction.

Assessment of the amino acid composition of the protein of muscle tissue and the lipoprotein part of the beaver tail is presented in Table 4.

Table 4. **Assessment of amino acid composition of the protein of muscle tissue and the lipoprotein part of the beaver tail**

Indicators		Hinder part of the beaver carcass (muscle tissue)			Lipoprotein part of the tail (without heat processing)			Lipoprotein part of the tail (with heat processing)		
Indispensable amino acid (IAA)	Content of IAA in "reference" protein g/100 g of a protein	Content of IAA, g/100 g of a product	Content of IAA, g/100 g of a protein	Amino acid score, %	Content of IAA g/100 g of a product	Content of IAA, g/100 g of a protein	Amino acid score, %	Content of IAA, g/100 g of a product	Content of IAA, g/100 g of a protein	Amino acid score, %
Val	4.3	0.8	3.8	87.5	0.6	10.2	236.4	0.5	8.3	193.8
Ile	3.2	0.7	3.6	111.4	0.2	2.5	76.8	0.1	1.8	57.3
Leu	6.6	1.3	6.6	100.5	0.3	4.6	**69.5**	0.2	3.5	**53.0**
Lys	5.7	1.4	7.1	124.2	0.4	5.7	100.7	0.3	4.7	81.9
Met + Cys	2.7	0.4	1.7	64.2	0.3	4.6	170.0	0.3	4.2	154.3
Thr	3.1	0.7	3.3	105.4	0.5	8.2	264.4	0.5	8.3	268.8
Trp	0.9	0.1	0.5	**58.2**	0.1	1.6	192.9	0.1	1.7	196.1
Phe + Tyr	5.2	1.1	5.5	105.7	0.3	4.1	78.8	0.3	4.2	80.1
Total amount of the calculated IAA		32.03			41.48			36.67		
KRAS, %		36.39			79.14			82.64		
BV, %		63.61			20.86			17.36		
U		0.58			0.53			0.46		
PSI		0.23			0.28			0.37		
ISAS		0.82			0.61			0.58		

As can be seen from Table 4, protein of the beaver muscle tissue has the most balanced amino acid composition. Its limiting amino acid is tryptophan with an amino acid rate of 58 %. The biological value of muscle tissue protein is 64 %. And the special balance coefficient (ISAS) is closest to 1 and is 0.82. The utility coefficient of the amino acid composition (U) and the index of comparable redundancy, which should tend to 0, in the muscle tissue are 0.58 and 0.23, which indicates an imbalance of amino acids relative to the physiological norm. The protein of the lipoprotein part of the tail is largely unbalanced in amino acid composition. The limiting amino acid is leucine (amino acid rate 69 and 53 %). It is also characterized by a low biological value (20.86 and 17.36 %) and a high KRAS (79 and 82 %). The special balance coefficient (ISAS) is satisfactory and is 0.61 and 0.58, and the utility coefficient (U), on the contrary, is significantly higher than zero (0.53 and 0.46).

An important role in assessing the quality of a product is played not only by the biological value of the protein, but also by the balance of the fatty acid composition of the fat tissue. The nutritional value of lipids is characterized by the content of saturated fatty acids (SAFA), monounsaturated fatty acids (MUFA) and especially by polyunsaturated fatty acids (PUFA), the main groups of which are n-3 and n-6 acids.

The obtained data on the content of SAFA, MUFA and PUFA in the lipids of muscle tissue, lipoprotein part of the tail and calculated in their mixture are presented in Table 5.

