Forecast of the nutritional value of catfish (*Clarias gariepinus*) in the spawning period

L Shadyeva¹, E Romanova¹, V Romanov², E Spirina¹, V Lyubomirova¹, T Shlenkina¹, Y Fatkudinova¹

¹Ulyanovsk State Agrarian University named after P.A. Stolypin, 432017, 1 Novy Venets Blvd., Ulyanovsk, Russian Federation

E-mail: vvr-emr@yandex.ru

Abstract. In different periods of the life cycle, the chemical composition of fish muscle tissue is subject to significant fluctuations. These changes are most pronounced during the spawning period, when there is a switch to generative exchange. The studies of the nutritional value of the meat of African catfish (*Clarias gariepinus*) in the spawning period showed that the protein content of this species of fish falls into the category of protein products containing a full range of essential amino acids; by the fat content in muscle tissue, it can be attributed to the varieties of fatty fish. According to the research, the muscle mass of this fish species contains high levels of mono- and polyunsaturated fatty acids and is characterized by high levels of linoleic acid, which is an essential fatty acid. The content of linoleic acid in the muscles of African catfish is much higher than in the muscles of pink salmon. The content of linoleic acid in the caviar of African catfish is seven times higher than in the caviar of pink salmon. African catfish caviar also contains a large amount of oleic acid, which plays an important role in the prevention of cardiovascular diseases. The results showed that during the spawning period, the nutritional value of the muscle tissue of the African catfish remains high. The results of the study are important for the development of African catfish caviar production and give a positive answer to the question whether it is possible to obtain edible caviar from catfish without compromising the production of commercial fish of high nutritional value.

1. Introduction

In terms of nutritional value, fish meat is among the most valuable food products. Thus, 1 kg of walleye meat in France is accepted as a standard of value of protein products of animal origin [1].

Muscle tissue of fish is characterized by high-grade proteins, easily digestible biologically active fats, minerals, fat-and water-soluble vitamins A, D, group B and other substances. Water accounts for 52% to 85% of fish weight [1, 2]. Knowledge of the chemical composition of fish is necessary for the rational use of fish resources for food, medical and other purposes.

In the comparative aspect, the chemical composition of fish meat is characterized by significant differences from the meat of farm animals. The nutritional value of fish meat is determined by species characteristics, lifestyle (pelagic, bottom, passage, semi-passage), environment (marine, freshwater), metabolism, sex, age, physiological state of fish and other factors [6, 7].

The chemical composition of fish meat is due to the peculiarities of their annual cycle, which, depending on the species and breeding conditions, is divided into certain periods (pre-spawning preparation, spawning, post-spawning recovery).
Thus, it should be noted that at different periods of the life cycle, the chemical composition of fish muscle tissue is subject to significant fluctuations. Sometimes these changes can be quite significant. In this regard, according to some authors, there is a change in the nutritional value of fish [1, 2]. Therefore, it is important to know the periods of the highest nutritional value when growing commercial fish in high-tech industrial aquaculture - installations of recirculating aquaculture systems (RAS). It is during these periods that it is necessary to complete the growing cycle and move on to the sale of live fish to the consumer.

The most constant value is the total content of moisture and fat in the meat of fish of different species.

The protein of fish meat includes all the essential amino acids, this determines the special value of fish as one of the most high-quality sources of protein nutrition.

One of the most important components of nutrition and energy value of fish is fat. According to the literature, this indicator varies quite widely in comparison with other components. For example, if the content of raw protein in fish fillets of different species varies between 6...28%, the content of raw fat has a wider range of fluctuations between the limit values: from 0.1 to 67%.

Such variability can be caused by various factors: species differences of fish, provision of forage resources, peculiarities of metabolism, sex, age, physiological state and other reasons.

At the same time, often the fish of the same name, caught in different waters, have different fat content, due to both the characteristics of forage and abiotic environmental factors, such as water temperature. It is scientifically proven that the lower its temperature, the greater the fat content in the muscle tissue of fish.

With increasing size and age of fish, the amount of fat in it also increases.

The pre-spawning period is mostly characterized by a sharp decrease in fat in the muscle tissue of fish. This is due to the fact that most of it accumulates in sexual products, mainly in the caviar. Moreover, in males, the fat content is subject to less fluctuations than in females, since in the gonads of males it is much less.

Depending on the fat content in the muscles of fish, they are conventionally divided into four groups:

- lean (skinny) – up to 2% fat (cod, perch, pike, humpback, blue catfish and many other oceanic fish);
- medium-fat fish - from 2 to 6% fat (striped catfish, spotted catfish, many carp, some salmon, most flounder, catfish, etc.);
- fatty – 6 to 20% fat (most sturgeon, European and far Eastern salmon, and others);
- very fatty-more than 20% fat (eel, lamprey, shea, Azov fish, hamsa, large herring, etc.) [3, 4].

Along with this, the following pattern can be traced: the fatter the fish, the less water in its tissues.

