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KAZAKHSTAN STARTER COMPOUND FEED FOR AFRICAN CATFISH (*Clarias gariepinus*): FORMULATION, QUALITY CHARACTERIZATION, AND EFFICIENCY IN AQUACULTURE

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Abstract

Currently, the breeding of *Clarias gariepinus* is a promising area of aquaculture in Kazakhstan. African catfish is a fast-growing, rapid-maturating, hardy and disease-resistant species. In the Almaty region, breeding of African catfish is most relevant due to a large number of geothermal sources which can significantly reduce the cost of fish growing. However, fish farmers use imported starter feeds. Here, we submit research data on approbation of the Kazakhstan starter feed for larvae of *C. gariepinus*. A technology has been developed for the production of mixed feed based on grain raw materials using the extrusion method (LLP Kazakh Research Institute of Processing and Food Industry, Almaty). The experimental feed is a 50.7 % protein, 11.53 % fat, and 17.31 MJ/kg of metabolic energy. Experimental rearing (LLP Kapshagai spawning and rearing farm-1973 and a peasant farm MG, Almaty region, 2020). Trout feed Aller Futura EX 0.5-0.2 mm (Aller Aqua, Denmark), the most common feed for growing *C. gariepinus* in Kazakhstan was a control. The experiment was arranged in duplicate, two pools for the control and two pools for the experiment. The fish was fed by hand 12 times during daylight hours in equal portions. The growth rate of juvenile *C. gariepinus* was assessed by control catches at 10-day intervals and a final catch. Volumetric method was used for the *C. gariepinus* larvae counting. Fish-breeding and biological parameters of the juvenile *C. gariepinus* were obtained by expert assessments. Absolute bodyweight gain, the feed conversion ratio and the survival rate of juveniles were 1313.7 g, 0.93 vs. 0.82 in the control and 75 % vs. 77 % in control, respectively, (the LLP KSRF-1973) and 1588.5 g, 0.93 vs. 0.88, 72 % vs. 74 % (the MG farm). Thus, the developed starter feed is not inferior to the standard in terms of nutritional value, it is physiologically complete, balanced in the main nutrients, including essential amino acids, and easier to digest. The compound feed is a well-flowing crumbs from dark to light brown in color, has high water resistance, swells quite well (swelling time is 40 minutes), and retains its shape during swelling. It was well eaten by fish. The granules practically did not break, did not crumble, and were of a size convenient for fish. Compound feed complies with sanitary standards in terms of microbiological indicators and can be stored for 10 months. The cost of the developed starter compound feed is 3 times lower than that of the imported one, and the cost of African catfish juveniles was less by 0.39-0.73 tenge per individual while fish breeding and biological parameters remained quite high. That is, in terms of the combination of price-quality, the Kazakhstani starter mixed fodder corresponded to the used standard sample. The results obtained allow us to conclude that the proposed feed is competitive, and its use will improve the efficiency of rearing juveniles of African catfish and the capabilities of fish farms in Kazakhstan

Keywords: aquaculture, starting compound feed, *Clarias gariepinus*, juveniles, fodder coefficient, survival, extruding

Aquaculture in Kazakhstan is currently experiencing rapid development and may well provide local population with fresh processed fish products. This requires technologies for breeding fast-growing fish of commercially valuable species. One of these species is the African sharp-toothed catfish *Clarias gariepinus*, since when growing this species, products can be obtained in a short time and with minimal labor. [1-4].

The meat of *C. gariepinus* (is high in nutritional value [5, 6], contains an optimal ratio of proteins, fats, amino acids, and polyunsaturated (omega-3) fatty acids, the amount of which is greater than in the meat of salmon fish. In addition, the clariid catfish as an object of aquaculture has a number of advantages compared to the fish species traditionally grown in Kazakhstan, such as precocity, endurance, rapid growth (the commercial weight of 1000-1500 g is reached at the age of 6-7 months, puberty at 11-13 months), resistance to water turbidity and disease [1, 2, 7]. *C. gariepinus* is omnivorous, but in nature, it is mainly a predatory fish. On day 5, *C. gariepinus* larvae begin to be fattened with natural feed, on day 10 day with artificial starter feeds of fine grinding (0.1-0.5 mm) [8]. It is especially important that *C. gariepinus* can be reared at very high stocking densities, since clariid catfish do not require high oxygen content in water due to the ability to breathe atmospheric air. Thus, this fish is omnivorous, unpretentious and undemanding in feed, with feed consumption of 0.8-1.2 kg per 1 kg of product, which significantly affects its cost and production costs [9, 10].

