Nutritional value and economic efficiency of production of complete compound feeds based on blue lupine

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Abstract. This paper presents ways to improve nutritional properties and reduce costs in the production of complete compound feeds for rainbow trout, in the structure of recipes of which blue lupine was introduced both in native and shell-less form, subjected to extrusion processing. Based on the results of the work, the price of one kilogram of standard control compound feed was determined: 82 rubles 76 kopecks. The inclusion of 9% blue lupine with a shell in the 2nd experimental recipe reduced the cost to 76 rubles 41 kopecks, which is 7.67% or 6 rubles 35 kopecks below the control option. The best result was achieved when using 21% blue lupine without a shell: the cost of compound feed was 70 rubles 46 kopecks per kilogram, which is 14.86% or 12 rubles 3 kopecks cheaper than the control. The cost of the 4-experiment full-fledged compound feed, the structure of which contained lupine without a shell in the amount of 26%, did not exceed 64 rubles 03 kopecks. This is 22.63% or 18 rubles 73 kopecks less compared to the control option. For enterprises engaged in the production of compound feeds, the level of profit from sales is critically important. Calculations showed that the 2-experiment compound feed provided a profit of 13.85% higher than the control one, the 3-experiment - by 26.62%, and the 4-experiment - by 40.69%. The profitability of the production of experimental compound feeds using blue lupine increased from 56% to 101%, which indicates a reduction in costs due to a more competitive price for compound feed with blue lupine. The findings highlight the importance of research to develop new ways to reduce the cost of aquaculture feed using blue lupine.

1 Introduction

The efficiency of feed production is a critically important aspect in animal husbandry. The main task in this case is not only to reduce the cost of producing compound feeds, but also to ensure their high-quality composition, which contributes to the production of high-quality products of animal origin, in particular, rainbow trout [1]. The efficiency of feed production lies in this sector effectiveness. Undoubtedly, the efficiency of feed production can be

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assessed by its ability to meet the needs of animal husbandry, while minimizing the monetary costs of producing one kilogram of compound feed [2]. The topics of efficiency in feed production have been studied less deeply than in other areas of agriculture. This is partly due to the peculiarities of this industry: practically no marketable products are formed in it [3]. As a result, it becomes difficult to calculate profit and profitability, which are key performance indicators. It is possible to objectively determine the cost of compound feed and its economic efficiency only in the context of a specific enterprise, where it is necessary to constantly compare the costs of independent production or purchase of ready-made feed according to a specific recipe [4]. Specialists need to constantly analyze the economic feasibility of using compound feed produced inside the farm and the possibility of additional income through cost optimization for its production. This can be achieved by replacing some expensive components of animal and soy feeds with alternative protein sources, such as vegetable protein from blue lupine [5, 6]. Blue lupine, which has a high content of easily digestible protein, can be an optimal component for rainbow trout feed. Another prominent Russian scientist, D.N. Pryanishnikov, noted that one should not forget about the expediency of using biological nitrogen lupin, which makes it possible to obtain grain feed at cost cheaper than cereals and some legumes, which have a high content of crude protein necessary for feed production [7, 8, 9, 10]. Therefore, it is worth increasing the production of high-quality grain forage with a high protein content, which is best provided by blue lupine, which contains 32-40% protein and is superior to soy protein in some amino acids such as leucine, isoleucine, and valine [11, 12]. The undoubted advantage of blue lupine is that 90% of its protein is easily digestible, water-soluble fractions, and the grain contains a small amount of trypsin inhibitors, which allows its use in commercial trout farming. It is important to consider this when preparing compound feed recipes, since the inadequate protein composition of fish feed leads to overconsumption of feed and a decrease in its productivity. The main objective of commercial trout farming is to grow fish quickly and at low cost, and balanced feeding plays a key role in this.

The purpose of the study is to develop new ways to reduce the cost of complete compound feeds for rainbow trout by integrating blue lupine into feed formulations, both in native and shell-less form, subjected to extrusion processing.

2 Materials and Methods

During the experiment, blue lupine of the Vityaz variety was used as a research material, both in the shell and without it. Based on it, 3 variants of recipes for complete mixed feeds for trout have been developed, which differ in the best nutritional values.

The following ingredients were used to create full-fledged feed recipes: blue lupine in and without a shell, wheat, soy cake, sunflower cake, corn, fish meal, premixes, and tricalcium phosphate.

For an accurate comparative analysis of experimental diets, a control complete feed for trout with similar components was prepared. Its composition includes soy and its processed products (cakes and meal) as a vegetable protein source. Fish meal (60-65%) was used as an animal protein source.

The biochemical analysis of the nutritional properties of compound feed was performed on an automated Agilent 1100 liquid chromatograph (USA) and an INFRASKAN-M spectral analyzer, modification 4200 (EKAN LLC, St. Petersburg).

