The use of white lupine in complete feed for trout

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Abstract. The article presents the material on the most up-to-date, the global problem of protein deficiency in complete feedback for fish. One of the ways to solve this problem may be the use of white lupine (Lupinus Albus) in the structures of feed recipes. An important condition for the successful development of fish farming and the implementation of planned products for the production of products, to ensure food safety, occupy feeding issues. The decision of this issue puts a number of tasks to ensure feedback, rational methods of production, on the basis of advanced scientific achievements that contribute to the technological, economic development of the industry. Therefore, in experienced formulations of complete feed, the main task was to replace the white most expensive protein component into Lupine, that is, fish flour. In the first experienced recipe, the amount of lupine natives was 10%, which made it possible to reduce the fisherous flour content by 7%. The second experimental recipe in its structure contained lupine white without a shell in an amount of 22%, this made it possible to reduce the content of fish flour by 14%. The third experienced rechart contained Lupine without a shell of 25%, which made it possible to reduce the content of fish flour by 19%. Consequently, the use of white lupine in the formulations of complete feed, makes it possible to improve their nutritional value. And the use of lupine without a shell makes it possible to replace high-fingered animal feed in greater volume.

1. Introduction

The main task of commercial trout farming is fish cultivation in the shortest possible time with minimal costs. One of the main factors affecting the rapid fish growth is the maintenance of optimal growing conditions and the full-value of feeding. The obvious urgency of the problem of intensive reproduction of salmonid fish natural populations causes the need to improve the technology of their breeding and cultivation with the use of full-fledged compound feeds and modern technical means of production [1, 2].

With intensive cultivation of fish, their full-fledged balanced feeding becomes of paramount importance. Plant-based products that are not characteristic of the natural food of predatory fish are economically advantageous, alternative animal protein source. In the industrial cultivation of fish for the fixing of plant proteins, the use of biologically active substances is of great importance [3, 4].

There is practically no experience of using lupin as a source of vegetable protein in fish feeding, therefore, it is of interest to study the effect of lupin processing products as part of compound feed on the fish growth, development, and marketability. It was decided to use white lupin as a vegetable protein
in the feed for rainbow trout. It is of interest to study the effect of feed with the inclusion of lupin processing products on the physiological state of fish and the profitability of its cultivation. Indicators of the timing of the fish growing cycle completion, the costs for optimal conditions of its maintenance, the quality and weight of the fish being grown, depending on the feed used, are of great importance in research [5, 6].

Complete feeding of trout with compound feeds is one of the main conditions for fish growing in the conditions of industrial fisheries. Trout feeding should take place in a timely manner and include all the necessary substances: fats, carbohydrates, vitamins, mineral salts, proteins with a set of essential amino acids, etc. [7, 8].

Fish feed in granular form of animal origin is popular. We are talking about meat, offal, and animal fat [9, 10].

The main direction in the study of complete feeds in trout farming is the search for a replacement of fish meal with alternative sources of protein. As an alternative source of protein, non-traditional types of feed raw materials of plant origin were considered, such as: native white lupin and white lupin without a shell, which in turn made it possible to establish the possibility of using it in the production of full-fledged compound feeds for rainbow trout [11, 12].

To develop complete recipes, it is necessary to operate with the norms of the trout’s nutritional needs [13, 14, 15, 16].

2. Materials and methods of research

The objects of research are white lupin and recipes of complete compound feeds with the inclusion of different amounts of white lupin. Extruded lupin, native, and shell-less lupin with different percentages of them were used in the development of the recipe for full-fledged compound feed. 15 recipes with different percentages of white lupin have been studied and developed. The scheme of white lupin inclusion is shown in Table 1.