Table 5. **Fatty acid composition in the lipids in the beaver carcass parts and in the complex mixture**

Name of the fatty acid	Acid code	Content of fatty acids in the lipids, g/100 g of lipids	
		Muscle tissue	Lipoprotein part of the tail
Myristic	$C_{14:0}$	1.10 ± 0.06	0.90 ± 0.05
Myristoleic	$C_{14:1}$	0.40 ± 0.02	0.60 ± 0.03
Pentadecanoic	$C_{15:0}$	1.60 ± 0.08	1.30 ± 0.07
Pentadecenic	$C_{15:1}$	0.00	0.20 ± 0.01
Palmitinic	$C_{16:0}$	15.50 ± 0.77	12.00 ± 0.60
Palmitoleic	$C_{16:1}$	1.50 ± 0.08	8.30 ± 0.42
Heptadecylic	$C_{17:0}$	2.30 ± 0.12	0.90 ± 0.04
Heptadecenoic	$C_{17:1}$	1.30 ± 0.07	1.80 ± 0.09
Stearinic	$C_{18:0}$	5.10 ± 0.25	2.00 ± 0.10
Oleinic	$C_{18:1h9c}$	17.70 ± 0.88	25.20 ± 1.26
Linolic	$C_{18:1n-6c}$	32.90 ± 1.64	22.60 ± 1.13
Linoleic	$C_{18:3n-3}$	18.70 ± 0.93	21.70 ± 1.08
Heneicosanic	$C_{20:0}$	0.40 ± 0.02	0.00
Gadoleic	$C_{20:1}$	0.70 ± 0.03	1.10 ± 0.06
Eicosadienoic	$C_{20:2}$	0.40 ± 0.02	0.30 ± 0.02
Arachidonic	$C_{20:4n-6}$	0.40 ± 0.02	0.70 ± 0.03
Docosapentaenoic	$C_{22:5}$	0.00	0.40 ± 0.02
∑SAFA		26.00 ± 1.30	17.10 ± 0.86
∑MUFA		21.60 ± 1.08	37.20 ± 1.86
∑PUFA		52.40 ± 2.62	45.70 ± 2.29
Coefficient of the fatty acid balance, unit fraction R_{Li}	I = 1…3	0.39	0.43
	I = 1…6	0.24	0.29
n-6 : n-3		1.78	1.07

From the data presented in Table 5 and Figure 1, it can be concluded that the fatty acid composition of lipids of muscle tissue and the lipoprotein part of the beaver tail is largely represented by polyunsaturated fatty acids. The ratio of n-3 (linolenic acid) and n-6 (linoleic acid) in muscle tissue made 1.78, and in the lipoprotein part of the beaver tail it made 1.07, which is sufficient to satisfy the daily human need for these acids.

The amino acid and fatty acid composition of the beaver carcass parts, as can be seen from the data in Tables 4 and 5, are not balanced.

The problem of imbalance in the amino acid composition of the beaver carcass parts can be solved by designing protein by means of combining muscle tissue and lipoprotein part of the tail in optimal

ratios. Due to the fact that the mechanical separation of the skin surface of the beaver tail from the lipoprotein part is rather laborious and leads to damage to the raw material, a technology has been developed for treating the beaver tail with an enzyme preparation followed by heat treatment. Therefore, for the design it is necessary to use the data of the heat-treated lipoprotein part of the tail.

Design and optimization of the amino acid composition of the complex mixture (CM) of the muscle tissue and lipoprotein part of the tail has been carried out using the "Index – PPAp" software for modeling combined food products, developed at the Department of Food Products Technology of the Federal State Educational Institution of Higher Education "Kaliningrad State Technical University". This software allows the protein design of a food product with a balanced composition of essential amino acids. To analyze the calculated data on the partial balance index of the amino acid composition, which tends to 1, the Harrington logistic desirability function has been applied. According to it, the desirability indices have been assigned to the values of the intervals that the partial index of the balance of the amino acid composition can take. So, if the values of the ISAS coefficient fell into the interval (0...0.2), then the function displays the assessment "very bad", (0.2...0.37) – "bad", (0.37...0.63) – "satisfactory", (0.63...0.8) – "good" and (0.8...1) – "very good".

The design result using the above program is shown in Figure 1 and Table 6.

