Conference Paper

Compound Feed Technology in Sturgeon Fish Aquiculture

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Abstract

The modern fish processing industry of the Russian Federation sets the task of increasing the efficiency of the use and development of the resource potential of the fishery complex by means of aquaculture and mariculture development, including sturgeon fish breeding. In this case, complex processing through the rational use of by-products of fish and hydrobiont. In Russia, China, the EU and other countries, most fish processing enterprises do not rationally use by-products of fish cutting, which leads to violation of environmental safety (waste deposits are littered with waste from the fishing industry). The article discusses the prospects of using alternative plant materials in the diet of sturgeon fish, presents the recipes for full extruded compound feed for this group of organisms, the quality indicators of compound feed for sturgeon. A comprehensive assessment of the quality of compound feed products was obtained according to the physicochemical and structural indicators of compound feed. The optimal terms and conditions of storage of the obtained feed were found. Based on the performed tests, it was concluded that it is advisable to use raw materials of plant origin in the composition of compound feed, which contributes to the growth of the live weight of fish, leads to the replacement of the costly components of the compound feed with cheaper raw materials of plant origin, provided that the nutritional value is not reduced, and the period and conditions of storage meet the existing requirements.

Keywords: extrudate, sturgeon fish, compound feed, fat acidity value, nutrient value, metabolizable energy, total acidity, fat peroxide value, storage period.

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1. Introduction

The organization of full-fledged feeding and the development of compound feed formulations for all representatives of the animal kingdom requires a clear idea of the needs of various species and different age groups of its representatives for the basic nutrient elements [1--4]. There is an urgent need to implement developments in the field of feeding and feed production [5--8].

The scale of development and the fish farm economy is largely determined by how well the issues of feeding and fodder production are scientifically and practically developed. For many countries, the issue of aquaculture of sturgeon fish is relevant in this aspect [9--11]. The unique experience of factory reproduction of these valuable species was, in due time, the basis for maintaining the sturgeon fishery. One of the most important fundamentals for the production intensification during the cultivation of any species of fish and animals is rational feeding, based on the use of highly effective compound feed [12]. Therefore, the urgent task is to create recipes for compound feeds that meet the requirements, using cheaper plant and animal analogues [13], as well as methods for their preparation allowing of control the density of feed pellets, while receiving not only floating and sinking, but also slow-sinking granules. In addition to high-quality raw materials, it is necessary to use its deep heat treatment through the extrusion process. Extrusion processing of raw materials improves the quality of feed produced and reduces its consumption per unit of fish growth [Shevtsov A.A., Vasilenko V.N. 2009].

2. Methods and Equipment

2.1. Methods

The samples of extruded compound feed were taken in accordance with GOST 13496.0-2016. Samples were sieved through a sieve of mesh size of 2 mm (GOST 13496.8) and subjected to analysis. Moisture content and particle size distribution of the feed was determined in accordance with GOST R 57059-2016. The determination of the granule sizes is carried out using a ruler, measuring the diameter and length of ten granules taken one nest to the other. According to the obtained data, the arithmetic mean value of the diameter and length of the granules is calculated. Appearance and color are sensory determined. 200 g of the tested compound feed is placed on a smooth surface of a sheet of white paper and, while mixing, examined in natural light. Smell definition is performed in accordance to GOST 13496-2018, Method of swelling characteristics definition (GOST 28758 - 97). A portion of extruded compound feed (granules) weighing 25 g is placed in a measuring cylinder of 500 cm^3 and the level corresponding to the volume occupied by the granules is noted on the cylinder. Then, the second mark is made on the cylinder, corresponding to the twofold volume occupied by the product. Then, water is poured into the cylinder at the temperature of 20 °C so that its upper level is 130 mm above the level of the granules. The time is counted from the moment the cylinder was filled with water until the swollen granules reached the second mark. Friability is tested by apparatus 17 -- EKG according to GOST 28497-2014. A sample of granular product of about 1 kg is sieved with laboratory screening with mesh size matching 0.75 of the diameter of the tested granules, to separate crumbs and fines. Qualitative characteristics were determined by standard methods: crude protein content was determined in accordance with GOST ISO 5983-2-2016 by the Kjeldahl method; crude fat - GOST 13496.15-2016; crude fiber - GOST R 57543-2017; the method for determining the mass fraction of ash insoluble in hydrochloric acid is stated in GOST 5901-2014; method for determining the acid number of fat - GOST 13496.18-85; method for determining total acidity - GOST 13496.12-98; method for determination of lysine and tryptophan, GOST 13496.21-2015.

3. Results

Table 1: Compound feed formulations for sturgeon fish.

