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INVESTIGATION OF DEPENDENCES OF THE MORPHOLOGICAL COMPOSITION OF BODY AND AMINO ACID COMPOSITION OF TROUT MEAT PROTEINS (*ONCORHYNCHUS MYKISS*) ON LEVELS OF THE ENERGY VALUE OF FEEDS

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ABSTRACT
The article studies the effect of using complete compound feeds with different energy levels on the morphological composition of the body and the amino acid composition of trout meat proteins. The experiment aimed to establish the influence of different levels of energy nutrition of commercial rainbow trout on the morphological composition of their body and the amino acid composition of meat proteins. For this purpose, five experimental groups were formed using the analog method. The study lasted 210 days and was divided into two periods: comparative (10 days) and main (200 days). During the comparative period, the study fish consumed compound feed of the control group. During the main period, the energy level in experimental compound feeds for different experimental trout groups ranged from 16 to 20 mJ per 1 kg. It was found that with an increase in the mass of two-year-old trout, the mass of muscle tissue and the yield of edible parts probably increases. Feeding fish with an increased amount of metabolic energy (20 $mJ.kg^{-1}$) resulted in a significant change in the weight of internal organs, including the heart, liver, and kidneys. Increasing the metabolic energy in the compound feeds of fish from 18 $mJ.kg^{-1}$ to 19 – 20 $mJ.kg^{-1}$ leads to a significant increase in bowel mass by 13.3 – 5.0%. An increase in the level of metabolic energy in rainbow trout diets from 18 $mJ.kg^{-1}$ to 19 – 20 $mJ.kg^{-1}$ contributed to a likely increase in the methionine content in meat. A similar pattern was observed for the tryptophan content. It was found that the content of most essential amino acids in the protein of rainbow trout meat exceeds the corresponding values in the "ideal" protein, except for the content of isoleucine and leucine, which refers them to limiting amino acids.

Keywords: rainbow; feeding; compound feed; commodity quality; amino acid; Oncorhynchus mykiss

INTRODUCTION
Trout meat is a product that has benefits for human health. This is due to its composition, which contains many important substances **(Archibisova and Suslov, 2018)**. Trout meat is the richest source of easily digestible animal protein, vitamins A, D, group b vitamins, as well as trace elements such as selenium, zinc, iodine, magnesium, potassium, calcium, and phosphorus. In cooking, trout is very much appreciated due to the high taste qualities of its fatty meat **(Mushtruk, et al., 2020a)**. Trout meat contains a lot of unsaturated fatty acids, which can reduce the amount of "harmful" cholesterol in the blood, preventing the development of atherosclerosis and its complications in the form of coronary heart disease, as well as heart attacks and strokes **(Makarenko et al., 2021)**.

Trout meat contains many essential amino acids, which confirms the benefits of trout for people with anemia, diseases of the cardiovascular system, and people suffering from debilitating, long-term diseases **(Orel, 2020)**.

Since rainbow trout is one of the most valuable fish species for humans, the need for the Ukrainian consumer market for this product is growing, which encourages producers to develop fish farms, increase production capacity, and encourage increased productivity and product quality **(Kozakevych, 2017; Mushtruk, et al., 2020b)**. The most effective and efficient way to achieve the goals is to choose the right feed and feeding strategy. Analysis of literature sources has shown that the most effective way to achieve goals is to select the appropriate feed and feeding strategy. The consumption of a part of the feed for energy needs is often variable and requires a detailed study, taking into account all the features of the study object **(Buchtová and Ježek, 2011; Sukhenko et al., 2017)**.

So, the study of the influence of different energy nutrition of rainbow trout on the morphological composition of the body and the amino acid composition of meat proteins is necessary to determine the energy needs of fish for the successful operation of fish farms and meet the needs of consumers in a high-quality product.

Scientific hypothesis

Morphometric parameters can serve as an integral characteristic of the living conditions of fish in a particular water body. At the same time, among the relevant studies, this area remains the least studied. Therefore, research is aimed at establishing the influence of the main factors of energy supply and their impact on the morphological composition of the body and the amino acid composition of trout meat proteins.

MATERIAL AND METHODOLOGY

The research was conducted in the spring, summer, and autumn periods from 2017 to 2019 in ponds based on the training-research-production laboratory of fish farming of the Shipot farm in Perechinskyi District of Zakarpattia (Transcarpathian) region.

