International Journal on Emerging Technologies 11(3): 412-416(2020)

ISSN No. (Print): 0975-8364
ISSN No. (Online): 2249-3255

Industrial Carp Feeding Assessment of the Morphological Composition of the Body

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(Received 31 January 2020, Revised 03 April 2020, Accepted 06 April 2020)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: The article demonstrates the results of research carried out to solve the most important problem of the modern world – an increasing shortage of protein feed products. The possibility of using soy concentrate obtained by enzymatic hydrolysis in feeding carp has been studied. The used feed additive contributed to the nutritional value of carp. Assessment of the morphological composition of the experimental carps' bodies revealed a significant change in the weight of tissues and organs. In the group that received 0.75 ml of the feed additive per 1 kg of fish weight, the weight of edible parts increased by 15.8 %, and in the group that received 1.0 ml of the feed additive per 1 kg of fish weight — by 15.4 %, compared to the group that did not receive the additive in the diet. The analysis of the amino acid composition of the muscle tissues in the studied samples shows that fish protein in the group that received 0.75 ml of the feed additive per 1 kg of fish weight has fewer differences in the composition of essential amino acids, which subsequently increases its biological value by 15.86 %, compared to the group in the diet of which pancreatic hydrolyzate of soy protein was not used. The analysis was performed using the high-performance liquid chromatography.

Keywords: pancreatic hydrolyzate of soy protein, carp, biological value of meat, amino acid score.

I. INTRODUCTION

In the modern society, the health level of the active part of the population is declining. This is largely due to unbalanced nutrition; therefore, the task of a stable supply of high-quality food products to all segments of the population should be one of the main tasks of the country's economy [1, 2].
The foodstuffs produced by the fishing industry are an important source of animal protein. In many countries, especially in coastal states, aquaculture is considered to be the main component of ensuring food security of the state and plays an important role in supplying fish products to people [3, 4].
The scrupulous attention of scientists from many countries with developing aquaculture is focused on developing full-fledged fish feeding. The feed formulations for fish of various species and ages are being constantly updated, new components and feed additives are introduced into their composition, reflecting the latest data about the physiology and the metabolism of aquatic organisms [5, 6].
A serious problem of the present and the future is the growing shortage of protein feed products. In the current conditions, forage base of animal husbandry, including aquaculture, is poorly provided with biologically complete protein. Scientists are constantly working to improve fish feed formulations, search for new ingredients and enzyme compositions that increase growth and reduce feed costs, and, as a result, increase the profitability of fish farming. Reducing the cost of feed is possible due to the partial replacement of the main and expensive components (fish meal and fat) with alternative sources of protein of plant origin [6].
In recent years, many works and experimental studies have been devoted to the optimization of protein metabolism in fish through the use of animal and plant hydrolyzates [2, 5-8].
During the hydrolysis of proteins carried out using proteolytic enzymes, pathological changes in the hydrolysis products do not occur, and the components obtained as a result of cleavage are physiological in nature, easily penetrate the cell and are included in the processes of cellular metabolism.

II. METHODS

The scientific studies aimed at determining the chemical and the amino acid composition of the muscle tissues of carp upon using pancreatic hydrolyzate of soy protein in the diet were performed on the basis of the fish farm of LLC Industrial Fish Breeding Center in the Engels district of the Saratov region.
The study was aimed at assessing the effectiveness of using pancreatic hydrolyzate of soy protein for feeding carp, and its effect on the fish quality.

The objective was assessing the commercial quality of the carp; analyzing the chemical and amino acid composition of the muscle tissues and the biological value of fish products.

The topic of the scientific studies was approved by the Grants Council of the President of the Russian Federation, and was funded by a grant of the President of the Russian Federation for State Support of Young Russian Scientists (No. MK-6216.2018.11).

For the experiment, 1,800 carps of the Parsky breed were chosen at the age (1+) with a weight of 21.0 g and put into three cages, 600 carps in each. The duration of the studies was 18 weeks.

The young fish in group I received the feed that consisted of sunflower meal (30.5 %), sorghum (11.0 %), barley (6.0 %), wheat (5.5 %), fish meal (10.0 %), feed yeast (34.0 %), inorganic phosphorus (1.0 %), chalk (1.0 %), and premix (1.0 %). For groups II and III, the same granular compound feed was used with the introduction of the pancreatic hydrolyzate of soy protein by spraying at the rate of 0.75 ml and 1.0 ml per 1 kg of the ichthyomass, respectively.