In Kazakhstan, technologies for the production of feed for heat-loving fish species (tilapia) began to be developed earlier with good results obtained in experiments [11]. However, starter feeds are still imported from abroad (in particular, when growing catfish, the most common feed for trout is Aller Futura EX 0.5-0.2 mm, Aller Aqua, Denmark), which significantly increases the cost of fish products. Therefore, at present, it is especially important to create formulas for starting compound feeds and their production use for the wide distribution and cultivation of *C. gariepinus* in the warm-water farms of the republic. Such compound feeds were created jointly by NPC SPC of fisheries (Almaty) and TOO KazNIIPPP (Almaty) and tested under production conditions. Based on the results of these tests, work continued to improve the feed composition and properties [8, 12].

In this report, for the first time, it was confirmed that the improved formula of the starter feed from local ingredients fully meets the physiological needs of juvenile catfish. Production tests of compound feed and economic calculations of rearing juveniles show that the cost of sales when using this feed turned out to be lower than for imported feed by 1.3% in TOO Kapshagai Spawning and Nursing Farm-1973 (TOO KNVKh-1973) and by 2.3% in the Farm MG (KH MG). The starter feed of Kazakhstan production is balanced in terms of the main nutrients, has an increased digestibility, and is cost-effective and quite competitive.

The purpose of our study is to evaluate the physiological and economic efficiency of the composition-optimized starter feed for *Clarias gariepinus* juveniles developed in Kazakhstan.

Materials and methods. The composition of the starter feed and the technology of its production (TOO KazNII processing and food industry, Almaty) were developed and optimized taking into account the physiological needs of *Clarias gariepinus* larvae in the main nutrients [12, 13]. The nutritional value of raw materials and feed, its organoleptic and physico-chemical parameters, technological properties, microbiological parameters were evaluated according to the standards, including GOST 13496.0-2016, GOST ISO 6498-2014, GOST 13496.13-2018, GOST 28254-2014, GOST 13496.3-92 (ISO 6496-83), GOST 13496.4-2019, GOST 32905-2014, GOST 32933-2014, GOST 13496.2-91, GOST 26657-97, GOST 28497-2014, GOST 28758-97, GOST ISO 7218-2015, GOST

10444.15-94, GOST 10444.12-2013, GOST 31878-2012, GOST 31659-2012 (ISO 6579:2002), GOST 32011-2013 (ISO 16654:2001), GOST 10444.7-86, GOST 8.207-76, and the sanitary requirements for commodities subject to veterinary inspection (supervision) (approved by the Decision of the Commission of the Eurasian Economic Union dated June 18, 2010 No. 317).

The granulometric composition of crushed and not crushed farinaceous raw materials was determined by laboratory sieving with the installation of sieves with a hole diameter of 2, 1 and 0.5 mm. Based on the sieve analysis data, the grinding size modulus was calculated. The mixing efficiency was evaluated by the coefficient of variation V_c as a qualitative indicator of the component distribution in the mixture:

$$V_C = \frac{100}{\bar{x}} \sqrt{\frac{\sum (x_i - \bar{x})^2}{n-1}},$$

where $\bar{x}$ is the arithmetic mean of the content of the studied component in the mixture, %; x_i is the value of the studied indicator in the i-th sample, %; n is the number of analyzed samples.

When calculating the coefficient of heterogeneity, the formula of Lastovtsev and Khvaltsov was used:

$$V_C = \frac{100}{C_0} \sqrt{\frac{\sum (C_i - C_0) n_i}{n-1}},$$

where V_c is the heterogeneity coefficient, %; n_i is the number of samples with C_i; concentration; C_0 is the concentration of the same ingredient in its ideal distribution in the mixture; Ci is the concentration of the same ingredient in its single distribution in the mixture.