The aim of the study was to identify the content of water, raw protein, fat and ash in the meat and caviar of female African catfish during the spawning period.

2. Materials and method

The object of the study was the female of African catfish (Clarias gariepinus). For analysis, we selected 10 samples of caviar and meat of mature females of African catfish during spawning.

Analysis of the chemical composition of meat and caviar of fish was carried out by standardized methods. Moisture content was determined by the method of evaporation. The amount of protein was determined by the Kjeldahl method, the determination of ash was carried out by burning in a porcelain crucible. The fat content was determined in the Soxhlet apparatus. The fractional composition of lipids was determined by chromatography in a thin layer of silica gel. The mass fraction of amino acids was determined by capillary electrophoresis on the system “Kapel 105 M” in accordance with the adapted technique.

The research was carried out on the basis of the certified educational-scientific-testing laboratory for determining the quality of food and agricultural products of the Saratov State Agrarian University named after N. I. Vavilov.
3. Results
According to the protein content in muscle tissue fish are classified as follows:
1) low-protein fish - up to 10 % of protein;
2) medieval - 10-15% of protein;
3) protein - 15-20% of protein;
4) high protein - more than 20 % of protein

As a result of the conducted researches, it is established that meat of females of the African catfish contains 17.03% of protein, caviar - 16.58%. This allows us to refer it to the category of protein products (table 1). We found that the fat content in meat - 6.1% the African catfish refers to fatty fish varieties.

We conducted studies of fat content during the spawning period. During the spawning period, the fish loses up to 30 % of all nutrients. Metabolism during this period switches to reproduction. Nutritional value after spawning is restored in different species of fish at different times. On average, it takes from 20 to 60 days. The fat content of African catfish caviar during spawning is $16.58 \pm 0.31\%$ (table 1).

| Table 1. Chemical composition of meat and caviar of female of African catfish during spawning. |
|---------------------------------------------------------------|
| **Indicators** | **Amount** | **in the muscles** | **in caviar** |
| Water, % | 75.60 ± 2.17 | 76.00 ± 0.53 |
| Protein, % | 17.03 ± 0.37 | 16.58 ± 0.31 |
| Fats, % | 6.10 ± 0.15 | 1.10 ± 0.06 |

At the next stage, we analyzed the fatty acid composition of the muscles and caviar of female of African catfish. The results of the analysis showed that all samples registered a high content of linoleic acid, which belongs to the essential fatty acids.

Muscle of African catfish contain 23.3% and caviar of 15.2% linoleic acid. It should be noted that the content of linoleic acid in the caviar of African catfish exceeds the same index of caviar and muscle tissue of pink salmon. Pink salmon caviar contains 2.3% linoleic acid. This is seven times less than in the caviar of African catfish (table 2).

| Table 2. The content of fatty acids in meat and caviar of African catfish. |
|---------------------------------------------------------------|
| **Fatty acid** | **African Clarine Catfish Muscle** | **African Clary Catfish Caviar** |
| Saturated | | |
| Myristine, % | 3.5 | 4.0 |
| Pentadecane, % | 0.3 | 0.6 |
| Palmitic, % | 19.7 | 29.6 |
| Heptadecene, % | 0.2 | 0.1 |
| Stearin, % | 4.6 | 8.0 |
| Monounsaturated | | |
| Myristolein, % | 0.1 | 0.2 |
| Palmitoleic, % | 4.6 | 0.9 |
| Oleic, % | 0.5 | 29.8 |
| Polynsaturated | | |
| Linoleic, % | 23.3 | 15.2 |
| Linolenic, % | 1.0 | <0.1 |
| Arachidonic, % | <0.1 | <0.1 |

The caviar of African catfish contains a significant amount of oleic acid-29.8%. For comparison, pink salmon caviar (red caviar) contains this acid in an amount of 21.7%, and pollock caviar-15.03%.

We analyzed the balance of fatty acid composition of caviar and meat of African catfish.
According to the recommendations of the Institute of nutrition of the Russian Academy of Medical Sciences, the optimal ratio of omega-6 and omega-3 is (9…10:1).

We obtained the following results. The ratio of omega-6 and omega-3 in the caviar of African catfish was 50:1, in muscles-7:1 (figure 1).

![Figure 1](image)

**Figure 1.** The content of omega-3 and omega-6 fatty acids in the muscles and caviar of African catfish.

Thus, African catfish caviar has a balanced fatty acid composition. Using it as a functional food product will fully satisfy the body’s need for polyunsaturated fatty acids, prevent diseases of the cardiovascular system, thereby improving the quality of life of the population.

Figures 2 and 3 show the amino acid composition of caviar and meat of African catfish.

![Figure 2](image)

**Figure 2.** The amino acid composition of caviar and meat of African catfish during spawning period.
During the analysis of the amino acid spectrum of caviar and meat of African catfish, we obtained the following results. Both caviar and muscle tissue of African catfish contain all essential amino acids. Leucine+isoleucine (3.22 and 2.25%) and glutamine (2.55 and 2.88%) co-responsibly occupied the dominant position in quantitative terms in the studied samples of African catfish caviar and muscle tissue (figures 2, 3).

