Effects of New Mixed Feed Based on Nontraditional Feed Additives on Fatty Acid Profile of Tilapia (Oreochromis Niloticus)

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***Abstract*: This article presents data of the effect of new feed additives on the fatty acid composition meat of Nile Tilapia.**

Test subjects were divided into four groups (different ages), experimental fish were contained in special reservoirs. The following feed types were used in the research: No. 1 (for fish bred in ponds), No. 2 (for young fish), No. 3 (for a commercial group of fish), No. 4 (for fish bred in pools). Experimental studies were conducted near the Chundzha natural hot spring in the Almaty region. Gas chromatography was used to determine the amount of fatty acids in fish meat. The use of new feeds has led to an increase the content of Fattyacids (FA) and monounsaturated fatty acids (MUFA) and polyunsaturated fattyacids (PUFA) in particular.

***Index Terms*: fatty acids, fish, feed additive, quality, safety.**

I. INTRODUCTION

Tilapia has valuable biological and economic qualities. In the 20th century, the tilapia genus included just over 100 species, distributed mainly in the tropical regions (Central America, Africa, Southeast Asia and the Middle East) [1], [2]. Today, the volume of industrial cultivation of tilapia is second after carp [1]-[3]. Tilapia accounts for more than 90% of world fish production, thus, this species play the leading role in the global production of tilapia [4]. Nile tilapia is one of the most popular and widely used breeding objects in aquaculture. It can reach a mass of 5 kg and is the largest representative of its genus [5]. The oil of fish is the best fount of fat types that are vital for children. Without a sufficient supply of these fatty acids, normal brain development does not occur [6], [7]. The content of fatty acids in fish depends on its species, age, and feed [8]. Fish meat contains a small amount of carbohydrates in the form of glycogen and a high percentage of water (60-86%) [9]. The energetic value of fish meat is directly proportional to the fat content. It was found that the content of saturated and unsaturated fatty acids in fish fat varies greatly: it usually contains 15-36% of saturated fatty acids (SFA) [10]-[12] and 58-85% of unsaturated fatty acids [13]. The most substantial of USFA is Linoleic acid (LA), which is important and should be ingested with food.

Results of the research of the fish meat quality vary in different studies. The differences are mainly due to the variations of fish used in the analysis: different ages, breeding systems and feed [14]. Fat of fish contains cholesterol. Fish meat contains the same amounts of cholesterol as pork or beef and the cholesterol content does not correlate with the fat content [15]. Under artificial conditions, it is important to include feed additives in the diet. In general, industrially grown fish is poor in very valuable omega-3 fatty acids. Low-quality omega-6 FA are extended in fish. The addition of feed additives increases the usefulness of meat products. Consumption of fish meat that contains large amounts of omega-6 fatty acids is not recommended for people suffering from autoimmune diseases, allergies (asthma in particular), heart pathologies, obesity, diabetes and arthritis. Research shows that the optimal ratio of these fatty acids is 1:1, and if omega-6 is prevalent, the product is considered harmful to the human body. However, in tilapia meat, this ratio can vary from 1:3 to 1:11 [16]-[17]. An important distinctive feature of fish fat is the domination of USFA in its composition (up to 84%), including highly unsaturated acids with four to six ethylenic bonds, which are absent in fats of terrestrial animals [18]. In contrast to the fats of homoiothermic animals, fish fat has a liquid texture with specific taste and smell and can be easily absorbed by the human body [19]. The nutritional value of fish significantly depending of fat content; therefore, the fatness of fish is an important indicator of determination the grade of products. The fat content in fish meat varies greatly from 0.5 to 30%, most often from 2 to 12% [20].

II. MATERIALS AND METHODS

Nile tilapia fish were used as objects for research. New formula feeds were added to the ration of fish. They were developed based on the research project of “AsylTasEngineering” LLP: “Production of organic food from fish (Tilapia, African *Clarias gariepinus*, etc.) grown with the use of local environmentally-friendly feed in accordance with international standards”

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(Table I).Experimental studies were conducted near the Chundzha natural hot spring in the Enbekshikazakhsky district of the Almaty region.

