Fatty acid composition of *Clarias gariepinus* fish reared in artificial pond conditions, Uzbekistan

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Abstract. The article presents the gas chromatographic analysis of fatty acids of African catfish (*Clarias gariepinus*) raised in the aquaculture conditions of Uzbekistan. Fish also contains significant amounts of all essential amino acids, especially lysine, which cereals are relatively poor in. Therefore, fish protein can be used to supplement the amino acid composition and improve the overall protein quality of mixed diets. The study showed that the fish contains mono- and polyunsaturated fatty acids such as oleic (C18:1-9 cis), linoleic (C18:2), eicosapentaenoic (C20:5), docosapentaenoic (C22:5). The ratio of ω-6/ω-3 PUFAs is 3:1, which is optimal for preventive nutrition. The data shows a high potential for using African catfish in dietary and functional nutrition.

1 Introduction

Fish is highly nutritious, tasty, and easily digestible. It is highly sought after by large segments of the world's population, especially in developing countries. It is estimated that about 60 percent of the population in many developing countries depend on fish for more than 30 percent of their animal protein supply, while nearly 80 percent of most developed countries get less than 20 percent of their animal protein from fish. However, with the growing awareness of the health benefits of fish consumption and the subsequent rise in fish prices, these figures are rapidly changing. Fish also contains significant amounts of all essential amino acids, especially lysine, which cereals are relatively poor in. Therefore, fish protein can be used to supplement the amino acid composition and improve the overall protein quality of mixed diets [1].

Most fish meat is a natural source of unsaturated fatty acids, which makes it a very valuable component of the anti-sclerotic diet. Knowledge of the chemical composition of fish is necessary for the rational use of fish resources for food, medicinal, and other purposes. The comparative aspect of the chemical composition of fish meat is characterized by significant differences from the meat of productive animals. The nutritional value of fish meat is determined by species characteristics, way of life (pelagic, benthic, transient,

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semitransparent), habitat (marine, freshwater), metabolic peculiarities, sex, age, physiological state of fish, and other factors [2].

Gas chromatographic analysis of fatty acids of African catfish (*Clarias gariepinus*) grown in Uzbekistan is an important study in determining the nutritional value of this species in aquaculture. The main objective of the study is to determine the fatty acid composition of this species and assess its nutritional value. The research shows that African catfish oil contains a large amount of polyunsaturated fatty acids (PUFA), especially ω-3 and ω-6 acids, which makes it a valuable product for dietary and preventive nutrition.

The relevance of the study of the fatty acid composition of African catfish (*C. gariepinus*) grown in Uzbekistan is due to several important factors.

Under the limited water resources and climatic conditions of Uzbekistan, the African catfish is a promising aquaculture target. It can be reared under conditions that are unsuitable for most other fish species, making it important for the development of local fish farming. With increasing attention to food security and import substitution, farming of African catfish in Uzbekistan could be an important step towards providing the population with quality and healthy locally produced food. African catfish utilize feed efficiently and can be farmed with minimal water supply and feeding costs. This reduces pressure on natural resources and makes it an environmentally sustainable aquaculture target.

The use of modern methods of analysis, such as gas chromatography, makes it possible to determine the quality and safety of food products. Thus, the study of the fatty acid composition of African catfish is relevant both from the point of view of scientific interest and from the practical point of view, as it contributes to the development of aquaculture, improvement of nutritional quality, and food security.

African catfish is characterized by a high content of polyunsaturated fatty acids, especially ω-3 and ω-6. These acids are important for human health as they have a positive effect on the cardiovascular system, reduce the risk of inflammatory diseases and play a key role in metabolic processes. The study of the fatty acid profile allows a more accurate assessment of the nutritional value of fish and its potential use in dietary and preventive nutrition .

This study aims to investigate the fatty acid composition of African catfish (*C. gariepinus*) farmed in Uzbekistan using gas chromatography to assess its nutritional value and potential use in dietary and preventive nutrition. The object of the study was samples of African catfish (*C. gariepinus*) raised in the aquaculture conditions of Uzbekistan. Fish samples were obtained from experimental farms where catfish were reared under optimal conditions for their species - water temperature was maintained within 25-30°C, which corresponds to their natural preferences.

2 Methods

The fatty acid composition of lipids was investigated by gas chromatography. Samples of fish tissue were subjected to fat extraction, then their transesterification was performed to obtain fatty acid methyl esters. Gas chromatography was performed according to standard methods (GOST R 51483-99), which allowed us to determine the mass fraction of individual fatty acids [3].