Figure 1 Two-year-old rainbow trout (*Oncorhynchus mykiss*), which was obtained in the autumn of fish farming of the Shipot farm in Perechinskyi District of Zakarpattia (Transcarpathian) region.

Figure 2 Collection of ichthyological materials of fish farming of the Shipot farm in Perechinskyi District of Zakarpattia (Transcarpathian) region.

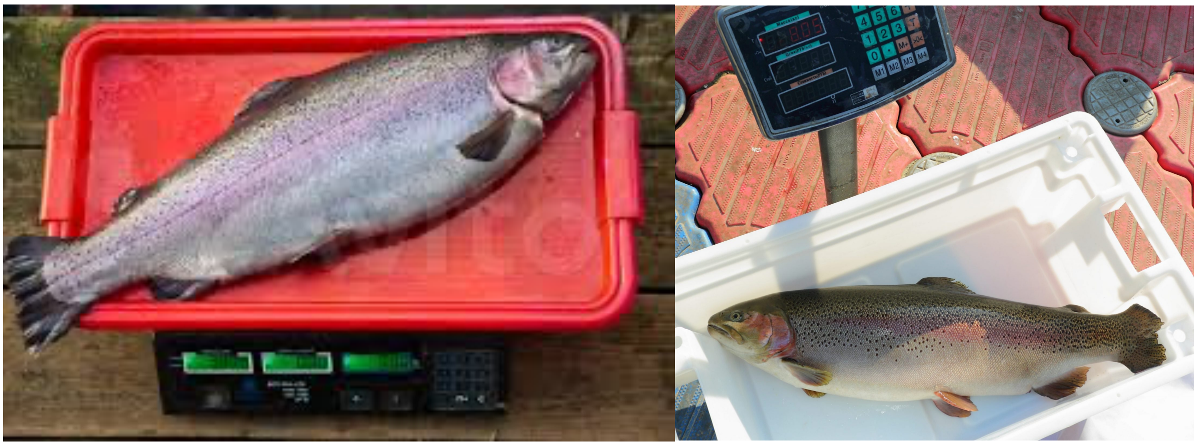

Figure 3 Conducting a morphometric analysis of two-years of the rainbow trout (*Oncorhynchus mykiss*).

Samples

Using the analog method, five experimental groups were formed, from which fresh fish was sampled for further study in the amount of five specimens with an average weight for the group (Figure 1, 2, and 3).

Chemicals

Formaldehyde (CH_2O, producer «Inter-Synthesis» Limited Liability Company, Ukraine, chemically pure for analysis).

Formalin (water solution formaldehyde, producer «Inter-Synthesis» Limited Liability Company, Ukraine).

Animals and Biological Material

Experimental studies were performed on two-year-old rainbow trout *Oncorhynchus mykiss* (Walbaum, 1792).

During the morphological analysis, 200 samples of rainbow trout were caught, and during the morphological analysis, 100 specimens were processed.

Instruments

Electronic laboratory scales (TBE-0.15-0.001-a-2, producer «Inter-Synthesis» Limited Liability Company, Ukraine)

Technical electronic scales (BTHE-6-H1K-1, producer "Inter-Synthesis" Limited Liability Company, Ukraine).

Binocular microscope (XSP-139B LED Ulab, producer "Laboratory equipment" Limited Liability Company, Ukraine).

Stereoscopic microscope (MBS-9, producer "Laboratory equipment" Limited Liability Company, Ukraine).

Amino acid analyzer (Biotronik LC 2000 (Germany), producer "Laboratory equipment" Limited Liability Company, Ukraine)

Laboratory Methods

To achieve the task of the experiment used standard methods of morphometric analysis **GOST (1985)**.

Processing of ichthyological materials was performed according to standard methods generally accepted in ichthyology **(Sabaj, 2020)**.

The size composition of fish was carried out on live material according to the scheme developed by I. F. Pravdin for salmon fish **(Souza et al., 2019)**.

The mass fraction of amino acids – by ion-exchange chromatography on the automatic amino acid analyzer Biotronik LC 2000 (Germany), the proportion of tryptophan - by the colorimetric method after alkaline hydrolysis of the studied samples. Biometric processing of the study results was carried out according to N.A. Plokhinskyi **(Park et al., 2018)**.

