

Efficiency of Using Natural Zeolites in Cultivation of African Catfish

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Abstract. The article represents the results of studies in zeolite use in fish feeding. The influence of zeolites on the exterior and interior characteristics of African catfish grown in high-technological industrial aquaculture was evaluated. Zeolites were introduced into fish feed in the amount of 3 % and 5 %. The use of zeolites in feeding of African catfish has had a positive impact on the growth, exterior and interior indicators of fish. In five-month-old catfish, when using zeolites, the average daily growth increased by 4.15 g (with 3 % addition of zeolites) and by 4.68 g (with 5 % addition of zeolites), compared to fish that did not receive zeolites. In the experimental groups, there was also an increase in absolute growth by 124.4 g-with 3 % addition of zeolites and 140.2 g-with 5 % addition of zeolites. The commercial weight of fish using zeolites increased by 24.05 % and 35.52 %, respectively. The results show that when growing commercial fish, the use of zeolites in the feed composition fastens its growth and significantly reduces feed costs.

1 Introduction

Fish is one of the main food products of population of our planet. Nowadays, natural fish resources, with increasing amounts of fishing, do not have time to be replenished. In this regard, there is a need to increase the extent of managed reproduction of fish resources. To solve this problem, it is necessary to develop aquaculture. Aquaculture is understood as breeding, maintenance and cultivation of fish in natural and artificial reservoirs, on marine plantations, in industrial aquaculture, including in recirculating aquaculture systems (RAS).

Feed composition plays an important role in cultivation of fish in industrial aquaculture [1–4]. In order to increase productivity and improve the quality of products obtained, it is necessary to organize a full-fledged feeding, which would not only ensure the rapid growth of fish, but also enrich it with proteins, fats and carbohydrates, vitamins, amino acids and minerals [5–7]. Zeolites can become suppliers of mineral substances that stimulate growth. Zeolites are widely used in agriculture in Russia and other countries [7–10]. They are used as sorbents [3, 5, 7, 10, 11], which have proven themselves well in animal husbandry, poultry farming, crop production and other agricultural sectors. In recent years, zeolites have also been tested in fish farming. Cases of their use in cultivation of European sea bass, rainbow trout and many other fish species were described [3, 11–13, 14]; the use of zeolites for cleaning the aquatic environment from various pollutants is no less important [11–17].

In fish farming, zeolites were also used as sorbents for water purification. Zeolites in reservoir adsorb potentially pathogenic and pathogenic microbiota, which prevents fish diseases, improves blood circulation, and increases fish resistance and growth rate [2]. In general, the use of zeolites improves the sanitary parameters of the fish habitat.

Table 1. Mineral and chemical composition of zeolite-containing rocks of Ulyanovsk field

Name of components		Content			
Минералы (%, wt)					
Clinoptilolites (zeolite)		18			
Opal-cristobalite		31			
Calcite		19			
Clay minerals of montmorillonite		18			
Hydromicas		6			
Cilica		8			
Oxides for air-dry quantity (%, wt)		Elements (mg/kg)			
SiO ₂	56.8	Be	1.6	Ag	0.15
TiO ₂	0.30	As	25	Zn	90
Al ₂ O ₃	3.12	F	310	Co	11
Fe ₂ O ₃ total	2.27	Sc	< 10	Ni	34
MnO	0.00-0.01	Pb	< 500	Zr	90
CaO	13.24	Mn	360	Cr	63
MgO	1.87	P	11	Sr	440
Na ₂ O	0.12	Sn	1.3	Ba	330
K ₂ O	1.44	Nb	10	Hg	0.06
P ₂ O ₅	0.16	Ca	6	V	18
CO ₂	10.27	V	79	Vb	1.6
H ₂ O	7.16	Li	32	B	44
The amount	99.83	Cu	14	Ge	< 2
SiO ₂ amorphous	27.13	Cd	< 1		

Te, Sb, Ta, Tl, W, Jn, Bi – not detected.

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In our research, we used zeolites from the Ulyanovsk region deposit when feeding fish.

The Ulyanovsk region has large reserves of mineral resources, including highly siliceous rocks (diatomites, flasks, berg-meal, zeolites). Zeolite tuffs of various deposits can be distinguished by their color, strength, and physical and chemical properties. The composition of zeolite of the Ulyanovsk Region deposit includes up to 40 mineral elements (table 1).

Unlike volcanic zeolite rocks, the microelement composition of sedimentary zeolite has low content of beryllium, lead, gallium, copper, zirconium, strontium, barium, yttrium, ytterbium, tin, arsenic and is characterized by an increased level of vanadium, nickel, lithium, manganese, boron and chromium. At the same time, the level of toxic elements is within the norm.