Four groups (50 fish in each) were formed, individuals from each group were kept in artificial pools at a fish farm. The water temperature was 20-26 °C.

Table I. Nutritional content of new feeds for tilapia

Nutrients	No. 1	No. 2	No. 3	No. 4
Proteins, %	26.26	36.18	40.53	32.02
Fat, %	5.11	6.31	8.03	5.08
Fibre, %	3.14	3.46	2.75	3.81
Ash, %	5.86	8.34	10.04	6.82
NFES (nitrogen-free extractive substances), %	46.82	34.64	28.4	40.37
Starch, %	22.09	6.92	3.8	11.31
Sugar, %	2.04	2.05	1.61	2.32
Energetic value, kcal/100 g	403.07	367.25	364.96	374.92

We used new types of feed for the study, which were prepared using the following recipes:

№1 – for tilapia bred in ponds: fish flour – 46%, meat-and-bone tankage – 9%, blood tankage – 5%, wheat – 11%, algae – 1%, hay – 2%, nutrient yeast – 4%, soya-bean powder – 6%, helianthus extraction cake (powder) – 2%, the oil of fish – 4%, premixes – 1%.

№2 – for young tilapia fish: fish flour – 40%, meat-and-bone tankage – 5%, blood tankage – 12, nutrient yeast – 13%, soya-bean flour – 10.9%, gluten – 15.8%, fish oil – 2.2%, premix (P 111-3) – 1%, detergent – 0.05%, oxidation inhibitor – 0.05%.

№3 – for tilapia of the commercial group: nutrient yeast – 26.4%, fish flour – 18%, meat-and-bone tankage – 12%, soya-bean flour – 17%, wheat bran – 5%, wheat – 5%, blood tankage – 2%, wheat germ – 5%, corn gluten meal – 6%, soya-bean extraction cake – 2.5%, premix (PM 2) – 1%, oxidation inhibitor – 0.05%, detergent – 0.05%.

№4 – for tilapia bred in pools: fish flour – 44%, meat-and-bone tankage – 7%, blood tankage – 5%, wheat – 11%, algae – 2%, hay – 3%, powdered skim milk – 10%, nutrient yeast – 4%, soya-bean flour – 7%, sunflower extraction cake – 2%, fish oil – 4%, premixes – 1%.

Feeding, weight control and fish management practices fully complied with the management guidelines of the Tengryfish LLP fisheriesThe fish was gutted and well packed. Passed them for analysis in the laboratory on the day of slaughter. Fish tissue samples were homogenized, frozen and hydrolyzed.

For determination the FA composition of meat using gas chromatography with the use of Agilent Technologies 7890A GC system. Supelcowax 10 was used as a liquid phase, the film thickness was 0.25 microns. Each acid methyl ester was identified using its retention time, which was compared with the retention time of a mixture of FA methyl esters in Supelco 37 standard [21].

Chemstation software was used for calculation of the percentage of FA. The content of FA is presented as a comparative percentage (% of the total content of FA) in meat.

III. RESULTS AND DISCUSSION

The using of new recipes may increases levels of PUFA in fish. The data of the analysis the FA composition of tilapia meat is shown in Table II, content of SFA is shown in Fig. 1, the content of MUFA in Fig. 2 and the content of PUFA is shown in Fig. 3.

Table II. Fatty acid content in the muscular tissue of tilapia after the use of the new feeds (proportion of the total amount of FA ± standard deviation)