During the production of pilot batches of compound feed and development of the technology for its production by extrusion (TOO Pet Food KZ, Almaty region), the ingredients of plant and animal origin were crushed to 0.2-0.5 mm grains, dosed according to the recipe, mixed, the moisture content of the mixture was adjusted to 30% including the initial level and subjected to extrusion at a 110 to 140 °C and a pressure of 4 MPa. Fat heated to 48 °C was added by spraying in a drum machine. The resulting starter feed for *C. gariepinus* had the form of grits with a particle size of 2 mm.

To establish the shelf life under production conditions (TOO Pet Food KZ), 100 kg (5 bags) of each compound feed were stored for 2, 4 and 10 months at 10-25 °C and relative humidity from 60 to 75% in dry, clean, pest-free grain stocks, well-ventilated closed warehouses in packaged form, away from direct sunlight, sources of heat and moisture. The quality of feed during storage was assessed in terms of peroxide value and acid value of fat according to GOST 13496.18-85, GOST 13496.2-91, and GOST R 51850-2001.

Before the start of production tests of the developed compound feed, a general hydrochemical analysis of water in fish reservoirs was performed; during the experiments, the water temperature and the content of dissolved oxygen in the pools were determined 3 times a day, the pH of the aquatic environment once day. For measurements, a Consort 932 thermooximeter (Consort, Belgium) was used.

Production tests of the effectiveness of compound feed were carried out on juveniles of clariid catfish in fish farms of TOO KNVKh-1973 and KH MG (Almaty region). The duration of the production experiment was 30 days. Danish feed for trout Aller Futura EX 0.5-0.2 mm (Aller Aqua, Denmark) was used as a control. The experiment was carried out in duplicate (two pools for control and two pools for experiment), the fish were fed in equal portions by hand 12 times during daylight hours. Based on the results of control every 10 days and the final

catch, the growth rate of *C. gariepinus* juveniles was estimated. The number of larvae was measured by volume accounting. Fish breeding and biological indicators (initial and final weight of fish, absolute gain, relative gain, average daily gain, survival) and the feed coefficient were determined by the method of expert assessments; food intake and feeding behavior of fish were recorded [14-17].

The cost of fish seed material of clariid catfish when rearing on starter feeds of Kazakhstani and imported production was calculated according to the recommendations [18-20].

Statistical processing of the results of assessing the physicochemical and technological characteristics of the feed was performed in accordance with GOST 8.207-76 and GOST 11.004-74 (ST SEV 876-78). Statistical analysis of fish breeding and biological indicators was performed according to G.F. Lakin [21]. Data are presented as means (*M*) and their standard errors (±SEM). Differences between experiment and control were considered statistically significant at $p \leq 0.05$.

Results. Given the fact that artificial fish foods are made from raw materials such as fishmeal and fish oil, there are environmental and economic (high cost) restrictions on their use. Therefore, in the development of effective feed formulations, alternative sources of protein of plant and animal origin are of interest [22-24].

Currently, there are no domestic artificial starter foods for larvae and fry of *Clarias gariepinus* in Kazakhstan. As a result, the biological characteristics of fish in these age periods have not yet been of practical importance, and its nutritional requirements for feed in aquaculture have not been fully studied.

Based on the analysis of publications [12, 13], we determined the amount and the main sources of protein necessary and corresponding to the physiological needs of *C. gariepinus* juveniles, and the nutritional and energy value of starter mixed feeds used in the industrial cultivation of catfish:

Indicator	Value
Exchange energy	18.0 MJ/kg
Mass fraction (MF) of crude protein	Not less than 50.0 %
MF crude fat	Not less than 8.0 %
MF crude fiber	No more than 2.0 %
MF Raw ash	No more than 10 %
MF Lysine	Not less than 2.4 %
MF methionine + cystine	Not less than 1.1 %
MF Phosphorus	Not less than 1.2 %
Acid number of fat	No more than 30.0 mg KOH/g
Peroxide value of fat	No more than 0.2 %J/г
Moisture in compound feed:	
in granular	No more than 13.5 %
in extruded	No more than 10.0 %
Crumbly:	
granules	No more than 3.0 %
extrudate	No more than 2.0 %
Water resistance of granules	Not less than 30.0 мин

Raw materials for the production of starter feed (average samples) were evaluated by organoleptic properties and quality indicators (Table 1).