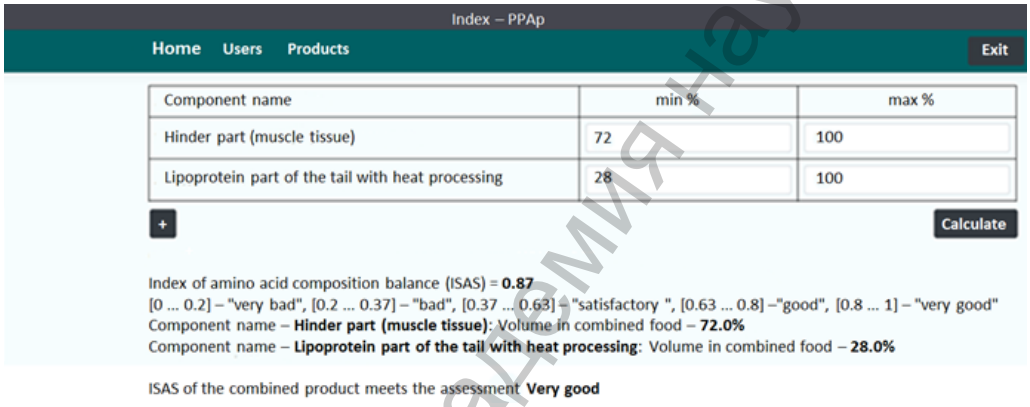

Figure 1. Result of calculation by "Index – PPAp" software

As can be seen from Figure 1, the best ratio of muscle tissue and lipoprotein part of the beaver tail is 72 and 28 %. This ratio provides a high ISAS indicator (0.87), which corresponds to "very good" value.

Table 6 presents an estimate of the amino acid composition of the protein in the mixture of muscle tissue and lipoprotein part of the tail.

Table 6. **Assessment of the amino acid composition of the protein in the mixture of muscle tissue and lipoprotein part of the tail**

Component	Mass fraction in CM, %	Mass fraction of protein, %	Content of indispensable amino acids, g/100 g of a protein							
			Val	Ile	Leu	Lys	Met + Cys	Thr	Trp	Phe + Tyr
Muscle tissue	72	20.2	3.8	3.6	6.6	7.1	1.7	3.3	0.5	5.5
Lipoprotein part of the tail	28	6.0	8.3	1.8	3.5	4.7	4.2	8.3	1.7	4.2
Protein content in CM		16.2	Val	Iso	Leu	Lys	Met + Cys	Thr	Trp	Phe + Tyr
Content of IAA in CM g/100 g of a product			4.2	3.4	6.3	6.8	2.0	3.8	0.6	5.4
Content of IAA in a protein according to FAO/WHO (reference)			4.3	3.2	6.6	5.7	2.7	3.1	0.9	5.2
Amino acid score, %			98.5	105.8	95.6	119.8	73.5	122.3	**72.5**	103.0
KRAS, %			23.40							
BV, %			75.10							
U			0.04							
PSI			0.10							
ISAS			0.87							

As can be seen from Table 6, the projected ratio of muscle tissue and lipoprotein filler (72 to 28 %) allows for the best balance of the amino acid composition of the product, at which the biological value of the protein is 75 %, the utility coefficient and the indicator of comparable redundancy tend to zero.

For a visual display of the result of the program, Figure 2 shows a histogram of comparison of the amino acid rates of the components of the formulation and the designed product.