Description of the Experiment

The scientific and economic experiment aimed to establish the influence of different levels of energy nutrition of commercial rainbow trout on the morphological composition of the body and the amino acid composition of trout meat proteins.

For this purpose, five experimental groups were formed using the analog method (Table 1). During the comparative period of the experiment, which lasted 10 days, the experimental fish consumed compound feed of the control group.

During the main period of the experiment (200 days), the level of metabolic energy in the trout feed of the experimental groups was regulated by changing individual components of compound feed (using combined mathematical methods for optimizing the calculation using the AgroSoftWinOpti program).

Feeding of rainbow trout during the research period was carried out 4 – 6 times a day, in the daytime at regular intervals. The required amount of feed was calculated following the indicators of individual fish weight and ambient temperature at the time of feeding.

Table 1 Scheme of scientific and economic experiment.

Group	Density at the beginning of the experiment, exe./ m^2	Average mass at the beginning of the experiment, kg	Experiment periods	
			comparative (10 days)	main (200 days)
			exchange energy content in 1 kg of compound feed, mJ	
1-control	50	0.0502 ±1.72		18.0
2-experiment	50	0.0507 ±2.41		16.0
3-experiment	50	0.0505 ±3.14	18.0	17.0
4-experiment	50	0.0509 ±1.53		19.0
5-experiment	50	0.0503 ±2.83		20.0

Table 2 Content in 1 kg of compound feed, %.

Indicator	Group				
	1st	2nd	3rd	4th	5th
Exchange energy, mJ	18.00	16.00	17.00	19.00	20.00
Crude protein	48.00	48.00	48.00	48.00	48.00
Crude fat	18.00	18.00	18.00	18.00	18.00
Crude fiber	2.50	2.72	2.40	2.56	2.44
Calcium	1.80	1.80	1.80	1.80	1.80
Total phosphorus	1.20	1.20	1.20	1.20	1.20
Lysine	2.70	2.70	2.70	2.70	2.70
Methionine	0.90	0.90	0.90	0.90	0.90
Vitamin A, ths. MO	10	10	10	10	10
Vitamin D_3, ths. MO	3	3	3	3	3
Vitamin E, mg	200	200	200	200	200

The nutritional value of experimental production compound feeds is shown in Table 2.

Experimental trout were weighed every 10 days. The weighing of fish was carried out on electronic scales in a tared container with water, with an accuracy of 0.1 g. Cultivation of commercial two-year-olds was carried out in ponds with an area of 100 m^2 with a density of 50 sp./m^2, and the water level in them is 1 m. The total number of trout individuals in experimental studies was 25 thousand specimens.

The assessment was carried out according to the main fish-ichthyological parameters: body weight, industrial body length, head length, the largest and smallest body height, and the length of the caudal fin. Measurements were made with a centimeter tape with an accuracy of 0.1 cm. The individual weighing was carried out on electronic commodity scales with an accuracy of 1.0 g. For the study, fresh fish was used in the amount of 5 specimens with an average weight in the group.

Commercial qualities of rainbow trout were determined by the main indicators of the size and mass composition of raw materials-the mass of fish, head, fins, bones, muscle tissue, bones, skin, and internal organs. Based on the obtained weighing data, the ratio of the mass of individual parts of its body to the mass of a whole fish was determined **GOST (1985)**.

Based on the obtained indicators, the amino acid score of essential amino acids was calculated for a more complete and versatile characterization of raw materials and products:

$$AC_i = \frac{AK_{pr}}{AK_{st}} \cdot 100$$

Where:

AC_i is the score of essential amino acid, %; AK_{pr} - essential amino acid content in 1 g of the test protein, g.100g^{-1}; AK_{st} -the content of the same essential acid in 1 g of "Ideal" protein, g.100g^{-1}.

Limiting acid was considered the one with the lowest speed.

Studies of the growth rate of rainbow trout were carried out based on the results of control catches. At least 100 sp. of each group was weighed on an electronic scale.

Description of the Experiment

Sample preparation: For two years, 500 specimens of rainbow trout (*Oncorhynchus mykiss*) of different sizes and weight groups were studied.

Number of samples analyzed: According to the results of experimental studies in the first year, 200 samples were analyzed, and in the second year of research, 300 samples, respectively.

Number of repeated analyses: All measurements of instrument readings were performed 5 times.

Number of experiment replication: The number of repetitions of each experiment to determine one value was also 5 times.