The daily feed rate was calculated considering the water temperature and the weight of the fish. The feed consumption and fish survival rate were determined every day [9].

The fish were grown in a system of floating cages for scientific studies in fish keeping and farming that had been developed by Vasiliev *et al*., (2013) [10] the cages had been made of 2.5 × 2.5 × 3.2 m knotless latex webbing with a mesh size of 10 mm on the walls and 3 mm on the bottom.

This method of industrial cultivation made it possible to exclude the consumption of the natural food base of the reservoir, while satisfying the physiological needs of farmed fish.

In the studies, the commercial quality of the fish grown in industrial conditions was studied at the end of the scientific and economic experiment; for this purpose, the ratio of edible to inedible parts of the body was determined, following the methods adopted in fish farming [11]. Three carps from each experimental group were taken for the studies.

The chemical composition of the muscle tissues was determined using standard methods that contributed to the most accurate determination of indicators.

The initial moisture content was determined according to AFNOR NF V04-401 Meat, meat products, and fishery products – Determination of moisture content.

The raw ash content was determined according to GOST 31727-2012 (ISO 936: 1998). Meat and meat products. The method of determining the mass fraction of total ash.

The content of fat was determined from fat-free residue according to GOST 23042-2015. Meat and meat products. Methods of fat determination.

The content of protein was determined according to the Kjeldahl's method.

The content of calcium was determined according to GOST R 55573-2013. Meat and meat products. Determination of calcium by titrimetric methods

The content of phosphorus was determined using the colorimetric method in GOST 32009-2013 (ISO 13730: 1996). Meat and meat products. Spectrophotometric method for determination of total phosphorus content.

The content of nitrogen-free extractive substances (NFES) was determined by the calculation method.

The amino acids were identified using pre-column modification by 6-aminoquinoline hydroxysuccinimidyl carbamate – AccQ according to the Waters AccQ-Tag method using the reactants kit WAT 052880. This method ensured specific quantitative modification of the primary amino groups, amino acids, and amino sugars, and featured high sensitivity and high separation efficiency.

The obtained experimental data were subjected to biometric processing, with due regard to the recommendations of Tarchokov e*t al*., (2016) [12] using the MS Excel 2013 software package.

III. RESULTS

The main object of commercial fish farming is carp. This is due to its biological properties, high quality of fish products, and the relatively low cost [3, 4, 13].

An important indicator in assessing the quality of fish products is the yield of edible parts in the fish. In the first stage of the studies, the authors assessed precisely this indicator. In determining the rate of edible to inedible parts of the body, the fish were weighed. After that, the scales and fins were removed, the head was cut off, and the entrails were removed with separation of the internal organs. Next, the fillet was cut from the carcasses, separating the meat from the bones, and the skin was removed from the fillet. The various parts were weighed, and the ratio of edible to inedible parts of the fish was calculated and expressed as a percent of the fish weight (Table 1).

Assessment of the morphological composition of the experimental carps' bodies revealed a significant change in the weight of tissues and organs. With the addition of pancreatic hydrolyzate of soy protein to the diet, the content of muscle tissues in groups II and III significantly increased, compared to group I. The increased weight of edible parts in group II (by 15.8 %), and in group III (by 15.4 %), and the decreased yield of inedible parts from the weight of the carcass in group II (by 12.3 %), and in group III (by 12.8 %), compared to group I, were noted.

The nutritional value of the carp is due to the chemical composition of its main tissues, and the biological value is determined by the protein part. The muscle tissues, as you know, have a complex chemical composition, including water, proteins, fats, and minerals the level of which depends on many factors, such as feeding and keeping conditions (Table 2).

Analyzing the obtained data, one can say that in the muscle tissue of the carp, the introduction of pancreatic hydrolyzate of soy protein into the diet significantly increased the content of crude protein in group II by 4.9 % ($P \geq 0.95$), and in group III — by 3.7 % ($P \geq 0.95$), as well as increased the content of fat in group II by 10.4 %, and in group III — by 10.8 %, compared to group I. The share of ash in the structure and chemical composition of the tissues is insignificant and corresponds to the content of minerals in the used diets.