Content of fatty acids	Groups (n = 50)			
	№1	№2	№3	№4
Content of SFA				
12:0 (Dodecanoic acid)	0.03±0.02	0.04±0.02	0.04±0.02	0.03±0.02
13:0 (Tridecanoic acid)	0.01±0.04	0.02±0.02	0.01±0.02	0.01±0.02
14:0 (Tetradecanoic acid)	3.87±0.07	3.77±0.03	3.74±0.03	3.45±0.02
15:0 (Pentadecanoic acid)	0.38±0.05	0.38±0.04	0.35±0.05	0.37±0.03
16:0 (Hexadecanoic acid)	16.17±0.08	16.06±0.07	16.23±0.10	15.35±0.08
17:0 (Heptadecanoic acid)	0.59±0.03	0.54±0.05	0.53±0.02	0.49±0.03
18:0 (Octadecanoic acid)	3.26±0.02	3.45±0.04	3.16±0.04	3.26±0.05
20:0 (Eicosanoic acid)	0.22±0.02	0.17±0.02	0.24±0.02	0.22±0.02
22:0 (Behenic acid)	1.27±0.05	1.33±0.05	1.49±0.05	1.54±0.04
23:0 (Tricosanoic acid)	0.05±0.06	0.04±0.03	0.05±0.02	0.05±0.02
24:0 (Lignoceric acid)	1.41±0.03	1.45±0.04	1.26±0.05	1.55±0.03

Total amount of SFA	**27.26**	**27.25**	**27.10**	**26.32**
Content of MUFA				
14:1 (Myristoleic acid)	0.24±0.04	0.25±0.03	0.24±0.03	0.22±0.02
16:1(Palmitoleic acid)	5.28±0.08	5.24±0.05	5.35±0.04	5.94±0.02
17:1 (Heptadecenoic acid) (cis-10)	0.24±0.02	0.22±0.02	0.24±0.02	0.36±0.03
18:1 n9 (Oleic acid)	20.28±0.11	21.78±0.10	21.53±0.07	20.09±0.08
20:1 (11-eicosenoic acid)	2.43±0.05	2.37±0.04	2.43±0.03	2.43±0.02
24:1 (Nervonic acid)	1.62±0.06	1.53±0.06	1.54±0.02	1.49±0.02
Total amount of MUFA	**30.09**	**31.39**	**31.33**	**30.73**
Content of PUFA				
18:2 n-6 (Linoleic acid)	10.12±0.02	10.25±0.03	10.36±0.02	10.46±0.03
18:3 n-6 (GLA)	0.44±0.02	0.37±0.02	0.29±0.02	0.27±0.02
18:3 n-3 (ALA)	1.98±0.05	1.87±0.04	1.95±0.03	1.87±0.04
20:2 (*cis*-11,14-eicosadie-noic acid)	0.51±0.03	0.46±0.04	0.56±0.04	0.66±0.04
20:3 n-6 (*cis*-8,11,14-eico-satrienoic acid)	0.22±0.07	0.23±0.07	0.20±0.06	0.22±0.07
20:3 n-3 (*cis*-11,14,17-eico-satrienoic acid)	0.57±0.02	0.52±0.02	0.57±0.02	0.57±0.02
20:4 n-6 (*cis*-5,8,11,14-eicosatetraenoic acid)	0.68±0.07	0.78±0.07	0.72±0.06	0.88±0.07
20:5 n-3 (*cis*-5,8,11,14,17-EPA)	4.06±0.03	4.12±0.03	4.13±0.03	4.22±0.03
22:2 (*cis*-13,16-docosadi-enoic acid)	1.06±0.02	1.03±0.02	1.03±0.02	1.07±0.02
22:6 n-3 (*cis*-4,7,10,13,16,19-docosa-hexaenoic acid)	16.08±0.02	15.04±0.02	15.33±0.02	15.35±0.02
Total amount of PUFA	**35.72**	**34.67**	**35.14**	**35.57**
PUFA/SFA	1.31±0.05	1.27±0.08	1.29±0.06	1.35±0.02

The biochemical composition of meat depends on the form, age, also diet and environmental factors. Fish is a source of essential fatty acids. [22]. Our results may be concluded that feeding of the fish using feed prepared according to the new recipes with non-traditional feed additives resulted in the following tendencies: an increase in the content of oleic acid (18:01), myristic acid (14:00) and palmitoleic acid (16:01), and a significant decrease in the content of stearic (18:00) and eicosanoic (20:1) acids.

Contents of FA in the fish of experimental group were as follows: SFA – from 26.32 to 27.26%, MUFA – from 30.09 to 31.39%, PUFA – from 34.67 to 35.72%.