1. Physicochemical properties of ingredients for the development of starter feeds for *Clarias gariepinus* in aquaculture (average samples)

Ingredient	Metabolic energy, MJ/kg	Percentage							
		linoleic acid	crude				NFE	P	Ca
			protein	fat	cellulose	ash			
Flour from:									
fish	11,17	0,52	54,82	15,80		18,80	6,90	3,30	4,92
blood	11,74	0,10	78,20	1,10		5,60	9,43	0,38	0,42
meat and bone	9,04	0,78	48,20	25,20		22,20	11,7	4,89	9,23
Corn gluten	14,81	1,12	49,60	5,08	5,20	2,00	16,88	0,52	0,32
Yeasts	9,20	0,05	36,50	1,44	1,67	4,90	46,22	1,40	0,73
Soybean meal	9,63	0,54	42,02	1,20	10,6	7,00	32,2	0,65	0,37

Continued Table 1

Embryos:									
corn	21,67	20,70	16,20	46,50	3,20	5,80	23,7	0,32	0,11
wheat	13,85	3,41	29,90	10,90	3,00	5,60	37,6	0,39	0,29
Wheat gluten	15,80		75,10	1,80	0,60		13,8	0,30	0,43
Soy isolate	11,90		89,52	4,04		5,00		0,29	0,39
Wheat bran	7,20	1,77	14,40	4,10	9,88	4,97	54,87	1,00	0,24
Wheat	12,34	0,99	11,50	1,60	2,77	1,84	70,8	0,30	0,08
Oats	12,00	1,58	12,25	4,72	2,25	1,62	67,34	0,32	0,11
Corn	14,90	1,80	8,56	4,00	2,60	1,53	74,2	0,23	0,02
Fish oil	34,31	7,10		98,10					
Soybean oil	35,88	49,30		99,90					
Bentonite								2,34	

N o t e. NES — nitrogen-free extractive sudstances.

On this basis, we calculated the variation rates for including ingredients in starter feeds for *C. gariepinus* larvae in aquaculture:

Component	Percentage
Wheat	0-20
Peas	0-15
Wheat bran	0-5
Meal, cake:	
soy	0-20
sunflower	0-10
Corn gluten	0-15
Flour:	
meat and bone	0-15
meat	0-20
bloody	0-27
fish	0-70
Yeasts	0-15
Skimmed milk powder	0-10
Bentonite	0-1
Soy isolate	0-15
Wheat gluten	0-4
Oil:	
soy	0-3
sunflower	0-3
linen	0-4
Fish oil	0-8

There is an active search in the world for innovative ways to grow predatory fish seed stock, such as *C. gariepinus*, using artificial starter foods [25, 26]. The physiological usefulness of starter feeds for juvenile fish lies in the ability to satisfy the body's needs for basic nutrients and biologically active substances, to ensure high growth rate and survival at an early stage of development.

The starter feeds developed by us are physiologically complete in terms of nutritional value (protein content is not less than 50.0%, fat content is not less than 8.0%). The composition of the starter feeds being developed included components with a high content of crude protein and a low fat content, since the formulation was developed for extruded feeds. The rest of the fat (soybean oil, fish oil) was injected by spraying (Table 2).

2. Nutritional value of optimized starter feed for *Clarias gariepinus* in aquaculture

Parameter	Concentration
Moisture content, %	9,04
Crude protein, %	50,7
Crude fat, %	11,53
Crude fiber, %	0,83
Ash, %	10,0
Linoleic acid, %	1,58
Nitrogen-free extractive substances (NES), %	15,68
Lysine, %	3,46
Methionine, %	1, 02
Methionine + cystine, %	1,6
Tryptophan, %	0,6

Continued Table 2

Sugar, %	0,5
Starch, %	6,22
Phosphorus, %	1,85
Calcium, %	2,85
Gross energy, kcal/100 g (MJ/kg)	492,78 (20,61)
Metabolic energy, kcal/100 g (MJ/kg)	413,93 (17,31)
Composite energy value of feed, %	Protein — 58.4; fat — 22.1; carbohydrates — 19.5

As a control, the starting feed for trout Aller Futura EX 0.5-0.2 mm (Aller Aqua, Denmark) was chosen, which is 60% proteins, 15%fat, 5.7% carbohydrates, 12.6% ash, 0.7% fiber, 1.4% phosphorus, with energy value of 472.3 kcal/100 and digestible energy of 396.7 kcal/100 g.