Table 1: The results of check slaughtering of the experimental carps, g.

Weight	Group		
	I	II	III
Fish	615.70 ± 3.2	706.20 ± 3.4	705.30 ± 3.1
Head and fins	101.59 ± 2.4	117.23 ± 2.2**	117.79 ± 2.3**
Skin	27.71 ± 1.3	29.66 ± 1.0	28.21 ± 1.2
Bone tissue	51.72 ± 1.1	58.61 ± 1.3*	58.54 ± 1.0*
Muscle tissue	397.74 ± 2.3	462.56 ± 2.1***	461.27 ± 2.2***
Internal organs and fat	16.01 ± 0.7	16.95 ± 0.9	16.22 ± 0.8
Gills, mucus, blood, abdominal fluid	20.93 ± 0.8	21.19 ± 0.7	23.27 ± 0.9
Edible parts	413.75 ± 2.1	479.51 ± 2.0***	477.49 ± 2.2***
Inedible parts	201.95 ± 1.2	226.69 ± 1.3***	227.81 ± 1.0***

*P ≥ 0.95, **P ≥ 0.99, ***P ≥ 0.999

Table 2: Chemical composition of the muscle tissues of the carp, %.

Indicator	Group		
	I	II	III
Moisture	75.6 ± 1.3	72.6 ± 1.4	74.8 ± 1.2
Crude protein	18.9 ± 0.2	21.9 ± 0.5*	19.6 ± 0.3*
Crude fat	2.7 ± 0.3	3.0 ± 0.2	3.2 ± 0.4
Ash	2.8 ± 0.1	2.5 ± 0.2	2.4 ± 0.1

*P > 0.95

Based only on the chemical analysis of the muscle tissues, it is impossible to assess the nutritional value of the fish, as it is a source of complete protein. The nutritional value of the fish is determined mainly by the content of protein substances of the muscle tissues and the composition of amino acids [14, 15].

The biological value of substances is associated with their ability to act as the source material for building the most important elements of protein origin. Therefore, the amino acid composition is one of the most important indicators of its quality. Protein synthesis in an animal organism is the result of the amino acid metabolism and depends not only on their intake with the food but also on the ability of the organism to transform amino acids into body protein.

To study the amino acid composition of the muscle tissues of the carp, specimens were taken at the end of farming with an average weight of about 700 g. The results of the amino acid analysis are shown in Table 3.

Analysis of the obtained data about the amino acid composition of the carp muscle tissues showed that the content of protein was balanced. By the content of lysine, threonine, phenylalanine, valine, the values in group I exceeded the values in groups II and III that received hydrolyzate of soy protein. It was found that the content of essential amino acids such as lysine, leucine, and isoleucine prevailed in the proteins of the muscle tissue of the carp. Of the nonessential amino acids in the proteins of the muscle tissue of the carp, the content of alanine and glutamic acid prevailed.

For greater clarity of the usefulness of the protein, the authors calculated the amino acid score, which was defined as the ratio of the content of the essential amino acids in the product to the content of the essential amino acid in the “ideal protein”; the composition of the ideal protein was considered the latest physiological needs of people in various age groups, as adopted in 2011 by the FAO [13].

Table 3: The amino acid composition of the muscle tissues of the carp, g/100 g of protein.