Statistical analysis

The statistical evaluation of the results was carried out by standard methods using statistical software Statgraphics Centurion XVII (StatPoint, USA) – multifactor analysis of variance (MANOVA), LSD test. Statistical processing was performed in Microsoft Excel 2016 in combination with XLSTAT (version 2019.3.2). Values were estimated using mean and standard deviations. We calculated the arithmetic mean (unweighted) value (M), the arithmetic mean error ($\pm m$), which made it possible to estimate with a certain probability the deviation of the arithmetic mean deviation, Fulton fatness rate. The statistical reliability of the results of the research was provided by analyzing samples with the number of fish from 10 to 25 specimens.

RESULTS AND DISCUSSION

Today, the whole world sets up its production according to the principles of sustainable development, in Europe farms try to develop, adhering to its basic principles, but at the Open Data Science (ODS) summits, each time the question is raised about the problem of incomplete implementation of important points of the principle **(FAO, 2016)**. This encourages researchers to improve production technology, scientifically substantiating their developments and proposals. Many studies suggest using interesting alternatives in feeding and keeping rainbow trout **(Voorhees et al., 2019; Voorhees et al., 2018; Jones et al., 2020; Huysman et al., 2019)**. Working through an array of scientific publications, it became obvious that the range of available study objects is extremely wide. Scientists have studied many indicators, starting with the etiology (behavior) of trout, ending with the mortality rate **(Crank, Voorhees and Barnes, 2019; Keshavarzi et al., 2018)**. Choosing the subject and object of our study, the decisive argument was the consumer's need for a high-quality product, which focused our attention on the growth rate and high-quality composition of trout meat.

Comparison of the efficiency of energy use in fish feeding has been studied by many foreign specialists, whose scientific works confirm the influence of the studied factor on the object of the study **(Brooks et al., 2019; De Sá, et al., 2018; Mao et al., 2018)**.

The data of our studies indicate that commercial trout fed with compound feeds with different energy nutritional values had different masses in all time periods of the main period of the experiment. It was found that at the end of the experiment (7th month), the highest mass was reached by two-year-olds who were fed with compound feed with an exchange energy content of 19 and 20 mJ.kg^{-1}, which prevailed over analogs who were fed with feed with an exchange energy level of 18 mJ.kg^{-1}by 0.015 and 0.0334 kg (p <0.05), respectively, or by 5.2 and 11.5%. At the same time, trout fed with compound feed with an exchange energy content of 16 and 17 mJ.kg^{-1} were inferior to their peers fed with feed with an exchange energy level of 18 mJ by 0.0292 (p <0.01) and 0.0128 kg, respectively, or by 10.1 and 4.4%. A direct correlation between the content of metabolic energy and the bodyweight of fish was also recorded in studies by foreign scientists **(Carozza, Bianchi and Galbraith, 2019; Hicks et al., 2019; Houk et al., 2018)**.

It is known that the level of metabolic energy is one of the most significant factors influencing the intensity of tissue development and biosynthetic processes in the fish body, affecting both the level of productivity and the exchange of other compounds **(Rubio-Gracia et al., 2020; Sheiko et al., 2019; Jutfelt, 2020)**.

The mass composition of fish, that is, the ratio of fish body parts is one of the important characteristics for developing norms for the consumption of raw materials and the yield of finished products.

To make rational use of fish raw materials and establish yield standards for semi-finished products and finished products, we studied the mass composition of rainbow trout, depending on the influence of part typical factors, in particular feeding conditions (energy nutrition).

The results of the conducted studies show that different levels of metabolic energy in compound feed for rainbow trout during cultivation affect its commercial qualities in different ways (Table 3).

Analysis of data on the mass composition of rainbow trout indicates certain stability of the relative mass of the skin and internal organs. When achieving high mass indicators, there is an increase in the relative mass of muscle tissue and a slight decrease in the yield of inedible parts (group 5). This, in turn, leads to an increase in the yield of edible parts, the difference between the control and the indicators of the 5th group is statistically significant (p <0.001).

In general, it was found that with an increase in the mass of two-year-old trout, the mass of muscle tissue and the yield of edible parts increases.

A more complete description of rainbow trout grown in industrial conditions using compound feeds of various energy nutritional values were obtained after studying the internal organs (Table 4).