The aim of our research was to evaluate the effectiveness of use of natural zeolites from the Ulyanovsk deposit in feeding African catfish.

2 Materials and methods

To conduct the experiment, three groups of 15 individuals each, aged 4 months, were formed. The experiment lasted 60 days. The first group received the basic diet (BD), the second group received 3 % (BD+3 %) of zeolite in addition to the basic diet, and the third group received 5 % (BD+5 %) of zeolite.

The fish were kept in pools equipped with filters on quartz sand. The volume of the pools is 3.8 m³, the depth is 85 cm. The oxygen content is 70 %. The daily water change was at least 25 %. We used extruded feed from the company LimKorm for feeding.

Morphometric studies were carried out according to the generally accepted methodology. Measurements were carried out using a caliper with an accuracy of 1 mm. The fatness coefficient was calculated according to the formula proposed by Fulton. Fatness coefficient (Ac) – characterizes the fatness, "fleshiness" of fish. The fatness coefficient is defined as the ratio of mass to body length: according to the formula of T. Fulton,

$$K_y(\phi) = \frac{P \cdot 100}{L^3}$$

where P is the fish mass (g), L is the length (cm) in carp, salmon to the end of the scaly cover, in sturgeon and other species the entire length or to the end of the caudal fin lappet .

To characterize the intensity of growth, we used the indicators of absolute, relative and average daily growth.

The absolute average daily increase in live weight for a certain period is determined by the formula:

$$A = \frac{W_1 - W_0}{t}$$

where A is the average daily increase in live weight (g) or measurements (cm); W₀ is the initial mass (kg) of the animal or the initial value of measurement (cm); W₁ is the live weight of animal (or the value of measurement) at the end of the period; t is the time of the experiment in days.

Relative growth is the value of the growth rate of animal, expressed in percent, calculated by the formula:

$$K = \frac{W_1 - W_0}{W_0} \cdot 100 \%$$

where W₀ is the initial mass (kg) of the animal or the initial measurement value (cm); W₁ is the live mass of the animal or the measurement value at the end of the period.

3 Results

The dynamics of morphometric characteristics in catfish depending on the content of zeolites in used feed was studied. The analysis of obtained results showed that the content of zeolites in the feed influenced the growth rate of catfish. In particular, such exterior indicators as zoological and commercial length and body weight were informative. Higher rates were observed in the experimental group, in which the addition of zeolites reached 5 % of the feed weight.

The research results on the effectiveness of zeolites use in feed for such fish species as the African clary catfish are shown in Tables 2, 3.

During the research, it was found that the introduction of a zeolite-containing additive in the diet of clary catfish had a positive effect on the external indicators.

Zoological length is the length from the tip of the head ("top of the snout") to the end of the longest blade of the caudal fin. The zoological length throughout the experiment in the control group was lower compared to the second and third experimental groups (Figure 1).

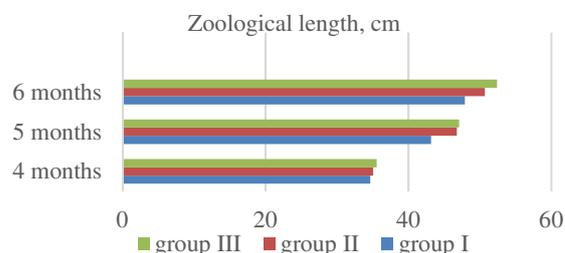


Fig. 1. Zoological length of catfish

During the first month of the experiment, the zoological length in the second experimental group was 8.33 % greater than in the first, and in the third, compared to the control, by 9.03 %. The next 30 days, this difference was 5.84 and 9.39 %, respectively. During 60 days of the experiment, the fish in the control group increased their length by 13.2 cm, the fish in the second experimental group grew by 15.6 cm, and in the third experimental group-by 16.8 cm. Thus, the introduction of zeolite into the diet contributed to the rapid growth of individuals.

Fishing length is the length from the tip of the head ("top of the snout") to the beginning of the caudal fin. Studying this indicator, it can be noted that during the experimental period, it was higher in the experimental groups than in the control group, both at the age of 5 months and at the age of 6 months (Figure 2).