The research materials were fish tissue samples: muscle tissue and fat fraction of African catfish. Reagents for lipid extraction: Chloroform and methanol were used for fat extraction according to Folch's method. A gas chromatograph was used to analyze fatty acid methyl esters obtained from fish tissue lipids [4].

The fat content of the samples was determined by extraction using a 2:1 mixture of chloroform and methanol according to the standard Folch's method. Samples were dried to constant weight to obtain accurate data on the fat content of tissues. To prepare the lipids

for analysis, transesterification was carried out to give fatty acid methyl esters. This process is necessary for subsequent analysis by gas chromatography. Gas chromatographic analysis was performed on an instrument with a capillary column filled with liquid phase (e.g., SE-30). The technique was based on GOST R 51483-99, which regulates the determination of fatty acid methyl esters in food fats. The temperature regime was maintained in the range from 80°C to 220°C, which ensured the separation of components. Fatty acids were identified according to standards by comparing the results of chromatographic analysis with reference data. The mass fraction of saturated, monounsaturated, and polyunsaturated fatty acids was determined. The results were analyzed using statistical data processing methods to obtain average values and determine their reliability [5].

Instrument gas chromatograph capillary column chromatograph for gas chromatographic analysis of fatty acids of African catfish (Clariasgariepinus), capillary column SE-30, filled with liquid phase, column type 25 m long and 0.25 mm diameter, carrier gas - helium or nitrogen, mobile phase conditions used pressure of 10 psi (about 69 kPa). Temperature regime: the column temperature was programmed between 80°C and 220°C with an increase rate of 1-2°C per minute. The maximum temperature reached 280°C, detector temperature: 250-300°C. A gas chromatographic detector such as a flame ionization detector (FID) or mass spectrometric detector (MSD) was used to detect fatty acids. Samples of fatty acid methyl esters derived from lipid transesterification were used for analysis. The injection mode was a 1:50 split, sample volume: of 1-2 µl. Depending on the sample composition and the duration of the temperature gradient program, the average time of a complete cycle of analysis was approximately 30-60 minutes. All measurements were carried out by GOST R 51483-99 "Vegetable oils and animal fats. Determination by gas chromatography of the mass fraction of methyl esters of individual fatty acids to their sum". This method allows obtaining accurate quantitative data on the composition of fatty acids in fish lipid samples [5].

3 Result and Discussion

The study determined the total fat content of fish tissue samples, including myristic acid (14:0), palmitic acid (C16:0), palmitoleic acid (16:1 9-cis) stearic acid (C18:0), oleic acid (C18:1 9-cis), linoleic acid (C18:2), eicosapentaenoic acid (C20:5) and docosapentaenoic acid (C22:5). The composition of individual fatty acids, including monounsaturated and polyunsaturated fatty acids, as well as the ratio of ω-6/ω-3 fatty acids, which is an important indicator of the nutritional value of the product, was determined.

Gas chromatographic analysis of the fatty acid composition of African catfish (*C. gariepinus*) grown in Uzbekistan showed the following results (Table 1).

Table 1. Indicators of the fatty acid composition of African catfish (*Clarias gariepinus*) farmed in Uzbekistan.

Fatty acid	Index	Content,%	[6]	[7]	[8]
Miristina	14:0	2,68±0.05	4,2	3,69	1,01
Palmitic	16:0	21,72±0.17	22,0	24,06	24,14
Hexadecenoic	16:1	0,69±0.04	-	-	-
Palmitoleic acid	16:1 9-cis	4,71±0.06	3,6	4,84	4,74
margarine	17:0	0,44±0.01	-	-	0,25
stearic	18:0	5,12±0.03	8,1	10,00	6,71
Elaidin	18:1 9-trans	0,15±0.01	-	-	-
oleic	18:1 9-cis	28,08±0.22	26,0	32,72	41,1

Vaccene	18:1 11-trans	2,39±0.03	-	-	-
iso-octadecadiene	18:2	0,12±0.00	-	-	-
Linoleic	18:2	19,88±0.12	12,3	7,16	16,48
-Linolenic acid	18:3 ω -6	1,92±0.08	0,6	1,01	0,66
-Linolenic acid	18:3 ω -3	0,63±0.02	0,9	0,13	-
parinarial	18:4	0,68±0.01	1,6	-	-
Arachnoid	20:0	0,16±0.01	0,2	0,03	-
Gondoin	20:1	2,41±0.14	2,5	4,01	-
Eicosadiene	20:2	0,22±0.02	ND	-	-
Eicosatrienoic	20:3	0,51±0.01	0,6	0,32	-
arachidonic acid	20:4	0,23±0.01	0,3	3,18	2,07
Eicosapentaenoic acid	20:5	3,11±034	0,7	0,73	0,27
Erucova	22:1	0,23±0.02	1,3	1,15	-
docosatetraenoic	22:4	0,14±0.01	1,3	-	-
docosapentaenoic	22:5	0,61±0.02	3,7	-	0,36