Thus, the improved Kazakh starter feed for larvae and fry of *C. gariepinus*, manufactured by TOO Pet Food KZ is a well-flowing grist from dark to light brown. The ratio of components in the recipe creates a complete biological complex that provides balancing the feed in terms of exchange energy, protein, limiting amino acids, vitamins and minerals, and physical and chemical parameters. This compound feed fully meets the physiological needs of *C. gariepinus* juveniles.

One of the important indicators of produced feed pellets is their water resistance, which reduces feed losses, increases feeding efficiency and improves the ecological situation in water bodies, which is currently being given special attention [27]. Properly formulated feed can contribute to minimal water pollution [27]. According to the requirements of GOST 28758-97, the crumbling of extruded feed should not exceed 3%. In the experimental batch of starter compound feed developed by us, crumbling did not exceed 2.35%. The compound feed retained its shape during swelling, the swelling time was 40 min, that is, the developed starter compound feed has high water resistance, while swelling quite well.

The quality of compound feed made by extrusion is significantly improved due to thermodynamic methods of processing raw materials (pressure, temperature). During extrusion, gelatinization of starch occurs, that is, amylopectin is formed, as a result, the absorption of carbohydrates is significantly improved. Extrusion processing significantly improves the palatability of the feed by inactivating certain enzymes, making it more palatable; when exposed to high temperatures, toxins and pathogenic microflora are neutralized [26, 28, 29]. Protein under the influence of high temperature (1300 °C) and pressure breaks down into amino acids, which are much easier to digest. Losses of amino acids occurring during extrusion are not critical. The temperature of decomposition is 224 °C for lysine, 282 °C for tryptophan, 284 °C for phenylalanine, 283 °C for methionine, 337 °C for leucine, 284 °C for isoleucine, 315 °C for valine, 258 °C for threonine; the total proportion of essential amino acids in the diet remains almost unchanged compared to the original [28-30].

3. Fat oxidation in the optimized starter feed for *Clarias gariepinus* during commercial storage (TOO Pet Food KZ, Almaty region)

Parameter	Shelf life	Value
Acid number of fat, mg KOH/g	0	8.34
	2	16.93
	4	20.09
	10	26.36
Fat peroxide value, %J/g	0	0.10
	2	0.12
	4	0.17
	10	0.19

It is known that in stored raw materials and finished products, fat is oxidized to the formation of peroxides and acids, under the influence of which fat-soluble vitamins are destroyed and not absorbed by fish, which leads to diseases

and even death. In the feed for *C. gariepinus*, oxidation was assessed by the acid and peroxide values of fat as indicators of fat hydrolysis and oxidation (Table 3).

When stored for 10 months in all samples, an increase in acid number (up to 26.36 mg KOH) and fat peroxide number (up to 0.19%) was observed. The maximum permissible values according to the Unified veterinary (veterinary and sanitary) requirements for commodities subject to veterinary control (surveillance) are 30 mg KOH/g and 0.2 J%/g, respectively.

The absence of growth of pathogenic microflora during 10-month storage means that the sanitary indicators of the feed did not decrease during this period. Microbiological studies of compound feed did not reveal spore-forming bacteria *Bacillus subtilis*, *B. mesentericu*s, as well as lactic acid bacteria, yeast and filamentous fungi in samples with different shelf life.