Analysis of the obtained data revealed changes in internal organs depending on the content of metabolic energy in experimental compound feeds. Feeding fish with an amount of metabolic energy (20 mJ.kg^{-1}) resulted in a significant change in the weight of internal organs, including the heart, liver, and kidneys.

The use of compound feeds with a high content of metabolic energy in feeding rainbow trout led to a significant change in intestinal mass. As you know, the digestive system of trout reacts quite quickly to changes in the physicochemical characteristics of the feed. During the research of M.A. Shcherbina, it was found that the stomach of rainbow trout also takes an active part in the absorption of nutrients. At the same time, the main place of absorption is the anterior part of the intestine and the part adjacent to the pyloric appendages, where up to 90% of proteins, fats and carbohydrates can be absorbed with optimal feeding **(Hu et al., 2018; Liu et al., 2019; Kasozi et al., 2017)**.

As a result of the analysis of the morphological body composition of rainbow trout, it was found that an increase in the amount of metabolic energy in fish feed to 19 mJ.kg^{-1} (group 4) and 20 mJ.kg^{-1} (group 5) leads to an increase in intestinal mass by 5.0% and 13.3% compared to the same control indicator. The difference is statistically significant (p <0.05; p <0.01).

It is known that the level of energy nutrition affects the need for amino acids in fish **(Raji et al., 2020; Jia et al., 2017; Smetanska et al., 2021)**, but to characterize the nutritional and biological value of fish raw materials, it is important to study changes in its amino acid composition (Table 5).

Analysis of the amino acid composition of fish raw materials shows that meat proteins (amino acid composition of muscle tissue proteins) of rainbow trout have a high biological value and contain all essential amino acids, among which lysine predominates (2.23 – 2.74 mg.100g^{-1}), leucine+isoleucine (1.79 – 2.03 mg.100g^{-1}), threonine (1.14 – 1.69 mg.100g^{-1}). In scientific studies **(Rajabzadeh et al., 2018; Roohani et al., 2019; Nogales-Mérida et al., 2019)**, the amino acid composition of various fish raw materials was analyzed and only the lysine content was determined.

Study results show that increasing the energy level of feeding rainbow trout contributes to an increase in the accumulation of essential amino acids. Thus, the amount of methionine in the meat of fish of the experimental groups was in the range of 0.47 – 0.87 mg per 100 g of product. However, it should be noted that an increase in the level of metabolic energy in the diets of fish of the experimental groups from 18 mJ.kg^{-1} (control group) to 19 – 20 mJ.kg^{-1} (4th and 5th groups) contributed to an increase in the content of methionine in meat by 33.8 – 47.5 % (p <0.01, p <0.001). The highest methionine content was found in trout meat of the 5th experimental group, which received compound feed with an increased (up to 20 mJ.kg^{-1}) content of metabolic energy.

Analyzing the data on the content of methionine in fish meat, the diet of which was with a reduced content of metabolic energy, it should be noted that reducing its level to 16 mJ.kg^{-1} (2nd experimental group) contributed to a decrease in the content of methionine from 0.59 to 0.48 mg.100g^{-1} of the product, and up to 17 mJ.kg^{-1} – led to a slight increase in its level, compared with analogs of the control group. In scientific studies **(Rogoskii et al., 2020; Čapla et al., 2020)** analyzed the content of methionine in fish meat, it should be noted that scientists observed a decrease in its level to only 10 mJ.kg^{-1}, which helped reduce the content of methionine from 0.42 to 0.38 mg.100g^{-1} of product.

The same pattern was observed for the tryptophan content. In the muscles of rainbow trout of the 3rd, 4th, and 5th experimental groups, the tryptophan content was 11.5 – 65.4% higher than in the analogs of the control group. The highest content of tryptophan was in the meat of fish of the 5th experimental group and amounted to 0.43 mg.100g^{-1} of the product, which is 48.3% and 22.8% more compared to the indicators of fish of the 3rd and 4th experimental groups.

Amino acids such as serine, arginine, and threonine are hydrophilic amino acids that determine the moisture-retaining ability of fish meat. As can be seen from the conducted experimental studies, proteins contain a sufficient amount of these amino acids, which explains the rather high moisture-retaining ability of meat.