Of the essential amino acids of caviar and meat, the limiting species is tryptophan-0.25 and 0.2%, respectively. Tryptophan plays an important biological role in the human body. It takes part in the synthesis of serotonin, which is one of the most important neurotransmitters, which makes it extremely necessary to enter the body in depression, insomnia.

4. Discussion
The results of our study of the chemical composition of the muscles and caviar of African catfish indicate a high nutritional value of representatives of this species of fish. The muscles and caviar of the African catfish contain the full spectrum of amino acids, including sufficient amounts of essential amino acids.

Studies of fatty acid composition of muscles and caviar also confirmed the high nutritional value of African catfish. This makes it possible to attribute it to functional food products that reduce the risk of cardiovascular diseases.

Linoleic acid plays an extremely important role in ensuring human physiological processes. It is not produced in the body, therefore, its source for humans are food. The extreme importance of this acid is determined primarily by the fact that it participates in the formation of phospholipids of cell membranes [1].

Regular intake of linoleic acid in the body reduces the risk of cardiovascular disease. According to research conducted by the Institute of nutrition of the Russian Academy of medical Sciences, more than 80% of the population of the Russian Federation are deficient in this acid. Deficiency increases the likelihood of coronary thrombosis. Studies conducted in Japan have shown that increased consumption of linoleic acid, a class of omega-3 polyunsaturated fatty acids, is associated with a decrease in the level of inflammatory markers, such as C-reactive protein [3, 4, 5].

It is scientifically proven that linoleic acid has a long-term positive effect on the prevention of type II diabetes [9, 10, 11].
Oleic acid can be synthesized by the body in liver cells, and can enter the body with food. It is one of the most digestible by the human body.

Oleic acid has two vital functions:
- energy (releases energy during decay);
- plastic (takes part in the construction of biological membranes, which make up the skeleton of plant and animal cells).

Oleic acid has another name – “omega-9”. The biological significance of this acid for the human body is that its consumption prevents the development of atherosclerotic plaques on the walls of blood vessels. At the same time, the risk of atherosclerosis, myocardial infarction or stroke is minimized. Oleic acid has an effect on the regulation of the nervous, endocrine and digestive systems, supports the immune system and improves glucose uptake, which reduces the risk of hyperglycemia. According to the results of studies by American scientists, omega-9 is one of the most powerful tools in the fight against breast cancer [3, 4, 5]. Lack of oleic acid can cause the development of arthrosis and arthritis.

Amino acids are the most important components involved in the synthesis of biologically active compounds (proteins, enzymes, hormones). In addition, they carry out the integration of major metabolic fluxes in the organism. According to the number and variety of functions in energy metabolism and synthesis of secondary products, amino acid metabolism occupies the first place in the metabolism of a living organism [8].

The importance of amino acids for the body is primarily determined by the fact that they are used for the synthesis of proteins.

In addition to protein synthesis, amino acids are involved in the formation of many other important biological compounds: purine and pyrimidine nucleotides, serotonin, melanin, histamine, adrenalin, etc.

Amino acids increase the body’s resistance to the action of extreme factors of the external environment, possess immune - and phagocytosis effect [14-15].

According to the literature, insufficient valine content contributes to changes in osmoregulation in fish [14, 15]. With a lack of methionine, lipid metabolism may be impaired, with a reduced content of threonine, the synthesis of many biologically active substances is disrupted [8].

5. Conclusion

Our studies have shown that the meat of African catfish can be classified as protein products. The muscle tissues of this species of fish contain all the essential amino acids. African catfish caviar also contains all the essential amino acids in its composition. According to the fat content, as our studies have shown, African catfish can be attributed to fatty fish varieties.

Based on our research, we concluded that during the spawning period, when generative exchange prevails, the nutritional value of African catfish remains high. The results of our research are important for the development of caviar production of African catfish and provide an answer to the question whether it is possible to obtain caviar without compromising the production of commercial fish of high nutritional value.

Our results indicate that the use of female of African catfish as producers of raw caviar does not affect the quality of fish produced. It is quite clear that spawning modifies metabolism, giving it specific features. However, the food value of commercial fish during this period remains high. It can be concluded that in the spawning period, the African catfish is a functional food product in terms of the content of essential fatty acids and essential amino acids.

Protein content in the muscle and caviar of African catfish can be attributed to the protein products out there, the fat content of the catfish can be classified as fatty fish.

African catfish muscles are rich in polyunsaturated linoleic fatty acid, and caviar is rich an oleic (omega-9) acid.

African catfish caviar has a balanced fatty acid composition, which allows it to be used for preventive purposes, for therapeutic nutrition as a functional product enriched with omega-9, omega-6 and omega-3 fatty acids.
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