The chemical composition of blue lupine was studied in accordance with standard methods of zooanalysis. The degree of alkaloid content in blue lupine was analyzed in detail in the Laboratory of Plant Physiology of the Lupin Research Institute, based on a specially developed methodology of the institute. The extrusion process on a TSE-85 feed extruder was used for the barothermic treatment of blue lupine with and without a shell, as well as

full-fledged compound feeds obtained from these materials.

The structure of the control and studied extruded compound feed with lupine with shell and without it is shown in Table 1.

Table 1. Experiment scheme.

Options	Compound feed structure
1-control	Soybean meal-18%, Sunflower cake-12%, Corn-13%, Wheat-12%, Fish meal-43%, Tricalcium phosphate-1%, Premix-1%.
2-experiment	**Lupine in a shell-9%,** Soy cake-16%, Sunflower meal-11%, Corn-12%, Wheat-12%, Fish meal-38%, Tricalcium phosphate-1%, Premix-1%.
3-experiment	**Shell-free lupine- 21%,** Soybean meal-12%, Sunflower meal-10%, Corn-9%, Wheat-12%, Fish meal-34%, Tricalcium phosphate-1%, Premix-1%.
4-experiment	**Shell-less lupine-26%,** Soy cake-10%, Sunflower meal-10%, Corn-8%, Wheat-15%, Fish meal-29%, Tricalcium phosphate-1%, Premix-1%.

During the dry extrusion process, when we worked with blue lupine and mixed feed, the moisture content of the feedstock was 12-16%. The effect on the specific amount of feed lasted less than 30 seconds, during which the raw materials undergo several stages of processing:

1. Heat treatment. At a temperature of 120-175°C, the digestibility of nutrients improves, as well as an increase in the biochemical characteristics of blue lupine and a decrease in the level of alkaloids.
2. Sterilization and disinfection. High temperature and pressure ensure the complete destruction of microbes in the feed, effectively suppressing enzymatic processes and reducing the activity of bacteria and fungi to safe levels.
3. Increase in volume. This is achieved by destroying the cell walls, changing the structure of granules and breaking the starch molecular chain, which ultimately increases the energy value of the product.
4. Grinding and mixing. Although some of the raw materials are pre-crushed, this operation continues in the heat chambers of the extruder until the product becomes homogeneous.
5. Dehydration. In 30 seconds, the moisture level in the extruder is reduced by 50% of the initial value.
6. Stabilization. High temperature and pressure neutralize the action of enzymes that can lead to product spoilage.

3 Results and Discussion

Every year there is an increase in purchase prices for raw materials traditionally used for the production of complete feed for trout, which strongly indicates the importance and necessity of our research to study and develop new ways to reduce the cost of feed for aquaculture by including blue lupine, subjected to extrusion processing, in feed recipes. The use of extruded blue lupine with and without a shell, presented in this study (Table 2), will reduce the cost of feed, reduce unit costs and generate additional profits in trout farming.

According to the ratio of the feed components included in the composition of complete compound feeds and their cost, the economic parameters of efficiency were calculated. The cost of 1 kg of compound feed, profit, and profitability of its production were calculated.

Table 2. Economic parameters of the efficiency of production of complete feed, 1 kg/ rub.

Indicators	Full-fledged complete feed							
	1 Control compound feed		2 Experiment Native lupin- 9%		3 Experiment Lupin without shell- 21%		4 Experiment Lupin without shell – 26%	
	g	*rub.*	*g*	*rub.*	*g*	*rub.*	*g*	*rub.*
Soy cake	180	11.60	160	10.31	120	7.73	100	6.44
Corn	130	3.46	120	3.20	90	2.40	80	2.13
Wheat	120	2.97	120	2.97	120	2.97	150	3.72
Sunflower cake	120	3.21	110	2.94	100	2.68	100	2.68
Premix	10	1.06	10	1.06	10	1.06	10	1.06
Tricalcium phosphate	10	0.25	10	0.25	10	0.25	10	0.25
Fish meal (60-65%)	430	60.20	380	53.20	340	47.60	290	40.60
Blue lupine	-	-	90	2.48	210	5.78	260	7.15
Cost, 1/*kg*	82.76		76.41		70.46		64.03	
Profit, *rub.*	46.20		52.60		58.50		65.00	
Profitability, *%*	56		69		83		101	

The control compound feed was developed on the basis of feeds used in trout farming, and contained protein of plant and animal origin. Fish meal in the amount of 430 g was used as a source of protein of animal origin, the price of which was 60 rubles 20 kopecks. Soy cake and sunflower cake in the amount of 180 g and 120 g, respectively, or 11 rubles 60 kopecks, and 3 rubles 21 kopecks, were used as cheaper vegetable protein. The structure of the compound feed also included cereals: forage wheat accounted for 120 g, the price was 2 rubles 97 kopecks; corn 130 g or 3 rubles 46 kopecks. The complete feed is balanced in terms of macro-microelements and vitamins by including premix P-5-1 and tricalcium phosphate in the recommended amount of 1% input into the feed structure or 10 g, respectively. The share of premix in the structures of compound feeds accounted for in monetary terms 1 rub. 6 kopecks, and tricalcium phosphate - 25 kopecks. The price of 1 kg of complete 1-control compound feed was 82 rubles 76 kopecks.