The results of the studies showed that the sum of essential amino acids in the muscle tissue of rainbow trout of the 3rd, 4th, and 5th experimental groups, whose compound feed contained an exchange energy content of 17 – 20 mJ.kg^{-1}, exceeded the indicator of the control group by 4.8%, 14.4%, and 23.5%, respectively. This is due to the predominance of essential amino acids such as lysine, methionine, threonine, phenylalanine, and tryptophan.

The sum of non-essential amino acids in trout meat of the studied groups ranged from 11.21 mg.100g^{-1} of protein (2nd experimental group) to 15.45 mg.100g^{-1} of protein (5th experimental group). The greatest amount of non-essential amino acids was found in trout meat, whose diet contained an increased content (20 mJ.kg^{-1}) of metabolic energy.

Thus, the sum of non-essential amino acids in the studied trout samples of the 5th experimental group was 25.2% higher than in the control group and amounted to 15.45 mg.100g^{-1} of protein.

Among the non-essential amino acids, aspartic acid (2.41 mg.100g^{-1} of protein), alanine (2.07 mg.100g^{-1} of protein), arginine (1.79 mg.100g^{-1} of protein), and glycine (1.62 mg.100g^{-1} of protein) were dominant in trout meat of the 5th experimental group.

Table 3 Commercial qualities of rainbow trout, (n = 5).

Indicator	Group				
	1st	2nd	3rd	4th	5th
Fish mass, kg	0.2903 ±8.14	0.2611 ±7.26*	0.2775 ±8.72	0.3053 ±7.33	0.3237 ±9.38*
Head mass, kg	0.0482 ±2.13	0.04386 ±1.96	0.0444 ±3.04	0.0512 ±4.36	0.0543 ±3.65
Fins mass, kg	0.0181 ±1.87	0.01697 ±1.98	0.0555 ±2.06	0.0198 ±1.21	0.0209 ±0.96
Bones mass, kg	0.0193 ±0.98	0.01749 ±1.06	0.01859 ±1.10	0.0206 ±1.32	0.0221 ±0.87
Muscles mass, kg	0.1518 ±6.98	0.13547 ±7.03	0.14153 ±6.74	0.1596 ±5.62	0.1716 ±3.21*
Skin mass, kg	0.01974 ±1.02	0.01775 ±2.01	0.01887 ±1.99	0.02084 ±1.24	0.02108 ±1.03
Internal organs mass, kg	0.01626 ±0.98	0.01462 ±0.78	0.01388 ±1.01	0.01703 ±1.03	0.01838 ±0.87
Mass of edible parts, kg	0.17418 ±5.23	0.15196 ±6.85*	0.1665 ±7.02	0.19936 ±6.54*	0.21752 ±6.24***
Yield of edible parts, %	60.0 ±3.01	58.2 ±3.69	59.3 ±3.87	65.3 ±2.0	67.2 ±2.67*
Mass of inedible parts, kg	0.11612 ±3.21	0.10914 ±3.47	0.1091 ±4.65	0.10594 ±2.45*	0.10618 ±2.33*
Yield of inedible parts, %	40.0 ±1.97	41.8 ±2.06	40.7 ±1.99	34.7 ±1.09*	32.8 ±1.41*

Note: $^{*}p$ <0.05; $^{**}p$ <0.01; $^{***}p$ <0.001 compared to the 1st group.

Table 4 Mass of internal organs of two-year-old rainbow trout, kg (n = 5).

Indicator	Group				
	1st	2nd	3rd	4th	5th
Heart	0.00095 ±0.005	0.0008 ±0.002***	0.0008 ±0.04***	0.0010 ±0.07***	0.00110 ±0.005***
Liver	0.00403 ±0.09	0.00368 ±0.04***	0.0034 ±0.04**	0.00426 ±0.11	0.00460 ±0.06***
Kidneys	0.00181 ±0.24	0.00162 ±0.22	0.00154 ±0.33	0.00187 ±0.21	0.00202 ±0.18
Stomach	0.00428 ±0.63	0.00399 ±0.42	0.00361 ±0.39	0.00443 ±0.29	0.00483 ±0.36
Intestines	0.00519 ±0.14	0.00434 ±0.13	0.00448 ±0.27	0.00545 ±0.11*	0.00588 ±0.13**

Note: $^{*}p$ <0.05; $^{**}p$ <0.01; $^{***}p$ <0.001 compared to the 1st group.

Table 5 Amino acid composition of rainbow trout meat proteins mg per 100 g of product, (n = 5).