All values are given in percent. ($p \leq 0.05$)

Studies also show that the ratio of ω-6/ω-3 PUFAs is 3:1, indicating the high nutritional value of this fish species. The content of monounsaturated fatty acids is about 38.95%, which confirms the high biological activity of catfish lipids. These data show that catfish is characterized by a high content of monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA), which gives it important dietary properties.

The ratio of ω-6/ω-3 fatty acids is 3:1, which is considered optimal for preventive nutrition and health maintenance. This indicates the high nutritional value of African catfish, as this ratio of ω-6/ω-3 fatty acids reduces the risk of cardiovascular diseases and inflammatory processes in the body.

Content of key polyunsaturated fatty acids. Particular attention should be paid to the high content of eicosapentaenoic (EPA, C20:5) and docosapentaenoic (DHA, C22:5) acids - 3.11% and 0.61% respectively. These long-chain ω-3 fatty acids play a key role in maintaining heart and vascular health, as well as normal nervous system function. Their content in African catfish makes this fish a valuable source of ω-3 PUFAs for dietary purposes.

According to the results of the study, the fatty acid composition of African catfish has a balanced composition similar to that of marine fish in terms of long-chain polyunsaturated fatty acids (ω-3 PUFAs) compared to other fish. For example, the eicosapentaenoic and docosahexaenoic acid content of African catfish compares favorably with fish such as lake grouper (Coregonusartedi) and redfish (Archosargusprotocephalus) [9, 10].

Nutritional benefits and prospects for use. The high content of oleic and linoleic acids (28.08% and 19.88%) makes African catfish a source of beneficial mono- and polyunsaturated fatty acids, which play an important role in the metabolism and maintenance of normal blood cholesterol levels. This makes the fish a promising product for use in dietary nutrition and the creation of dietary supplement products that contribute to the prevention of chronic diseases.

These data show that monounsaturated and polyunsaturated fatty acids constitute the major proportion of fatty acids, indicating the high biological activity of soma lipids and their importance for health.

The content of ω-3 polyunsaturated fatty acids in African catfish (*C. gariepinus*) grown in Uzbekistan shows that African catfish plays an important role in preventing cardiovascular diseases and maintaining general health, and the high amount of ω-6 fatty acids together with ω-3 acids make its lipid profile balanced and healthy [11].

The high content of oleic acid, an ω-9 fatty acid, makes African catfish a valuable source of monounsaturated fats, which are good for heart health and lowering cholesterol.

In the table, the sequence of fatty acids is arranged according to their chromatographic retention time. According to Adesola Osibona, the fatty acid content of C. gariepinusranges from 0.1% to 26%. These include myristic acid (C14:0; 4.2-5.2%), palmitic acid (C16:0; 22.0-32.2%), palmitoleic acid (C16:1; 3.6-13.2%), heptadecanoic acid (C17:0; 0.7.) -3.0%), stearic acid (C18:0; 8.1-9.5%), oleic acid (C18:1 16.2-26.0%) and linoleic acid (C18:2; 1.4) -12.3%) were in the highest proportion [6].

Fats are grouped into saturated fatty acids (SFAs), monounsaturated fatty acids (MUFAs), and polyunsaturated fatty acids (PUFAs). According to O.E. Taiwo, the total PUFA content was higher in the muscles of farmed catfish (38.86%) than in the muscles of naturally occurring fish (36.96%). The total PUFA content was 42.83% and 41.57% in the muscles of farmed and naturally occurring fish, respectively. The major PUFAs and PUFAs detected in the samples were C16:0 (palmitic acid) and C18:1 (oleic acid). In farmed fish (18.31%), 12.01% of PUFAs were n-3 and 6.30% n-6, while in naturally occurring fish, 11.85% were n-3 and 9.62% n-6 PUFAs, making a total PUFA content of 21.47% (in naturally occurring catfish) [7].