| Variants, No. | Type of processing | Lupin content in the recipe, % |
|---------------|--------------------|-------------------------------|
| Control       | -                  | 0                             |
| 1             | Extrusion, native lupin | 10                            |
| 2             | Extrusion, native lupin | 15                            |
| 3             | Extrusion, native lupin | 17                            |
| 4             | Extrusion, native lupin | 20                            |
| 5             | Extrusion, native lupin | 22                            |
| 6             | Extrusion, lupin without shell | 25                           |
| 7             | Extrusion, lupin without shell | 15                           |
| 8             | Extrusion, lupin without shell | 17                           |
| 9             | Extrusion, lupin without shell | 19                           |
| 10            | Extrusion, lupin without shell | 22                           |
| 11            | Extrusion, lupin without shell | 24                           |
| 12            | Extrusion, lupin without shell | 26                           |
| 13            | Extrusion, lupin without shell | 27                           |
| 14            | Extrusion, lupin without shell | 28                           |
| 15            | Extrusion, lupin without shell | 29                           |

Based on the obtained biochemical data of white lupine and feed components, recipes for full-fledged feed have been developed.

Generally accepted methods of zooanalysis were used in the work:
- Initial moisture is determined according to GOST R 57059-2016 Feed, compound feed, feed raw materials. Express method for moisture determination;
- Fiber is determined according to GOST 31675-2012 Feed. Methods for crude fiber content determination according to Henneberg and Shtoman;
- Raw ash is determined according to GOST 26226-95 Feed, compound feed, feed raw materials. Methods for crude ash determination;
- Fat determination is carried out according to the fat-free residue according to GOST 13496.15-97. Feed. Compound feed. Feed raw materials;
- Protein is determined according to GOST 13496.4-93 Feed, compound feed, feed raw materials. Methods for determination of nitrogen and crude protein content;
- To determine calcium, the oxalic method will be used GOST 26570-95 Feed, compound feed, feed raw materials. Methods for calcium determination;
- To determine phosphorus, the colorimetric method is used GOST 26657-97 Feed, compound feed, feed raw materials. Method for phosphorus content determination.

Nitrogen-free extractive substances (NFES) will be determined by the calculation method. The remaining macronutrients, trace elements, and vitamins that are not determined by standard methods will be considered according to the declared data of the feed manufacturer.

In our experience, the process of dry extrusion will be used with an initial moisture content of raw materials of 12-16%, the effect on the specific amount of feed took less than 30 seconds. During this time, the raw material will undergo several stages of processing:
- Thermal processing at a temperature of 120-175°C, which will increase the digestibility of nutrients, improve the taste qualities of compound feed, including reducing the content of antinutrients;
- Sterilization, disinfection. Extrusion will either completely destroy or suppress the activity of bacteria and fungi to acceptable levels;
- Increase in volume due to the rupture of cell walls, the destruction of the structure of granules and the rupture of the starch molecular chain, which contributes to an increase in the energy value of the product;
- Grinding, mixing. The product becomes completely homogeneous;
- Dehydration: in 30 seconds, the moisture content will decrease by 50% of the initial;
- Stabilization - the destructive effect of enzymes is neutralized.

3. Research results
For the preparation of recipes, the norms of trout nutritional requirements were taken, based on an in-depth analysis of literature data, scientific research, and achievements in the practical production of complete feed [13, 14, 15].

To create a balanced recipe, it is necessary to perform and observe a wide range of physiological and biochemical studies, which are aimed at studying the fish needs in obtaining nutrients, and on the other hand, to study the nutritional value of feed products, which are characterized by the ability to meet the needs of the body in necessary nutrients. Nutritionally balanced, full-fledged compound feed should contain a variety of feeds and additives. The variety of feeds to a greater extent prevents the nutritional deficiency of individual nutrients and makes the feed more balanced and nutritionally full-fledged. The nutritional value of the calculated complete feed is presented in Table 2.