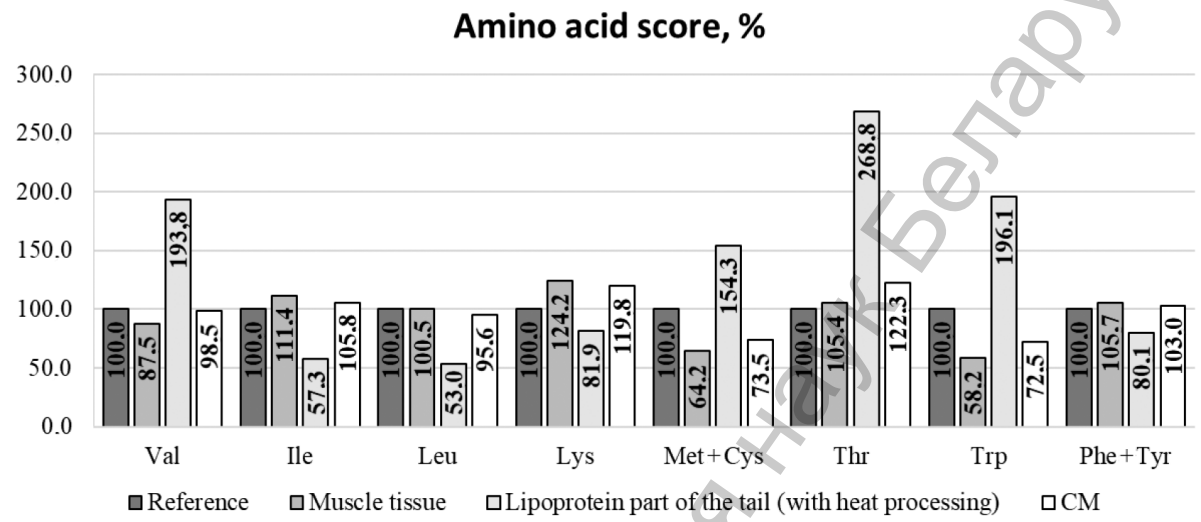

Figure 2. Histogram of amino acid rates comparison

The histogram in Figure 2 shows that the difference between the rates of essential amino acids of muscle tissue and the lipoprotein part of the beaver tail is smoothed in the complex mixture, which indicates that the selected ratio of components is satisfactory.

Fatty acid balance of muscle tissue lipids, beaver tail and the combined mixture is presented in Table 7.

Table 7. **Fatty acid balance of the muscle tissue lipids, lipoprotein part of the beaver tail and their mixture**

Indicator		Reference, g/100 g of lipids	Muscle tissue lipids, g/100 g of lipids	Lipids of the lipoprotein part of the tail, g/100 g of lipids	CM lipids, g/100 g of lipids
∑SAFA		30.0	26.0	17.10	18.29
∑MUFA		60.0	21.60	37.20	35.12
∑PUFA		10.0	52.40	45.70	46.59
Linolic acid		7.5	32.90	22.60	23.98
Linoleic acid		1.0	18.70	21.70	21.30
Arachidonic acid		1.5	0.40	0.70	0.66
Coefficient of the fatty acid balance, unit fraction R_{Li}	I = 1…3	1.0	0.39	0.43	0.42
	I = 1…6	1.0	0.24	0.29	0.28
n-6 : n-3		7.5	1.78	1.07	1.16

From the data presented in Table 7, it can be seen that the content of monounsaturated fatty acids in the lipoprotein part of the tail is 1.7 times higher than in muscle tissue, and the content of polyunsaturated and saturated fatty acids is 1.1 times less. The ratio of PUFA: SAFA in muscle tissue is 2.0, in the lipoprotein part of the tail – 2.7. Fatty acid balance coefficient calculated by SAFA, MUFA and PUFA R_{Li} = 1…3 and taking into account the contribution of individual balance of linolic, linoleic and arachidonic fatty acids R_{Li} = 1…6 corresponds to a high content of polyunsaturated fatty acids in the product.

The calculated values of the coefficients of fatty acid balance of the CM R_{Li} (1…3) = 0.42 and R_{Li} (1…6) = 0.28 [2].