Indicators	Group				
	1st	2nd	3rd	4th	5th
Essential amino acids (EAA)	**8.98**	**8.78**	**9.41**	**10.27**	**11.09**
Valin	1.71 ±0.03	1.64 ±0.05	1.71 ±0.02	1.78 ±0.04	1.82 ±0.03*
Leucine+isoleucine	1.82 ±0.05	1.79 ±0.06	1.84 ±0.09	1.98 ±0.02*	2.03 ±0.07*
Lysine	2.23 ±0.09	2.36 ±0.12	2.41 ±0.14	2.65 ±0.09*	2.74 ±0.07*
Methionine	0.59 ±0.01	0.48 ±0.01	0.66 ±0.01	0.8 ±0.02***	0.87 ±0.04***
Threonine	1.14 ±0.04	1.08 ±0.06	1.21 ±0.09	1.33 ±0.05	1.69 ±0.06***
Phenylalanine	1.23 ±0.05	1.19 ±0.08	1.29 ±0.07	1.39 ±0.04*	1.51 ±0.04**
Tryptophan	0.26 ±0.04	0.24 ±0.06	0.29 ±0.05	0.35 ±0.03*	0.43 ±0.01**
Non-essential amino acids (NEAA)	**12.34**	**11.21**	**13.46**	**14.07**	**15.45**
Alanine	1.87 ±0.06	1.77 ±0.04	1.91 ±0.09	1.99 ±0.09	2.07 ±0.06**
Arginine	1.51 ±0.05	1.41 ±0.02	1.64 ±0.07	1.69 ±0.10	1.79 ±0.01*
Histidine	0.93 ±0.01	0.83 ±0.01	0.99 ±0.02	1.11 ±0.01	1.23 ±0.03*
Proline	0.74 ±0.01	0.64 ±0.01	0.94 ±0.01	1.06 ±0.02	1.24 ±0.08***
Serin	1.34 ±0.09	1.21 ±0.08	1.40 ±0.10	1.44 ±0.05	1.64 ±0.09*
Glutamic acid	0.62 ±0.01	0.52 ±0.01	0.73 ±0.02	0.78 ±0.03	0.92 ±0.04***
Aspartic acid	2.11 ±0.09	2.01 ±0.10	2.21 ±0.11	2.21 ±0.14	2.41 ±0.08*
Glycine	1.32 ±0.08	1.12 ±0.06	1.44 ±0.13	1.49 ±0.12	1.62 ±0.06*
Cystine	0.96 ±0.01	0.86 ±0.01	1.06 ±0.06	1.11 ±0.14*	1.26 ±0.09*
Tyrosine	0.94 ±0.01	0.84 ±0.01	1.14 ±0.11	1.19 ±0.16*	1.27 ±0.06***
NEAA-to-EAA ratio	**0.73:1**	**0.78:1**	**0.70:1**	**0.73:1**	**0.72:1**

Note: $^{*}p$ <0.05; $^{**}p$ <0.01; $^{***}p$ <0.001 compared to the 1st group.

Table 6 Assessment of compliance of the amino acid composition of rainbow trout proteins with the ideal protein with the FAO/WHO scale, g.100g^{-1} of protein, (n = 5).

Amino acid	Group					FAO/WHO ideal protein
	1st	2nd	3rd	4th	5th	
Valin	8.02	8.20	7.48	7.31	6.86	5.0
Isoleucine	3.09	3.20	2.93	2.92	2.75	4.0
Leucine	5.44	5.75	5.12	5.22	4.90	7.0
Methionine+cystine	7.27	6.70	7.52	7.81	8.03	3.5
Threonine	5.35	5.40	5.29	5.46	6.37	4.0
Phenylalanine+tyrosine	10.18	10.16	10.63	10.60	10.47	6.0
Tryptophan	1.22	1.20	1.27	1.44	1.62	1.0
Lysine	10.46	11.81	10.54	10.89	10.32	5.5
Total	51.03	52.42	50.78	51.65	51.32	**36**

Table 7 Amino acid score of rainbow trout meat proteins, %.