Experimental recipes for complete compound feeds were nutritionally balanced according to the standards for feeding trout [13]. The main task in the development of experimental full-fledged compound feeds was to replace expensive feed components, such as fish meal and oilcakes, with blue lupine with and without a shell. The structure of the 2-experiment compound feed recipe contained feeds and additives identical to the control compound feed. The inclusion of blue lupine with a shell in the amount of 90 g or 2 rubles 48 kopecks. It was possible to reduce the content of fishmeal by 5%, which amounted to 380 g in physical terms, or 53 rubles 20 kopecks. The use of lupine with a shell allowed the content of soybean and sunflower oilcake to decrease by 2% and 1%, their amount in the recipe was 160 g and 110 g, or 10 rubles 31 kopecks. The use of lupine made it possible to replace corn by 1%, the amount of corn in the recipe was 120 g or 3 rubles 20 kopecks. Due to the use of blue lupine with a shell in the amount of 9% in the structure of the 2-experiment recipe, the cost of 1 kg of compound feed was 76 rubles 41 kopecks, which is 7.67% or 6 rubles 35 kopecks cheaper than the control.

When creating the 3-experiment recipe for complete compound feed, blue lupine was used without a shell. The content of blue lupine without a shell in the structure of the compound feed recipe was 210 g in the amount of 5 rubles 78 kopecks, which reduced the content of fishmeal by 9%, its amount in the recipe was 340 g or 47 rubles 60 kopecks. The

content of soybean cake and sunflower cake decreased by 6% and 2%, in the structure of compound feed they amounted to 120 g and 100 g or 7 rubles 73 kopecks and 2 rubles 68 kopecks. The corn content decreased by 4%, its quantity amounted to 90 g or 2 rubles 40 kopecks. The content and cost of feed wheat remained at the level of the control recipe. The use of blue lupine without a shell in an amount of 21% in the recipe structure made it possible to create compound feed costing 70 rubles 46 kopecks per 1 kg, which is 14.86% or 12 rubles 3 kopecks cheaper than the control.

4-experiment full-fledged compound feed contained in the recipe 250 g of blue lupine without a shell in the amount of 6 rubles 88 kopecks. The inclusion of lupin in the recipe made it possible to replace fishmeal by 14%, its amount was 290 g or 40 rubles 60 kopecks. The amount of soybean and sunflower oil cake decreased by 8% and 2%, respectively, and amounted to 100 g or 6 rubles 44 kopecks and 100 g or 2 rubles 64 kopecks. The corn content also decreased by 5%, to 80 g or 2 rubles 13 kopecks. The complete compound feed, like the control one, is balanced in terms of macro-microelements and vitamins with the inclusion of premix P-5-1 and tricalcium phosphate. The share of premix in the feed structure was 1 rub. 6 kopecks, tricalcium phosphate - 25 kopecks. As a result, the cost of the experiment complete feed was at the level of 64 rubles 03 kopecks. Compared to the control, the 4-experiment was 22.63% or 18 rubles 73 kopecks cheaper.

Undoubtedly, an important indicator for enterprises engaged in the production of compound feeds is the profit from their sale, as this is the main indicator of whether the production of experimental compound feeds with blue lupine can be considered effective. When calculating the profit from the sale of control and experimental compound feeds, the profit was higher in the 2-experiment relative to the control by 13.85% or 6 rubles 4 kopecks, in the 3-experiment - by 26.62% or 12 rubles 3 kopecks, and in the 4-experiment - by 40.69% or 18 rubles 8 kopecks. As a result of the study, it was confirmed that the profitability of the production of the developed experimental full-grain compound feeds with blue lupine will increase from 56% in the control compound feed to 69% in the 2-experiment compound feed, in the 3 and 4-experiment - to 83% and 101%, respectively. At the same time, the cost reduction is due precisely to the competitive cost of raw materials - blue lupine. Therefore, blue lupine must be included in complete feed for trout as a source of vegetable protein to increase profitability.

4 Conclusion

Thus, our study demonstrates that the key task of developing experimental full-fledged compound feeds is to replace expensive ingredients such as fish meal and oilcakes with blue lupine, both in the shell and without it. The profit from the sale of compound feeds is becoming a critically important indicator for manufacturing enterprises, since it determines the effectiveness of using blue lupine in the structure of complete compound feeds. Profitability analysis showed that in the second experiment compound feed the profit exceeds the control by 13.85% (6 rubles 4 kopecks), in the third - by 26.62% (12 rubles 3 kopecks), and in the fourth - by 40.69% (18 rubles 8 kopecks). The profitability of the production of experiment compound feeds with blue lupine increases from 56% in the control version to 69% in the second experiment and reaches 83% and 101% in the third and fourth, respectively. The cost reduction is due to the competitive price of blue lupine. Thus, the integration of blue lupine into trout feed as a source of vegetable protein will significantly increase their profitability without reducing the nutritional properties of complete feed.

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