The results of hydrochemical analysis of water in TOO KNVKh-1973 showed that it is suitable for fish breeding purposes. The oxidizability of water is low (1.12 mg/l in the well, 4.51 mg/l in the pond when heated), the phosphorus content did not exceed the standard (0.02 mg/l in the well, 0.09 mg/l in the pond). The mineralization of water from the well and the pond as a whole corresponded to the standard values (371 mg/l for the well, 665 mg/l for the pond). The increased content of nitrates in artesian water was corrected. Water from deep wells first entered the degasser tank, and then into the aerator tank, where it was saturated with oxygen. In general, in terms of hydrochemical parameters, water from an artesian well after carrying out the described measures becomes suitable for growing valuable fish species [31, 32]. The content of oxygen dissolved in water in the pools ranged from 6.0-8.2 mg/l, the pH was stable (average pH 7.9 for the pool), the temperature ranged from 19.2 to 29.3 °C (on average, 24.3 °C), the content of the main biogenic elements corresponded to generally accepted indicators [33]. The water samples from the water supply canal of KH MG were slightly alkaline (pH 7.96), the amount of organic matter was low (according to permanganate oxidation 5.9 mg O/dm^3), the content of biogenic elements was sufficient for the development of aquatic vegetation. The concentration of ammonium nitrogen accounted for 0.06 mg/dm^3, nitrites and mineral dissolved phosphorus for 0.001-0.003 mg/dm^3, nitrates for 1.3 mg/dm^3, iron for 0.03 mg/dm^3, siliconfor 3.5 mg/dm^3. In terms of technical properties, this water sample corresponds to the category of hard (with a total hardness of 6.1 mg-eq/dm^3), in terms of the total content of dissolved salts it belongs to fresh water with a mineralization of 715 mg/dm^3, in terms of dominant ions it belongs to the hydrocarbonate class, magnesium group. The quality of water from the water supply canal of KH MG according to the main indicators met the requirements for fish farms [31-33].

4. Fish breeding and biological parameters of *Clarias gariepinus* larvae of 5-week age when fed a standard and novel feed (N = 2, n = 25, TOO KNVKh-1973, Almaty region, 2020)

Parameter	Feed	
	novel	standard Aller Futura EX 0.5-0.2 mm
Growing time, days	30	30
Planting density, pcs/m^3	10000	10000
Initial weight, mg (M±SEM)	1.3±0.1	1.3±0.1
Final weight, mg (M±SEM)	1315±58.1	1380±62.3
Absolute weight gain, g	1313.7	1378.7
Average daily weight gain, mg	43.79	45.9
Feed ratio	0.93	0.82
Survival, %	75	77

In production tests, the proposed starter feed was well eaten by fish, the particles practically did not break, did not crumble, corresponded to the size required for grown fish, and had a high feed coefficient of 0.93. This is 0.11 higher

than for the most common in Kazakhstan feed company Aller Agua served as a control and meets the physiological requirements of catfish in terms of nutrition (Tables 4, 5). The survival of fish when using the two compared feeds practically did not differ and varied from 75 to 77% (see Tables 4, 5).

5. Fish breeding and biological parameters of *Clarias gariepinus* larvae of 5-week age when fed a standard and novel feed (N = 2, n = 25, KH MG, Almaty region,, 2020)

Parameter	Feed	
	novel	standard Aller Futura EX 0.5-0.2 mm
Growing time, days	30	30
Planting density, pcs/m^3	10000	10000
Initial weight, mg (M±SEM)	1.5±0.1	1.6±0.1
Final weight, mg (M±SEM)	1590±57.1	1680±61.2
Absolute weight gain, g	1588.5	1678.4
Average daily weight gain, mg	52.95	55.9
Feed ratio	0.93	0.88
Survival, %	72	74

At TOO KNVKh-1973, the average weight of *C. gariepinus* fed the developed feed was only 65 mg lower ($p > 0.05$) than that of fish fed standard feed, the average daily gain differed by 2.11 mg, the survival rate by 2% (see Table 4).

Satisfactory results were also obtained in both variants under the conditions of KH MG. The values of absolute and average daily gains in both variants differed slightly, by 89.9 and 2.95 mg, respectively; survival rates were within the standard values and with a difference of 2%; the value of the feed coefficient was 0.93 vs. 0.88; the mean weight of *C. gariepinus* was 90 mg lower ($p > 0.05$).