| Table 2. Nutritional value of complete compound feeds for trout. |
|------------------------|----------------|----------------|----------------|----------------|
| Indicators | Complete feed, CF | CF Lupin with shell-10% | CF Lupin without shell-22% | CF Lupin without shell-25% |
| EFU | 1.31 | 1.31 | 1.30 | 1.30 |
| EE, MJ | 13.20 | 13.06 | 13.00 | 12.80 |
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| Nutrient               | Recipe 1 | Recipe 2 | Recipe 3 | Recipe 4 |
|------------------------|----------|----------|----------|----------|
| Dry matter, g          | 877.90   | 880.90   | 881.40   | 883.70   |
| Crude protein, g       | 403.50   | 403.91   | 403.91   | 404.00   |
| PP, g                  | 343.00   | 340.29   | 324.89   | 315.22   |
| Lysine, g              | 64.60    | 69.28    | 54.04    | 55.93    |
| Methionine+cystine, g  | 106.67   | 116.87   | 99.30    | 113.33   |
| Tryptophan, g          | 103.22   | 114.88   | 98.76    | 114.34   |
| Raw fat, g             | 95.03    | 99.24    | 93.17    | 104.58   |
| Crude fiber, g         | 14.08    | 12.84    | 11.50    | 11.54    |
| NFES, including, g     | 125.38   | 73.85    | 101.74   | 88.04    |
| Starch, g              | 126.21   | 119.46   | 137.10   | 126.62   |
| Sugar, g               | 95.12    | 109.58   | 85.75    | 87.77    |
| Calcium, g             | 77.80    | 75.59    | 67.50    | 70.38    |
| Phosphorus, g          | 128.60   | 130.35   | 122.05   | 135.48   |
| Magnesium, g           | 78.35    | 87.79    | 75.46    | 87.51    |
| Potassium, g           | 14.95    | 14.11    | 12.42    | 12.57    |
| Sulfur, g              | 28.51    | 31.27    | 27.18    | 31.04    |
| Iron, mg               | 56.12    | 45.18    | 39.60    | 33.38    |
| Copper, mg             | 12.52    | 12.34    | 9.27     | 8.33     |
| Zinc, mg               | 61.68    | 55.38    | 51.37    | 47.86    |
| Manganese, mg          | 17.72    | 19.61    | 20.04    | 20.09    |
| Cobalt, mg             | 4.28     | 6.38     | 4.69     | 4.56     |
| Iodine, mg             | 37.90    | 44.20    | 35.37    | 41.72    |
| Carotene, mg           | 6.66     | 7.13     | 6.47     | 7.44     |
| Vitamin A, MU          | 18.13    | 19.41    | 17.69    | 20.30    |
| Vitamin D, MU          | 42.80    | 38.66    | 31.93    | 29.72    |
| Vitamin E, mg          | 10.62    | 7.92     | 7.16     | 5.90     |
| B1, mg                 | 1.91     | 1.82     | 1.33     | 1.09     |
| B2, mg                 | 3.02     | 2.64     | 2.07     | 1.72     |
| B3, mg                 | 7.27     | 5.90     | 4.94     | 4.10     |
| B4, mg                 | 73.77    | 28.93    | 48.01    | 37.86    |
| B5, mg                 | 104.12   | 126.55   | 73.25    | 59.52    |
| B12, mcg               | 119.06   | 102.59   | 81.55    | 68.20    |

In general, the recipes are balanced in terms of basic nutrients. The amino acid composition of the feed was considered in terms of total nutrition, minerals, protein, fat. Premix P-5-1 and tricalcium phosphate were used to balance recipes for macro and microelements, as well as vitamins.

The main (control) and experimental full-fledged compound feeds were manufactured at the factory of the manufacturer of premixes, PVMC, and compound feeds - CJSC Premix, city of Timashevsk, Krasnodar Territory.

In this experiment, various components of a full-fledged compound feed were used: soybean meal, sunflower meal, corn, wheat, fish flour 60-65%, premix P-5-1, tricalcium phosphate.

When creating recipes, a full-fledged balanced compound feed of the farm JSC "Breeding trout breeding plant "Adler" was taken as a basis. Based on it, 15 recipes of compound feeds were created, where some of the high-protein animal and vegetable feeds were partially or completely replaced with white lupin. In the future, the obtained feed recipes were subjected to biochemical analysis. According to the data obtained, 3 recipes were selected that are most optimally suitable for rainbow trout feeding.

The main ration of the enterprise includes vegetable and animal feed, as well as premix and mineral additives. In which 17% accounted for the soybean meal share. The amount of sunflower meal is 16%, corn - 14%, wheat - 7%. The source of protein of animal origin was fish meal (60-65%), in the recipe of full-fledged compound feed it accounted for 44%. The deficiency of vitamins, trace elements, and
macronutrients of calcium and phosphorus in the recipe was compensated by the introduction of tricalcium phosphate in an amount of 1% and a premix of 1%, according to the recommendations.