Elements and composition, %	Formulation 1 (for fingerlings, granule size 3 mm)	Formulation 2 (for fingerlings, granule size 4 mm)	Formulation 3 (for fingerlings, granule size 6 mm)	Standard formulation
Naked barley	28.00	29.00	20.00	30.00
Wheat	20.00	-	21.00	20.60
Pea	-	13.00	-	-
Corn	-	7.00	-	-
Field weed seeds	-	-	25.00	-
Soy hulls	18.00	18.00	20.00	18.00
Sunflower hulls	17.70	22.00	6.00	17.80
Meat meal	3.00	-	-	3.00
Fish meal	0.30	3.00	1.00	2.93
Crowfoot flour	10.00	-	-	-
Coniferous flour	-	3.00	-	
Feeding yeast	-	4.00	4.00	4.97
Monocalcium phosphate	2.00	-	2.00	1.70
Premix	1.00	-	1.00	1.00
Chalk	-	1.00	-	
Crude protein	26.27	26.07	25.07	26.09
Crude fiber	5.97	3.50	4.50	8.97
Lysine	1.31	1.50	1.20	1.22
Ca	0.74	0.78	1.00	1.40
P	1.07	1.30	0.60	0.68

Livestock production largely depends on the quality of feed used. At the present stage of development, manufacturers prefer the production of feed using extrusion technology, which naturally contributes to its further development and the introduction of innovations. Due to the unique combination of temperature, pressure, moisture, and time factor, the product, after processing it in the extruder, turns into sterile and stable feed. Particular attention should be paid to the higher digestibility of the resulting product (25-30% higher than usual), which allows to increase the weight gain during feeding (compared with traditional feed) and dramatically reduce the amount of waste.

Methods have been developed for deep processing of the initial grain raw materials which should contribute to the destruction of part of the cellulose-lignin fiber formations in natural forms into simpler types of monosaccharides and amino acids. Feed formulations are shown in Table 1.

The extrudate obtained under rational parameters of the extrusion process and the optimum ratio of feed components was analyzed by a set of indicators characterizing its feed properties, metabolic energy, nutrition, and the influence of conditions and storage period on the quality of the extruded compound feed for sturgeon fish were also studied (Table 2).

Table 2: Physical and chemical indicators of the finished product.

Indicator	Formulation 1 (3 mm)	Formulation 2 (4 mm)	Formulation 3 (6 mm)	Standard formulation
Moisture content, %	13.40	13.40	13.50	14.50
Granule length, mm, max	two diameters			
Granule water resistance, minutes	20.00	20.00	23.00	15.00
Granule swelling characteristic, minutes	27.00	27.00	28.00	25.00
Granule friability, %, max	3.15	3.20	3.16	5.00
Metabolic energy, minimum, kkal/100 g	365.00	378.00	370.00	-
Crude protein, minimum, %	50.00	45.00	40.00	-
Crude fat, minimum, %	10.00	14.00	13.00	-
Fiber, maximum, %	2.00	2.00	3.00	-
Ash, maximum, %	10.00	10.00	10.00	-
Phosphorus, minimum, %	0.80	0.80	0.80	-
Lysine, minimum, %	2.10	1.80	1.80	-

Organoleptic characteristics of the finished product were as follows: appearance - granules of cylindrical shape with glossy or matte surface, without cracks; color - corresponding to the color of bulk feed of which the granules were made, or darker (when entering dyes - the color of the corresponding dye); smell - corresponding to

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the set of benign components of the original feed without any musty, moldy or other extraneous odors. Laboratory tests were carried out to study the effect of storage conditions and period on the quality of extruded compound feed for sturgeon fish. For this purpose, an experimental lot of compound feed for fish with the optimal ratio of components of plant and animal origin was developed on an experimental industrial line. 4 feed samples of 1 kg each were put for four-month storage under experimental conditions (Table 3).

TABLE 3: Experimental storage conditions for extruded compound feed.

Experimental condition set number	Storage place	Pack	Temperature, °C	Relative humidity, %
1.	Thermostats	Plastic bags	0±2	
2.	»	Same	15±2	
3.	»	»	30±2	
4.	Exicators in thermostat	Open glass containers	15±2	50
5.	Same	Same	15±2	75
6.	»	»	15±2	90

4. Discussion

During the storage process gradual reduction of the compound, feed moisture was observed under W = 50 % and in plastic bags under t = 30 °C (Table 4). Under relative air humidity of 75 and 90 % moisture content during the storage period increased up to 9.8 and 10.5 correspondingly. Under W = 90 % in the top layer of the compound feed during the third month of the storage period a touch of mold appeared on the surface of the granules, which covered the surface completely by the end of the experiment and penetrated inside the granules [14, 15]. Extruded feed at the beginning of the storage period was characterized by relatively low contamination with fungal and bacterial microflora (see Table 4).