Particularly, a significant increase in content of the following acids was recorded in the specimens from the second group: C18:1 n9 oleic acid (21.78%), C18:0 stearic acid (3.45%), and C14:1 myristoleic acid (0.25%). In the first group: C24:1 acetic acid (1.62%), C18:3 omega-6-linoleic acid (0.44%), C18:3 omega-3-linolenic acid (1.98%), and C22:6 omega-3 (cis-4,7,10,13,16,19) docosa-hexaenoic acid (16.08%). In the third group (for which the new feed for a commercial group of tilapia was used): C16:0 palmitinic acid (16.23%) and C20:0 arachidonic acid (0.24%). In the fourth group: C22:0 (1.54%), c24:0 (1.55%), C16:1 (5.94%), C17:1 (cis 10) margaric acid (0.36%), C18:2 n-6 (5.94%), C20:2 (cis-11,14) (0.66%), C20:4 n-6 (0.88%), C20:5 n-3 (cis-5,8,11,14,17) EPA (4.22%), and C22:2 (cis-13,16) DPA (1.07%).

Epidemiological studies have shown that eating meat with excessive amounts of ω -3 FA is inversely proportional to probability of carcinoma, cardiovascular diseases, and mental disorders [23]. Because of this fact, PUFA must be separated: n-3 and n-6 FA. Nevertheless, the levels of n-3 and n-6 polyunsaturated fattyacids in the specimens from experimental group were statistically significant.

Contents of n-3 FA (from 21.35 to 22.71% in the experimental groups) is high than the contents of n-6 FA (12.46%, 12.95%). Analyses of the data on n-6/ n-3 FA relation showed that this value in the experimental groups was 0.53. Limit recommended value for the PUFA and SFA relation is 0.45 [24]. The ratio of C22:6 n-3 cis-4,7,10,13,16,19 and C20:5 n-3 cis-5,8,11,14,17 ranged from 0.82 to 3.85. The ratio of these substances in the paper by Aslan was 1.56% [25]. In our studies (the used feed was prepared according to new recipes based on non-traditional feeds), the ratio of these data was 3.94%.

Thus, the results of the study show that the composition of fatty acids depends on the nutritional value of feed and feed additives. Comparison of our research results with the research results obtained by Danabas [26] showed that there was no important difference in the content of FA in fish. Therefore, usage of new productional feeds based on non-traditional feed additives contributes no significant negative effect on the FA design of fish meat. As well as, an increase the level of PUFA was observed. At the same time, levels of these acids did not exceed the norm [27].

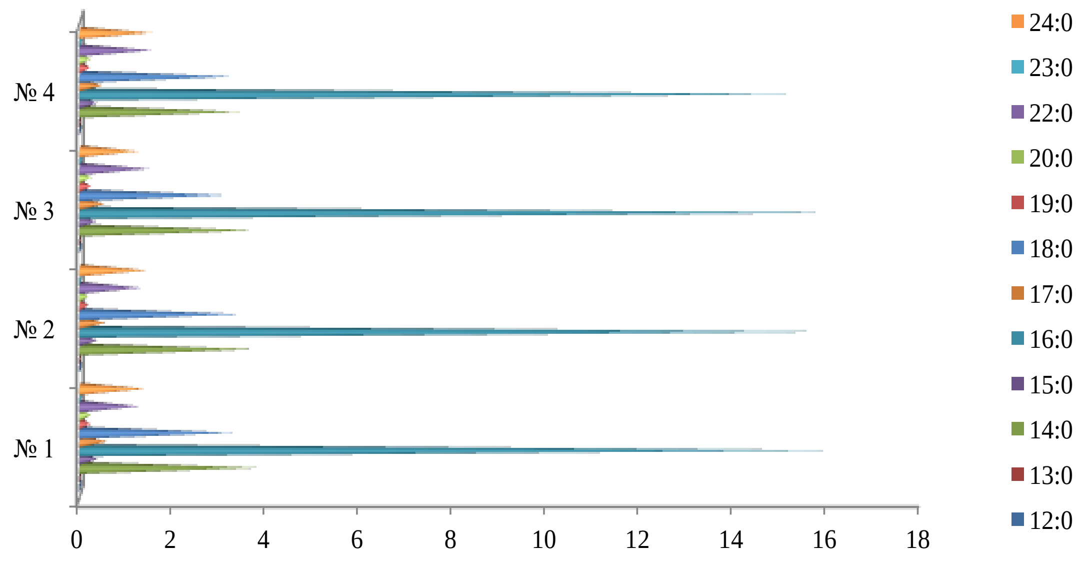

Fig. 1. Fatty acids content in tilapia after the use of the new feeds based on non-traditional feed additives