In the experimental recipes of full-fledged compound feeds, the main task was to replace the most expensive protein component, that is, fish meal, with white lupin. In the first experimental recipe, the amount of native lupin was 10%, and fish meal (60-65%) 37%. Soybean meal - 20%, sunflower meal - 16%, corn - 5%, wheat - 10%, tricalcium phosphate in the amount of 1% and premix - 1%. Since this experimental recipe used native lupin with a shell, the replacement of fish meal with lupin increased the fiber content in the recipe. It is necessary for the proper implementation of digestive processes in fish. Which in turn gives volume to concentrated feeds. It enhances intestinal peristalsis and partially activates the digestion of essential nutrients. But its content should not exceed 3%. Therefore, the introduction of 10% of lupin with a shell into the structure of the recipe made it possible to reduce the content of fish meal by 14% (60-65%), but increased the content of meals.

The second experimental recipe in its structure contained white lupin without a shell in an amount of 19%, soybean meal - 16%, sunflower meal - 16%, corn - 9%, wheat - 5%, tricalcium phosphate in the amount of 1% and premix - 1%. The introduction of lupin without a shell in the recipe structure allowed to reduce the content of fish meal by 14%, soybean meal by 1%, corn by 5%, wheat by 2%.

The third experimental recipe contained lupin without a shell in the amount of 22%. Fish meal (60-65%) - 30%, soybean meal - 16%, sunflower meal - 16%, corn - 9%, wheat - 5%, tricalcium phosphate in the amount of 1% and premix - 1%. The introduction of lupin without a shell in the recipe structure allowed to reduce the content of fish meal by 14%, soybean meal by 1%, corn by 5%, wheat by 5%.

Vegetable protein in comparison with animal one is digested in salmon fish a little worse, nevertheless, the lower cost of feed is due to the use of these proteins, compared with feeds that include animal protein in their diet, so the use of compound feeds with vegetable protein from lupine is justified.

The recent increase in prices for raw materials traditionally used for the manufacture of compound feeds for fish indicates the importance of the work being done. Reducing the cost of feed for aquaculture is of great importance. The use of white lupine, presented in this study, will reduce feed costs per unit of production and achieve significant gains. The cost of full-fledged compound feeds is presented in Table 3.

| Indicators      | Main compound feed of the farm | Experimental Native lupin-10% | Experimental Lupin without shell-22% | Experimental Lupin without shell – 25% |
|-----------------|-------------------------------|-------------------------------|-------------------------------------|-------------------------------------|
| Soy cake        | g | rub. | g | rub. | g | rub. | g | rub. | g | rub. |
| Corn            | 70 | 1.73 | 100 | 2.48 | 90 | 2.40 | 80 | 2.13 |
| Wheat           | 200 | 12.89 | 160 | 10.31 | 170 | 10.95 |
| Sunflower cake  | 160 | 4.28 | 160 | 4.28 | 160 | 4.28 | 180 | 4.82 |
| Premix          | 25 | 1.06 | 10 | 1.06 | 10 | 1.06 | 10 | 1.06 |
| Tricalcium phosphate | 0.25 | 10 | 1.06 | 0.25 | 10 | 0.25 |
| Fish meal       | 440 | 61.6 | 370 | 51.80 | 300 | 42.00 | 250 | 35 |
| White Lupin     | - | - | 100 | 2.50 | 220 | 5.50 | 250 | 6.25 |
| TOTAL           | 1000 | 83.61 | 1000 | 76.59 | 1000 | 67.04 | 1000 | 61.70 |
According to the recipe component ratios and the current wholesale prices for raw materials, the cost, profit, and profitability of the production of 1 kg of full-fledged compound feed were calculated.