Amino acid	Group				
	1st	2nd	3rd	4th	5th
Valin	160	164	150	146	137
Isoleucine	77	80	73	73	69
Leucine	77	82	73	73	70
Methionine+cystine	207	191	215	223	229
Threonine	134	135	132	137	159
Phenylalanine+tyrosine	169	169	177	177	175
Tryptophan	122	120	127	144	162
Lysine	190	215	192	198	188
Total	1136	1156	1139	1173	1189

So, as a result of experimental studies, it was found that an increase in the levels of metabolic energy in compound feeds of rainbow trout causes noticeable changes in the amino acid composition of meat, which improves its biological value.

An important indicator of the biological value of proteins is the correspondence of the content of essential amino acids to the ideal protein (Table 6).

The data in Table 6 show that the sum of essential amino acids in the protein of rainbow trout meat, regardless of the factor under study, exceeds their amount in the "ideal" protein. However, the content of isoleucine and leucine turned out to be lower than such an "ideal" protein, that is, these amino acids can be attributed to limiting ones.

Thus, the results of experimental studies established that the content of isoleucine in the proteins of fish raw materials of rainbow trout was in the range from 2.75 to 3.2 g.100g^{-1} of protein. The smallest amount of it was found in the protein of fish of the 5th experimental group, which were fed with compound feed with an exchange energy content of 20 mJ.kg^{-1}. A similar pattern was found in the leucine content. At the same time, trout meat has a high content of valine, methionine + cystine, threonine, phenylalanine + tyrosine, tryptophan, and lysine, which are quite important for the human body.

Results of calculating the amino acid score (Table 7) indicate a fairly high biological value of rainbow trout meat proteins.

The limiting amino acids in trout meat are methionine + cystine, phenylalanine + tyrosine, lysine, and valine. Analysis of experimental data showed that changes in the nutritional value of rainbow trout feed accompanied noticeable changes both in the amino acid composition of proteins and in the calculations of the amino acid score. In particular, an increase in the level of metabolic energy in fish feed to 19 – 20 mJ.kg^{-1} contributed to a significant increase in the level of essential amino acids. The dominant amino acids in fish meat protein of the 4th and 5th experimental groups were methionine + cystine (223% and 229%), lysine (198% and 188%), and phenylalanine + tyrosine (177% and 175%).

It was also found that trout use of compound feeds with exchange energy of 16 mJ.kg^{-1} (2nd experimental group) leads to a decrease in the amount of methionine + cystine, tryptophan in meat protein, and an increase in the content of lysine and valine compared to the control.

Trout cultivation on compound feed with a metabolic energy content of 17 mJ.kg^{-1} was accompanied by a decrease in the amount of amino acids such as valine, isoleucine, leucine, and threonine in meat protein. The limiting amino acids in trout meat protein of the 3rd experimental group were methionine + cystine (215%), phenylalanine + tyrosine (177%), and lysine (192%).

So, the analysis of experimental data showed the influence of the level of metabolic energy on the quality indicators of rainbow trout meat. The relationship of energy nutrition of fish with the intensity of metabolism and improvement of the quality of its meat is proved.

CONCLUSION

It was found that at the end of the experiment, the highest mass was reached by two-year-olds who were fed with compound feed with an exchange energy content of 19 and 20 mJ.kg^{-1}, which prevailed over analogs who were fed with feed with an exchange energy level of 18 mJ.kg^{-1} by 0.015 and 0.0334 kg (p <0.05) (5.2 and 11.5%), respectively. Trout fed with compound feed with an exchange energy content of 16 and 17 mJ.kg^{-1} were inferior to their peers fed with feed with an exchange energy level of 18 mJ by 0.0292 (p <0.01) and 0.0128 kg, respectively, or by (10.1 and 4.4%). It was found that an increase in the amount of metabolic energy in fish feed to 19 $mJ.kg^{-1}$ and 20 $mJ.kg^{-1}$ leads to an increase in intestinal mass by 5.0% and 13.3%, respectively, compared to the same control indicator (p <0.05; p <0.01). An increase in the level of metabolic energy in the diets of fish of experimental groups from 18 $mJ.kg^{-1}$ to 19 – 20 $mJ.kg^{-1}$ contributed to an increase in the content of methionine in meat by 33.8 – 47.5% (p <0.01; p <0.001). The content of most essential amino acids in the protein of rainbow trout meat exceeds the corresponding indicators in the "ideal" protein, which confirms the high biological value of this product. Prospects for further studies are related to determining the effect of amino acid nutrition on the two main limiting amino acids (lysine and methionine) on the commercial qualities of trout and the biological value of its meat protein.

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