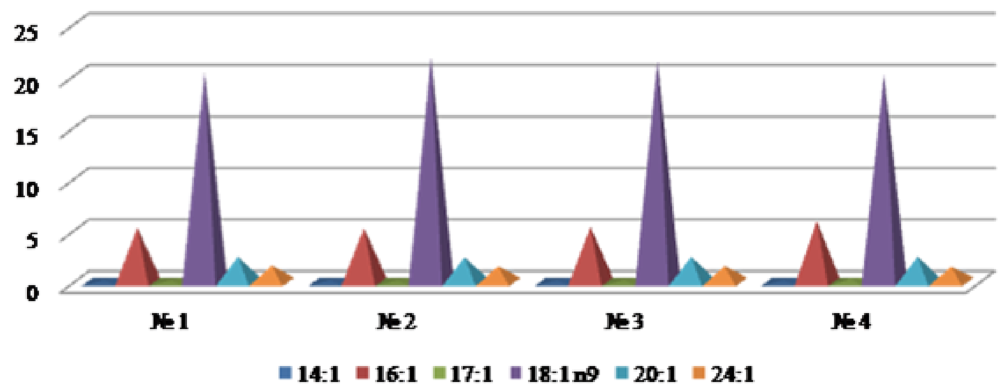

Fig. 2. MUFA content in tilapia after the use of the new feeds based on non-traditional feed additives

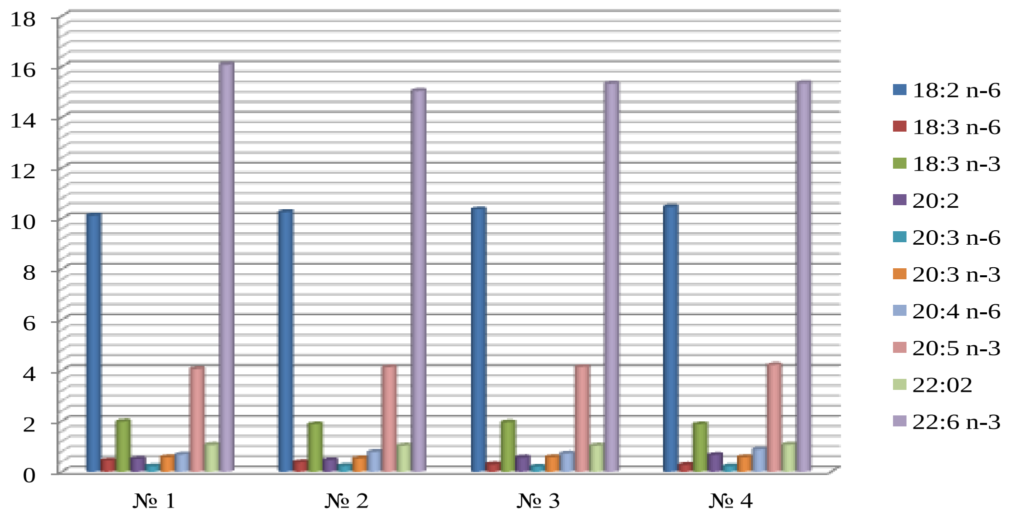

Fig. 3. PUFA content in tilapia after the use of the new feeds based on non-traditional feed additives

IV. CONCLUSION

The data of this study shown the effect of new feed formulations based on non-traditional feed additives from Kazakhstan on the FA composition of fish. Using of the feeds based on the new recipes have a positive result on the FA content in fish meat. It led to growth the total content of PUFA, and to falling the levels of SFA. This new information about non-traditional feed additives might be very important for the advances in the fishing industry, especially in developing countries. It will help improving on quality meat of fish, ensuring the health and safety of consumers.

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