It should be noted that in Kazakhstan there are no starter feeds for larvae and juveniles of *C. gariepinus* and there are no regulatory documents for such feeds. Our production tests showed good results in both trials.

6. Estimated economical indicators of juvenile *Clarias gariepinus* aquaculture with standard and novel feed (TOO KNVKh-1973, Almaty region, 2020)

Parameter	Feed	
	novel	standard Aller Futura EX 0.5-0.2 mm
Planting material (for 10,000 fry), tenge	200000.00	200000.00
Payroll fund for employees, including taxes, tenge	6400.00	6400.00
Amount of feed, kg	9.16	8.70
Feed price, tenge	505.58	1500.00
Total cost of feed, tenge	4630.14	13051.04
Overhead costs, tenge	10551.51	10972.55
General production costs, tenge	221581.65	230423.59
Product output, pcs.	7500.00	7700.00
The cost of products sold, tenge/pcs.	29.54	29.93
Final weight, mg	1315.00	1380.00
Price-quality ratio, tenge/mg	0.022	0.022

7. Estimated economical indicators of juvenile *Clarias gariepinus* aquaculture on standard and novel feed (KH MG, Almaty region, 2020)

Parameter	Feed	
	novel	standard Aller Futura EX 0.5-0.2 mm
Planting material (for 10,000 fry), tenge	200000.00	200000.00
Payroll fund for employees, including taxes, tenge	6400.00	6400.00
Amount of feed, kg	10.63	10.93
Feed price, tenge	505.58	1500.00
Total cost of feed, tenge	5375.90	16390.70
Overhead costs, tenge	10551.51	10972.55
General production costs, tenge	222364.70	233930.24
Product output, pcs.	7200.00	7400.00
The cost of products sold, tenge/pcs.	30.88	31.61
Final weight, mg	1590.00	1680.00
Price-quality ratio, tenge/mg	0.019	0.019

The calculated parameters for rearing catfish juveniles when fed with different starter artificial feeds in different fish farms are presented in tables 6 and 7.

The largest part of the cost in rearing juvenile catfish in TOO KNVKh-1973 was the cost of fish stock as an intermediate fish product, the 90.3% of the total production costs when using the feed developed by us and 86.8% for the feed of the company Aller Aqua. This is followed by other expenses (utilities, feed costs, wage fund, etc.), 9.7 and 13.2%, respectively.

In the farm KH MG, the main part of the cost for reared fry was the cost of fish seed, the 89.9% of the total production costs for the developed compound feed vs. 85.5% for the feed of the company Aller Aqua. Other expenses accounted for 10.1% and 14.5%, respectively.

Despite the fact that the cost of the starter mixed fodder of Kazakhstan production is 3 times less than that of the imported one, the cost of reared juveniles of catfish using the proposed mixed fodder turned out to be lower by 0.73 tenge per individuum at KH MG and by 0.39 tenge per individuum at TOO "KNVKh-1973 while fish rearing and biological indicators remain at the same lavel.

So, the starter feed for *Clarias gariepinus* developed in Kazakhstan, is a well-flowing grits from dark to light brown. In terms of nutritional value (protein content of 50.70%, fat content of 11.53%, metabolic energy 17.31 MJ/kg), physico-chemical properties and attractiveness, the starter compound feed fully meets the physiological needs of *C. gariepinus* juveniles. When tested in two fish farms, the absolute increase in live weight was 1313.7-1588.5 g (vs. 1378.7-1678.4 g in control), the feed coefficient was 0.93 (vs.0.82-0.88 in control), survival rate was 75 and 72% (vs. 77 and 74% in control). The average weight of *C. gariepinus* fed the developed feed was 65-90 mg lower ($p > 0.05$). However, the cost of the developed feed is significantly (3-fold) lower than that of the standard, and in terms of nutritional value it is not inferior to the standard. The cost of reared juveniles of catfish in farm trials was less by 0.39-0.73 tenge per individuum while fish breeding and biological indicators of juveniles remain the same. The developed feed complies with microbiological sanitary standards and is well stored for 10 months. The use of this starter feed makes it possible to increase the profitability of rearing *C. gariepinus* juveniles in pools.

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