According to H. Abdi, the fatty acid content of *C. gariepinus* varies from 0.27% to 41.1%. gariepinus varies from 0.27% to 41.1%. Linoleic acid (18:2n-6; 11.12-16.48%), arachidonic acid (20:4n-6; 1.36-4.10%) and gamma-linolenic acid (18:3n-6; 0.44-1.00%). The ω-3 PUFAs measured in the study included EPA (20:5n-3; 0.25-0.97%), DPA (22:5n-3; 0.36-0.54%), and DHA (22:6n-3; 1.17-4.17% content). The major n-3PUFA was 22:6n-3, which was 1.18% in C. gariepinus .

According to our data, the fatty acid content of *C. gariepinus* ranged from 0.12% to 29%. Oleic acid (18:1 9-cis) - 28.08%, palmitic acid (16:0) – 21.72%, linoleic acid (18:2) - 19.88%, stearic acid (18:0) - 5.12% and acids such palmitoleic acid (16:1 9-cis) - 4.71% were found in high amounts (Fig. 1.). ω-Linolenic acid (18:3 ω-6) - 1.92% which is higher than the literature data mentioned above shows the high potential of using African catfish in dietary and functional foods. The presence of a large amount of oleic acid (28.08%) in *C. gariepinus* grown in Uzbekistan indicates the positive effect of fish on cholesterol levels and the cardiovascular system. The high nutritional value of African catfish, its unpretentiousness to growing conditions, and its fast growth rate make it a promising target for further development of aquaculture in Uzbekistan and other regions.

A diet consisting only of roughage increases the pH level in the rumen and simultaneously increases the secretion of saliva. This, in turn, provides additional buffer protection for the rumen. This acidity level is created by the precipitation of bicarbonates and sodium phosphate. As a result of the evacuation of acids from the rumen, they are transferred with the chyme to the intestine and are carried into the blood, which is ensured by the buffering properties of the rumen fluid. In addition, when the rumen fluid environment is close to neutral (pH 6.4-6.8), very favorable conditions are created for the development of microflora.

In the lambs of the experimental group, the amount of VFA formed in the rumen and the percentage of acetic acid were 12.73% and 1.18 mmol/ml higher compared to the control group. In the control group, it was observed that the VFA fractions were at a normal level, but in the lambs of the experimental group, in our opinion, the increase in the proportion of propionic acid occurred due to a decrease in the proportion of fatty acids, which allowed us to conclude that the decrease in the proportion of fatty acids is associated

with the deposition of fats located in tissues and providing an increase in the live weight of animals.

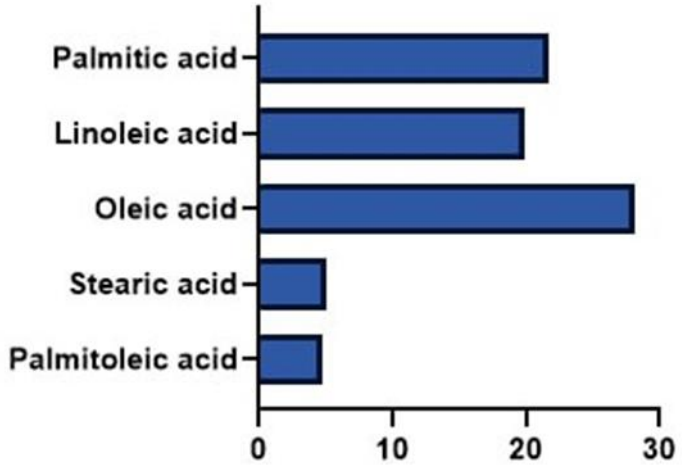

Fig. 1. Content of major fatty acids in African catfish (Clariasgariepinus) in the conditions of Uzbekistan.

4 Conclusion

The high nutritional value of African catfish, simplicity of growing conditions, and high growth rate make it a promising target for further development of aquaculture in Uzbekistan and other regions. Gas chromatographic analysis showed that African catfish grown under the conditions of Uzbekistan is rich in essential fatty acids, especially ω-3 and ω-6 acids, which indicates their high nutritional value. This makes fish a valuable source of healthy fats, which are essential for maintaining good health and preventing cardiovascular disease. The ratio of fatty acids is. ω -6/ ω-3 is 3:1, which is optimal for preventive nutrition. This indicates the high biological value of African catfish lipids for dietary use. The fact that it is a rich source of ω-9 acids, especially oleic acid (28.08%), has a positive effect on cholesterol levels and cardiovascular health. The fatty acid composition of African catfish makes it promising for the production of functional foods designed to maintain health and prevent chronic diseases.

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