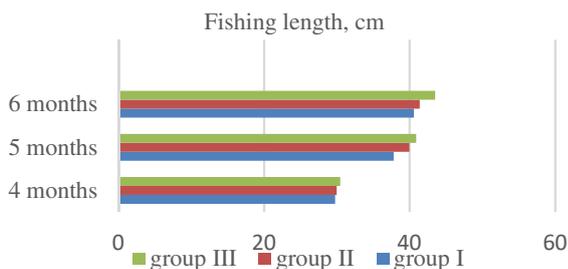


Fig. 2. Fishing length

These differences were 5.82 and 8.22 %, and 1.97 and 7.14 %, respectively. Thus, the additive in the amount of 5 % played a more pronounced positive role than the additive 3 %.

An important exterior indicator is the length of the carcass. On the basis of this indicator, you can judge the commercial qualities of fish. For 60 days of the experimental period, the length of clary catfish carcass in the first experimental group increased by 8.65 cm, in the

second experimental group by 9.56 cm, in the third by 11.07 cm (Figure 3).

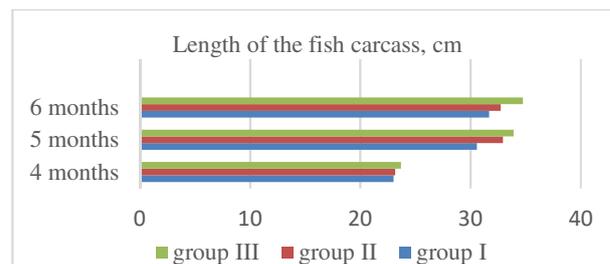


Fig 3. Length of the fish carcass

With age, African catfish change the proportions of the head and body. Increasing the length of the body and reducing the size of the head, make it easier for the fish to move. The most stable indicators were: the length of the head, the width of the head and the height of the caudal stem. Thus, when comparing these indicators, no significant differences were observed.

Table 2. Exterior parameters of clary catfish

Indicators	Age								
	4 months			5 months			6 months		
	I group	II group	III group	I group	II group	III group	I group	II group	III group
Zoological length, cm	34.7±3.7	35.1±2.6	35.6±3.4	43.2±3.9	46.8±1.8	47.1±0.6	47.9±0.5	50.7±1.3	52.4±1.0
Fishing length, cm	29.8±1.6	30.0±3.56	30.5±2.5	37.8±0.7	40.0±1.1	40.9±0.9	40.6±0.5	41.4±0.7	43.5±0.6
Length of the fish carcass, cm	23.03±1.4	23.17±1.9	23.69±2.3	30.57±1.6	32.95±3.3	33.9±3.2	31.68±0.6	32.73±1.3	34.76±1.9
Head length, cm	6.77±3.2	6.83±1.4	6.81±0.8	7.23±0.7	7.05±4.5	7.0±0.5	8.92±0.7	8.67±1.1	8.74±0.4
Head width, cm	5.56±0.8	5.72±1.3	5.64±0.8	6.64±0.4	6.48±0.5	6.48±0.5	7.09±0.5	6.99±0.5	7.01±0.6
Body height, cm	4.91±0.6	4.95±0.8	4.91±0.7	5.3±0.5	5.5±0.5	5.45±0.7	6.2±0.6	7.1±0.6	7.4±0.6
Length of the caudal stem, cm	4.9±0.3	5.1±0.6	5.1±0.7	5.4±0.7	6.8±0.7	6.2±0.6	7.3±0.6	9.3±0.3	8.9±0.5
Height of the caudal stem, cm	2.87±0.4	2.91±0.5	2.97±0.6	3.61±0.4	3.78±0.6	3.69±0.8	4.41±0.4	4.25±0.7	4.43±0.4
Weight, g	510.3±18.8	520.9±22.6	515.1±24.3	635±6.1	770±50.3	780±39.7	710±13.58	850±26.36	900±7.15

Based on the study of exterior indicators, we can conclude that the addition to the main diet of zeolites in the amount of 5 % is the most optimal. As a result of the introduction of zeolite in an amount of 5 % to the main diet, such indicators as zoological length, commercial length and carcass length increase in comparison with the control group. There were no significant differences between the experimental groups.

During the studies, it was found that the introduction of a feed supplement into the diet had a positive effect on body weight (Figure 4, Table 2).

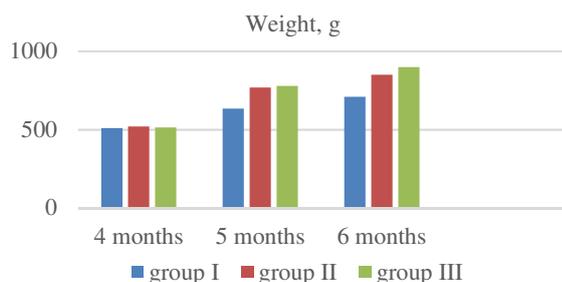


Fig. 4. Fish weight

The highest indicators of the average body weight of clary catfish were typical for the 2 and 3 experimental groups, where zeolite was introduced in addition to the main diet. In the beginning of the experiment, the average weight of fish in the experimental and experimental groups did not have significant differences.