Conclusion. Actual data have been obtained on the nutritional value of the muscle tissue and the lipoprotein part of the tail of the beaver inhabiting the Kaliningrad region, including sanitary-and-hygienic and microbiological safety indicators. Beaver muscle tissue is characterized by a high protein content (20.2 %) and a small amount of adipose tissue, while the lipid-and-protein part of the tail contains mainly lipids (85.1 %). The amino acid and fatty acid composition of proteins and lipids of muscle tissue and the lipid-and-protein part of the beaver tail was studied, and based on these data, the optimal ratio of these components in the mixture was designed, which made 72 and 28 %. The fatty acid composition of lipids in muscle tissue and the lipid-and-protein part of the beaver tail is mainly represented by polyunsaturated fatty acids (52.4 g / 100 g of lipids and 45.7 g / 100 g of lipids, respectively).

Based on the foregoing, it can be concluded that the data obtained on muscle tissue and lipoprotein part of the beaver inhabiting the Kaliningrad region can be used as comparative materials for the analysis of the physicochemical composition of the beaver carcass parts, and the results of designing the optimal ratio between muscle tissue and lipoprotein part of the beaver tail in a mixture (ratio 72 to 28 %) are applicable for the development of formulations for meat products.

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Information about the authors

Marina N. Alshevskaya – Ph. D. (Engineering), Associate Professor, Associate Professor of the Department of Food Technology, Kaliningrad State Technical University (1, Sovetsky Ave., 236022, Kaliningrad, Russian Federation). https://orcid.org/0000-0002-0632-9013. E-mail: marina.alshevskaya@klgtu.ru

Dmitriy L. Alshevskiy – Ph. D. (Engineering), Associate Professor, Associate Professor of the Department of Food Technology, Kaliningrad State Technical University (1, Sovetsky Ave., 236022, Kaliningrad, Russian Federation). https://orcid.org/0000-0003-4809-2998. E-mail: alshevsky@klgtu.ru

Yuri V. Mastyugin – Teacher, College of Mechatronics and Food Industry (7, Kommunisticheskaya St., 238347, Svetly, Kaliningrad Region, Russian Federation). https://orcid.org/0000-0001-9057-6035. E-mail: mail@proftop39.ru

Faina S. Karneeva – Postgraduate Student, Kaliningrad State Technical University (1, Sovetsky Ave., 236022, Kaliningrad, Russian Federation). https://orcid.org/0000-0002-9487-7756. E-mail: faina.karneeva@klgtu.ru

Ekaterina P. Bedo – Postgraduate Student, Uzbekistan State University of World Languages (21a, Kichik Khalka Yuli St., Block G-9a, Uchtepa District, 100173, Tashkent, Republic of Uzbekistan). https://orcid.org/0009-0006-3271-7876. E-mail: katerinabedo@gmail.com

Информация об авторах

Альшевская Марина Николаевна – кандидат технических наук, доцент, доцент кафедры технологии продуктов питания, Калининградский государственный технический университет (пр. Советский, 1, 236022, Калининград, Российская Федерация). https://orcid.org/0000-0002-0632-9013. E-mail: marina.alshevskaya@klgtu.ru

Альшевский Дмитрий Леонидович – кандидат технических наук, доцент, доцент кафедры технологии продуктов питания, Калининградский государственный технический университет (пр. Советский, 1, 236022, Калининград, Российская Федерация). https://orcid.org/0000-0003-4809-2998. E-mail: alshevsky@klgtu.ru

Мастюгин Юрий Викторович – преподаватель Колледжа мехатроники и пищевой индустрии (ул. Коммунистическая, 7, 238347, Светлый, Калининградская область, Российская Федерация). https://orcid.org/0000-0001-9057-6035. E-mail: mail@proftop39.ru

Карнеева Фаина Сергеевна – аспирант, Калининградский государственный технический университет (пр. Советский, 1, 236022, Калининград, Российская Федерация). https://orcid.org/0000-0002-9487-7756. E-mail: faina.karneeva@klgtu.ru

Бедо Екатерина Павловна – аспирант, Узбекский государственный университет мировых языков (ул. Кичик Халка Йули, 21а, квартал Г-9а, Учтепинский район, 100173, Ташкент, Республика Узбекистан). https://orcid.org/0009-0006-3271-7876. E-mail: katerinabedo@gmail.com