Experimental storage conditions number 1-5 did not contribute to the development of microflora during storage; there was some tendency to decrease in the content of spores of fungi and bacteria in the compound feed. Under W = 90%, due to intensive processes of moisture sorption and the development of microflora in the upper layer of compound feed, the number of fungal spores increased to 8805 units in 1 g. At the same time, the number of bacteria remained almost unchanged [15].

Despite the content of raw materials of animal origin in the extruded compound feed, it was characterized by relatively good indicators of the quality of fat and total acidity

Table 4: Change of moisture and microflora of the extruded compound feed during the storage period.

Storage period, months	Storage conditions					
	t = 0 °C	t =15 °C	t = 30 °C	W = 50 % t = 15 °C	W = 75 % t = 15 °C	W = 90 % t = 15 °C
Moisture (initial 9.4)						
1.	9.4	9.4	9.1	9.0	9.4	9.8
2.	9.5	9.5	8.3	8.3	9.4	-
3.	9.6	9.4	8.1	8.2	9.5	10.0
4.	9.5	9.4	7.9	8.0	9.8	10.5
Number of mold fungus spores, units/g (at the beginning of the experiment it was 23.0)						
1.	8.0	11.0	19.0	11.0	12.0	28.0
2.	2.0	7.0	24.0	11.0	13.0	55.0
4.	2.0	3.0	1.0	5.0	9.0	8805.0
Bacterial number, ths per 1 g (initial 22.5)						
2.	26.0	28.0	27.0	21.0	65.0	-
3.	20.0	25.0	16.0	24.0	28.0	35.0
4.	14.0	16.0	9.0	12.0	30.0	36.0

Table 5: Change of the total acidity and fat quality during the extruded compound feed storage.

Storage period, months	Storage conditions					
	t = 0 °C	t = 15 °C	t = 30 °C	W = 50 % t = 15 °C	W = 75 % t =15 °C	W = 90 % t = 15°C
Total acidity, °H (initial 4.3)						
1.	4.2	4.2	4.3	-	4.3	4.3
2.	4.3	4.0	4.6	4.0	4.4	4.5
3.	4.6	4.5	4.9	4.4	4.7	4.8
4.	4.4	4.6	5.2	4.5	5.0	5.2
Fat acidity value, *mg* KOH/g (initial 26.0)						
1.	30.0	26.0	27.0	-	-	-
2.	29.0	26.0	30.0	28.0	29.0	31.0
3.	30.0	28.0	30.0	29.0	32.0	33.0
4.	29.0	28.0	32.0	26.0	34.0	37.0
Fat peroxide value, % iodine (initial 0.10)						
1.	0.19	0.17	0.25	-	-	-
2.	0.15	0.19	0.34	0.22	0.21	0.17
3.	0.11	0.28	0.52	0.30	0.28	0.29
4.	0.13	0.27	0.40	0.28	0.31	0.24

(Table 5), which was due to the use of quality raw materials. During the storage period, there was a slight increase in the content of carboxyl groups in the compound feed, which proceeded more intensively under unfavorable storage conditions: under t = 30 °C, W = 90% and W=75 %.

Lipids were also stable in the composition of the extruded compound feed. At the initial value of 7.1%, the mass fraction of fat during the experiment ranged from 7.2 to 6.9. However, there has been a deterioration in their quality. Hydrolytic processes proceeded very slowly in the fats of the extruded compound feed, which can be explained by the inactivation of lipase and lipophosphotase enzymes during extrusion. There was a tendency to increase the hydrolysis of fats with increase of the storage temperature up to 30 °C, however, the increase in air and feed humidity led to considerable acceleration of lipid hydrolysis. According to the recommendations for storing feed for sturgeon fish, compound feed is not harmful when the acid number is below 70-100.

The oxidation processes proceeded more intensively in the compound feed. The formation of peroxides increased with the growth of the storage temperature, as evidenced by the maximum peroxide value (Table 5), constituting 0.19 at 0 t °C, 0.28-0.31 at 15 °C regardless of air and feed humidity, and 0.52% of iodine at 30 °C. The maximum number of peroxides under 0 °C was observed at the end of the first month, under 15 and 30 °C - at the end of the third month of storage.

5. Conclusion

According to the recommendations for storing the feed for sturgeon fish, feed fat should be considered toxic with a peroxide value above 0.30. According to the experimental results, it can be seen that at the temperature of about 0 °C, the extruded compound feed can be stored for up to 4 months. Given that the peroxide value at 15 °C in the third month, and at 30 °C in the second month of storage reached the maximum permissible norm, the storage period of the extruded compound feed at the temperature of about 15 °C should be limited to two months, and at higher to one month. Thus, we can conclude that the obtained recipe mixtures prepared according to the proposed technology have increased storage capacity compared to traditional ones and can be recommended for industrial use.