At the age of 5 months, the weight of fish in the second experimental group, which had 3 % of zeolites added to the feed, was 21.26 % higher than in the control group. In the third group, where the zeolite additive comprised 5 %, the differences between the control and experimental groups were 22.83 %.

At the age of 6 months, these differences were even more vivid and amounted to 19.72 and 26.76 %, respectively. Thus, the final weight of fish in the group receiving 3 % zeolite additive was 850±26.36 g, in the third group receiving 5 % zeolite additive was 900±7.15g.

The research results showed that the addition of zeolites in fish feed had a positive effect on the exterior performance of African catfish.

The fatness coefficient (FC) is a variable value. It depends on the age of the fish, its size, type and breed, as well as on the stage of maturity of the sexual products. In our experiments, the fatness coefficient ranged from

1.06–1.20. The Clary catfish of the second experimental group had a higher fatness coefficient. In this group, high fatness can be explained by more efficient use of feed.

The largest absolute increase in clary catfish was observed in the period from 4 to 5 months (Table 3). Thus, the absolute increase in the control group was 124.7 g, in the second 249.1 g and in the third 264.9 g. Thus, with 3 % addition of zeolites to feed, the absolute increase was 1.2 times, and with 5 % addition of zeolites to feed, the absolute increase was 2.12 times greater than in the control group.

At the age of 6 months, the differences between the control and experimental groups were even more marked (Table 3).

Table 3. Growth rate of clary catfish

Indicators	Age					
	5 months			6 months		
	Groups					
	Control	+3 % zeolite	+5 % zeolite	Control	+3 % zeolite	+5 % zeolite
Fatness ratio (by Fulton)	1.17	1.20	1.14	1.06	1.19	1.09
Average daily growth, g	4.15	8.3	8.83	2.5	2.66	4.0
Absolute increase, g	124.7	249.1	264.9	75	80	120
Relative growth rate, %	21.77	38.59	40.91	9.87	11.15	14.28

The average daily increase, as well as the absolute increase, was higher in the period from 4 to 5 months, rather than from 5 to 6 months. There were no significant differences between the experimental groups.

The relative growth rates in the fish of experimental groups were also higher at the age of 5 months.

4 Discussion

Changes in the exterior parameters of clary catfish grown using zeolite-containing rock in diets in the amount of 5 % contributed to an increase in such indicators as zoological length, commercial length and carcass length.

As a result of the experiment, it was established that the addition of the studied feed additive to fish diet had a positive effect on the increase in the mass of individuals. So the final weight in the second experimental group was 850 ± 26.36 g, in the third group it was 900 ± 7.15 g.

Our results are consistent with the data of other researchers [12, 15] on the positive effect of zeolite additives on the growth, development and physiological state of many fish species [11–15].

The use of zeolite-containing feed in fish farming, not only helps to increase the growth rate of fish, but also contributes to the cleaning of their habitat [14, 16, 19].

Zeolite in the composition of feed can be evaluated as a factor that stimulates growth, development and intensity of metabolism. Clary catfish use feed more effectively, grow faster, acquire increased resistance to diseases, become more viable, and are less exposed to digestive disorders.

The results of our research have shown the feasibility of using zeolites in the amount of 5 %.

Our results showed that the use of zeolites in the feeding diets of African clary catfish intensified the process of growing commercial fish.

5 Conclusion

In the conditions of modern civilization, when the demand for fish products is constantly growing all over the world and the requirements for its quality are becoming stricter, the development of year-round high-tech industrial aquaculture plays an important role. The use of intensive fish farming technologies allows controlling the parameters of the environment, but excludes the availability of natural food. Therefore, it is so important to properly compose a fish feeding diet.

Artificial diets, balanced by the main elements of nutrition, for all their effectiveness, do not fully meet the physiological needs of young and mature individuals of different ages.

This is due to the fact that natural food contains a wider set of biologically active components that are regulators of many metabolic processes in the body of fish.

Of particular importance is the introduction of feed probiotics, adaptogens [19, 20] and minerals necessary for fish metabolism into artificial compound feeds. In our research, we used zeolites as mineral substances. The results of our research have shown that the use of zeolites in the artificial cultivation of fish in high-tech aquaculture has a significant growth-stimulating effect.

Acknowledgments

The Russian Foundation for Basic Research has supported our study with the grant No. 18-416-730005.

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