Amino acid	Group			Amino acid score, %		
	I	II	III	I	II	III
			Essential			
Lysine	9.58 ± 1.1	8.61 ± 1.0	9.11 ± 1.2	199.65	179.34	189.85
Threonine	4.98 ± 1.2	3.16 ± 1.3	4.36 ± 1.0	199.00	126.35	174.58
Phenylalanine	3.88 ± 0.2	3.24 ± 0.1*	3.69 ± 0.2	154.11	136.40	149.73
Leucine + Isoleucine	13.20 ± 0.8	13.75 ± 0.7	13.62 ± 0.8	145.08	151.09	149.68
Methionine + cystine	3.23 ± 0.7	3.48 ± 0.9	4.12 ± 0.8	136.28	152.48	179.33
Valine	5.51 ± 0.6	5.44 ± 0.5	5.47 ± 0.7	137.73	136.12	136.69
Tryptophan	4.47 ± 0.7	5.11 ± 0.8	4.96 ± 0.9	90.46	107.71	116.27
Histidine	1.39 ± 0.1	1.52 ± 0.2	1.49 ± 0.1	87.06	94.79	92.93
			Nonessential			
Tyrosine	2.45 ± 0.5	2.37 ± 0.4	2.45 ± 0.6	—	—	—
Proline	2.50 ± 0.6	2.46 ± 0.4	2.49 ± 0.5	—	—	—
Serine	4.16 ± 0.4	4.44 ± 0.3	4.27 ± 0.2	—	—	—
Alanine	5.19 ± 0.29	5.52 ± 0.30	5.28 ± 0.31	—	—	—
Arginine	4.57 ± 0.37	4.59 ± 0.39	4.56 ± 0.36	—	—	—
Glycine	3.11 ± 0.23	3.25 ± 0.21	3.17 ± 0.25	—	—	—
Glutamic acid	7.74 ± 1.4	8.91 ± 1.6	9.59 ± 1.7	—	—	—
Aspartic acid	4.43 ± 0.35	4.13 ± 0.41	3.84 ± 0.50	—	—	—

*P > 0.95

In calculating the amino acid score, it was found that in group I, there were two limiting amino acids – histidine and tryptophan; in groups II and III, there was one limiting amino acid – histidine. With that, the amino acid score was higher by 7.73 % and 5.87 %, respectively, than in group I. This figure shows that protein was not fully digested, only 87.06 % in the fish in group I, 94.79 % in the fish in group II, and 92.93 % in the fish in group III. It means that such a product should be eaten only in combination with other products with sufficient amounts of histidine.

The total content of essential amino acids in 100 g of protein in group I was 44.74 g, in group II — 42.29 g, and in group III — 45.08 g. The weight of nonessential amino acids in group I was 31.69 g, in group II, it was higher by 1.61 g, and in group III — by 1.50 g.

The authors assessed the biological value of protein by the main indicators of its usefulness: the amino acid score, the usefulness coefficient of the amino acid composition, the coefficient of comparable redundancy, the coefficient of the difference in the amino acid composition, and the biological value of the fish (Table 4).

Best of all, the human body would use the protein of the fish from group II with the coefficient of usefulness equal to 0.65. As the coefficient of comparable redundancy shows, out of 100 g of protein of the carps in group II, only 3.26 g would not be absorbed by the organism, vs. 4.46 g in group III, and 4.53 g in group I.

Table 4: The biological value of the protein in common carp.

Indicator	Group		
	I	II	III
The coefficient of amino acid composition usefulness, units	0.57	0.65	0.60
The coefficient of comparable redundancy, g/100 g protein	4.53	3.26	4.46
The amino acid composition difference coefficient, %	56.61	40.75	55.71
Biological value, %	43.39	59.25	44.29

The coefficient of the amino acid score difference in the studied samples shows that protein of the fish in group II had smaller differences in the essential amino acid composition, which consequently increased its biological value by 15.86 %, compared to group I. Protein in group I had the lowest biological value. In group III, the biological value of the muscle tissues of the carp was higher than in group I by 0.90 % but lower than in group II by 14.96 %. This shows that the increased introduction of soy protein pancreatic hydrolyzate into the diet increases the total content of amino acids, but causes an disbalance, thus calling the Law of the Minimum into force, according to which deficiency of only one essential amino acid limits the efficacy of using not only other amino acids but the entire diet as well..

IV. CONCLUSION

The analysis of the obtained data shows that the use of soy protein pancreatic hydrolyzate contributes to increasing the yield of the edible parts of fish, significantly increases the content of crude protein in the muscle tissue, and saturates it with essential amino acids, increasing the biological value of the carp grown in industrial conditions. Further scientific research implies studying the effect of pancreatic hydrolyzate of soy protein in the feeding of juveniles of valuable fish species when switching to mixed nutrition and starter feed.

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How to cite this article: Guseva, Y. A., Vasiliev, A. A., Poddubnaya, I. V., Tarasov, P. S., Matsyupa, I. O., Zaitsev, V. V., Dikusarov, V. G., and Randelin, D. A. (2020). Industrial Carp Feeding Assessment of the Morphological Composition of the Body. *International Journal on Emerging Technologies*, *11*(3): 412–416.