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Conflict of Interest

The authors have no conflict of interest to declare.

References

[1] Vasilyeva, L., Elhetawy, A., Sudakova, N. (2019). History, Current Status, and Prospects of Sturgeon Aquaculture in Russia. *Aquaculture Research,* pp. 1-15. DOI: 10.1111/are.13997.

[2] Bronzi, P., Rosenthal, H., Gessner, J. (2011). Global sturgeon aquaculture production: An overview. *Journal of Applied Ichthyology,* vol. 27, pp. 169 - 175. DOI: 10.1111/j.1439-0426.2011.01757.x.

[3] Hoseinifar, S. H., Ringø, E., Masouleh, A., Esteban, M., (2014). Probiotic, prebiotic and synbiotic supplements in sturgeon aquaculture: A review. *Reviews in Aquaculture.* DOI: 10.1111/raq.12082.

[4] Cao, L., Naylor, R., Henriksson, P., Leadbitter, D., Metian, M., Troell, M., Zhang, W. (2015). Global food supply. *China's aquaculture and the world's wild fisheries. Science,* vol.347, pp. 133-135. DOI:10.1126/science.1260149.

[5] Mo, W., Man, Y., Wong, M. (2017). Use of food waste, fish waste and food processing waste for China's aquaculture industry: Needs and challenge. *The Science of the total environment,* vol. 613-614. 635-643. DOI: 10.1016/j.scitotenv.2017.08.321.

[6] Salemdeeb, R., zu Ermgassen, Erasmus & Kim, Mi & Balmford, Andrew & Al-Tabbaa, Abir. (2016). Environmental and health impacts of using food waste as animal feed: A comparative analysis of food waste management options. *Journal of Cleaner Production,* DOI: 140. 10.1016/j.jclepro.2016.05.049.

[7] Chiu, A., & Li, Luping & Guo, Shujing & Bai, Junfei & Fedor, Chris & Naylor, Rosamond. (2013). Feed and fishmeal use in the production of carp and tilapia in China. *Aquaculture,* vol. 414-415, pp. 127-134. DOI: 10.1016/j.aquaculture.2013.07.049.

[8] Cheng, Zhang & Mo, Wing & Man, Yu & Nie, Xiangping & Li, Kai-Bing & Wong, Ming. (2014). *Replacing fish meal by food waste in feed pellets to culture lower trophic level fish containing acceptable levels of organochlorine pesticides*: Health risk assessments. Environment International, vol. 73, pp. 22--27. DOI: 10.1016/j.envint.2014.07.001.

[9] Rad, F., Köksal, G., Kindir, M. (2003). Growth Performance and Food Conversion Ratio of Siberian Sturgeon (Acipenser baeri Brandt) at Different Daily Feeding Rates. *Turkish Journal of Veterinary and Animal Sciences*, vol. 27, pp. 1085-1090.

[10] Lee, S., Zhao, H., Li, Y., Binkowski, F., Deng, D., Shepherd, B., Hung, S., Bai, S. (2018). Evaluation of formulated feed for juvenile lake sturgeon (Acipenser fulvescens) based on growth performance and nutrient retention. *North American Journal of Aquaculture*, vol. 80. DOI: 10.1002/naaq.10026.

[11] Bauman, J., Woodward, B., Baker, E., Marsh, T., Scribner, K. (2016). Effects of Family, Feeding Frequency, and Alternate Food Type on Body Size and Survival of Hatchery-Produced and Wild-Caught Lake Sturgeon Larvae. *North American Journal of Aquaculture,* vol. 78, pp. 136-144. DOI: 10.1080/15222055.2015.1125979.

[12] Kolman, R., Kapusta, A. (2018). *Food Characteristics and Feeding Management on Sturgeon with a Special Focus on the Siberian Sturgeon*. DOI: 10.1007/978-3-319-61676-6_5.

[13] Mazurkiewicz, J., Przybył, A., Golski, J. (2009). Zastosowanie wybranych komponentów białkowych pochodzenia roślinnego w paszach dla jesiotra syberyjskiego, Acipenser baerii Brandt. *Archives of Polish Fisheries,* vol. 17, pp. 45-52. DOI: 10.2478/v10086-009-0002-3.

[14] Shevtsov, A.A., Vasilenko, V.N., Ozjerel'eva, O.N. (2011). *Modelling feed mixes. Tutorial.* Student's guidebook. Voronezh.

[15] Shevtsov, A.A., Vasilenko, V.N., Ozjerel'eva, O.N., Novikova, Ju.S. (2009). The effect of storage conditions on the quality of complete extruded compound feed for sturgeon fish. *Grain storage and processing,* №10 (124), Pp. 28-31.