The control compound feed contained in its composition the main protein component of animal origin - fish meal in the amount of 440 g, the price of which was 61 rubles 6 kopecks. The vegetable component of the protein was soybean meal and sunflower meal in the amount of 170 g and 160 g, respectively, or 10 rubles 95 kopecks, and 4 rubles 28 kopecks. The component of grain crops was feed wheat, it accounted for 70 g, the price was 1 rubles 72 kopecks, and corn 140 g or 3 rubles 73 kopecks. Balanced complete feed for macro-microelements and vitamins with premix and tricalcium phosphate in the recommended introduction amount of 1% into the feed structure or 10 g, respectively. The share of premix in the structures of compound feeds accounted in monetary terms for 1 rubles 6 kopecks, and tricalcium phosphate - 25 kopecks. The price of 1 kg of full-fledged control compound feed was 83 rubles 63 kopecks.

Experimental recipes of full-fledged compound feeds were changed. It should be noted that the main task in the preparation of recipes was to replace the expensive component of fish meal with native lupin and lupin without shell. Thus, the structure of the recipe in the 1-experimental compound feed for feed and additives was identical to the control group. Due to the inclusion of native white lupine in its composition in the amount of 100 g or 2 rubles 50 kopecks, the amount of fish meal was 370 g or 51 rubles 80 kopecks. Thus, the amount of fish meal decreased by 16%. Due to the inclusion of native lupin, the corn content decreased by 64%, the share of corn in the recipe was 50 g or 1 ruble 33 kopecks. As a result of ensuring the balance of the recipe, soy and sunflower cakes in the structure of the recipe increased, due to the high level of fiber in native lupine, so the cost of 1 kg of compound feed of the 1st experimental recipe was 76 rubles 59 kopecks.

In the 2-experimental recipe of compound feed, white lupin without shell was used. In the compound feed structure, the amount of white lupine without shell was 220 g for the amount of 5 rubles 55 kopecks. As a result of its inclusion, the content of fish meal decreased by 31.8%. In the compound feed structure, there was 300 g or 42 rubles of fish meal. The amount of soybean meal decreased by 5.8%, in the structure of compound feed it amounted to 160 g or 10 rubles 31 kopecks. The amount of sunflower meal remained at the control recipe level. Corn and wheat decreased by 50% and 28.5%, respectively. In the diet structure, their number was at the level of 90 g or 2 rubles 50 kopecks, and 50 g or 1 ruble 24 kopecks. As a result of the inclusion of lupin, the amount of corn and wheat decreased by 42.8% and 28.5%, respectively. Soybean and sunflower meal remained at the control recipe level. The cost of the obtained compound feed was 61 rubles 70 kopecks.

In the 3-experimental recipe of compound feed, the amount of white lupine without shell was 250 g to the amount of 6 rubles 25 kopecks. Replacement of a part of fish meal with lupin, allowed to reduce its content by 43.1%. The amount of fish meal was 250 g or 35 rubles. The amount of corn is 80 g or 2 rubles 13 kopecks. Wheat - 50 g or 1 ruble 24 kopecks. As a result of the inclusion of lupin, the amount of corn and wheat decreased by 42.8% and 28.5%, respectively. Soybean and sunflower meal remained at the control recipe level. The cost of the obtained compound feed was 61 rubles 70 kopecks.

As a result of white lupine inclusion in the structure of 1-experimental full-fledged compound feed, it was possible to reduce the cost of 1 kg compared to the control by 7 rubles 2 kopecks, in 2-experimental - by 16 rubles 57 kopecks, and in 3-experimental recipe - by 21 rubles 91 kopecks.

The profit from the sale was higher from the experimental compound feeds, in relation to the control. In 1-experimental - by 7 rubles or 15%, in 2-experimental - by 16 rubles 6 kopecks or 36.6%, and in 3-experimental - by 21 rubles 9 kopecks or 47.9%.

The profitability of the compound feed produced was also higher in the 1-experimental compound feed with native white lupine by 25.9%, in the 2-experimental compound feed with white lupine without shell - by 70.3%, and in the 3-experimental - by 100%.

4. Conclusion

The analysis and generalization of experimental materials obtained as a result of our research allow conclude that the use of white lupine in the recipes of full-fledged feeds allows to improve the nutritional value of full-fledged compound feeds. The use of lupine without shell makes it possible to replace high-protein animal feed in a larger volume. It allows to reduce the cost of complete feed, increase the profit
and profitability of their production.

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