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REARING LARVAE AND JUVENILES OF RAINBOW TROUT WITH DIFFERENT AMINO ACID NUTRITION

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Abstract. *The article considers the efficiency of using complete compound feeds with different levels of lysine and methionine in rearing larvae and juveniles of rainbow trout. The purpose of the experiment was to establish the effect of different amino acid levels in nutrition of juvenile trout on its productivity. For this purpose, five experimental groups were formed by the method of analogues. The experiment lasted 35 days and was divided into two periods: equalizing (5 days) and main (30 days). During the equalizing period, the experimental fish consumed feed of the control group. In the main period, the levels of lysine and methionine in experimental feeds for different experimental groups of trout ranged from 2.9 to 3.3% and from 0.95 to 3.15%, respectively. It is proved that increasing the content of lysine and methionine in feed for larvae and juveniles of rainbow trout to the levels of 3.2 and 1.1%, respectively, promotes increase in their weight by 10.7% (p <0.01) and growth intensity - by 6.4-11.1%, while further increase in these amino acids content in the feed reduces the productivity of fish. Polynomial equations for determining the juvenile fish weight at any stage of rearing at a high level of determination for each of the experimental groups have been calculated. It was found that with an increase in the content of lysine and methionine in feed to the levels of 3.2 and 1.1%, respectively, reduces feed costs per 1 kg of weight gain in trout larvae and juveniles by 4.1%, and a further increase in levels of these amino acids to 3.3 and 1.15%, respectively, increase this index by 1.1%. The experimental fish survival ranged from 83.9 to 85.1%. In the production of trout according to the criteria of maximum productivity and to the economic optimization criteria, it is recommended to use complete feed with the level of lysine - 3.2% and methionine - 1.1% for feeding trout larvae and juveniles.*

Key words: *rainbow trout, juveniles, fish feeding, compound feeds, lysine, methionine, productivity, economic efficiency*

Rationale and background. Fish meat is considered a vital food for humans and is a source of native protein, fat, minerals and vitamins. Its quality and nutritional value depend on both genotypic and phenotypic factors. Among the latter, the most important is sensible and balanced feeding of fish [9, 10].

An important component of a complete diet for trout is the amino acid composition of feeds. Lack of at least one amino acid in the feed inevitably leads to limited use of other amino acids

for the synthesis, which reduces its efficiency [8].

Amino acids are structural elements of proteins, and they also perform important functions in the process of metabolism, they are the most important substrates in metabolism of nitrogenous substances in the fish body. Lack of essential amino acids in the diet leads to increased protein intake, which significantly raises the cost of feed per a unit of weight gain in fish. The need for amino acids varies depending on the water temperature, fish holding conditions, their weight and age [3, 5, 6].

In complete fish feeds, the level of essential amino acids is 35-50% of the total amount of amino acids. The lack of one or another essential amino acid limits the use of other amino acids in the process of protein biosynthesis. Decreased levels of amino acids digestion and absorption in feed protein lead to a decrease in the amount of free amino acids in fish tissues, and as a consequence to their inferiority [4, 7].

Thus, the study of the influence of different amino acid nutrition for rainbow trout larvae and juveniles in modern industrial conditions of cold-water fish farms in Ukraine is necessary and relevant.

Materials and methods. Experimental studies on *Oncorhynchus mykiss* (Walbaum, 1792) rainbow trout larvae and juveniles were carried out at the "Shipot" farm, Perechyn district of Transcarpathian region.

The purpose of the scientific and economic experiment was to establish the effect of different levels of amino acid nutrition for trout larvae and juveniles on their productivity.

To do this, according to the method of analogues, five groups were formed – the control and 4 experimental ones (table 1). During the equalizing period, the experimental fish consumed feed of the control group. In the main period, juveniles of all groups consumed a similar diet, except for the level of lysine and methionine in it. These amino acids were added in varying proportions, as provided by the experimental design.

Feeding of rainbow trout in the larval and juvenile periods of the study was carried out with starting compound feed 12 times a day, during the day - at regular intervals, using grain sizing 0.2-0.4 mm. The required amount of feed was calculated according to the indices of juveniles' individual weight and the temperature of the environment at the time of feeding.

Test fishing of experimental trout was carried out once every 5 days. The total of 100 specimens from each group was subjected to weighing with electronic balance. The holding density of the experimental fish at the beginning of the experiment was 10 thousand specimens/m^2. Rearing of larvae and rearing of juveniles was carried out in trays with the area of 4 m^2 at the holding density of 10 and 5 thousand specimens/m^2, respectively, the water level in the tanks for larvae was 0.2 m,

for juveniles - 0.5 m. The total number of trouts in the experiments amounted to 200 thousand specimens. Juveniles in the experiment were kept under generally accepted conditions in trout breeding [1].

1. Design of scientific and economic experience

Group of fish	fish-holding density at the beginning of experiment, specimens./m^2	Mean weight at the beginning of experiment, mg	Experimental periods			
			equalizing (5 days)		main (30 days)	
			content in 1 kg of compound feed, %			
			lysine	methionine	lysine	methionine
1- control	10000	156±14.5	3.1	1.05	3.1	1.05
2- experimental	10000	154±10.3			2.9	0.95
3- experimental	10000	158±14.9			3.0	1.00
4- experimental	10000	156±13.5			3.2	1.10
5- experimental	10000	153±11.6			3.3	1.15

The study results were processed by the method of variation statistics [2] by means of MS Excel and STATISTICA 7.0 software using built-in statistical functions.

Results of the study and their discussion. It was found that in the main period of the experiment, due to different amino acid nutrition of trout larvae and juveniles, there were noticeable changes in the indices of their weight gain (table 2).

2. Weight of experimental trout larvae and juveniles at different amino acid nutrition, mg

Day of experiment	Groups of fish				
	1	2	3	4	5
1	156±14.5	154±10.3	158±14.9	156±13.5	153±11.6
5	271±23.4	267±15.9	273±21.8	271±17.6	270±13.8
10	407±28.2	377±21.6	404±27.6	413±27.3	412±22.5
15	533±35.6	497±27.8	549±32.0	600±32.2	590±29.1
20	698±32.0	622±31.4	721±36.1	782±29.8	773±34.3
25	842±39.7	735±36.1	862±34.9	939±35.4*	921±32.7
30	962±41.5	841±38.3	984±39.6	1065±42.3*	1043±39.0
35	1076±43.8	944±41.2	1107±42.7	1191±46.9*	1164±44.8

*$p<0.05$ – compared to group 1.

It was proved that during the main period of the experiment the highest weight was observed in those trout larvae and juveniles, who were fed compound feed with lysine and methionine content at the level of 3.2 and 1.1%, respectively (group 4). At the end of the experiment (the 35th day) the highest weight was reached by the juveniles of this group, which outperformed the analogues of all other groups, respectively (according to the experimental design) by 10.7 ($p < 0.01$); 26.2 ($p < 0.001$); 7.6 and 2.3%.

The description of the growth of trout larvae and juveniles using mathematical methods confirmed the ascending shape of the growth curve (fig.).

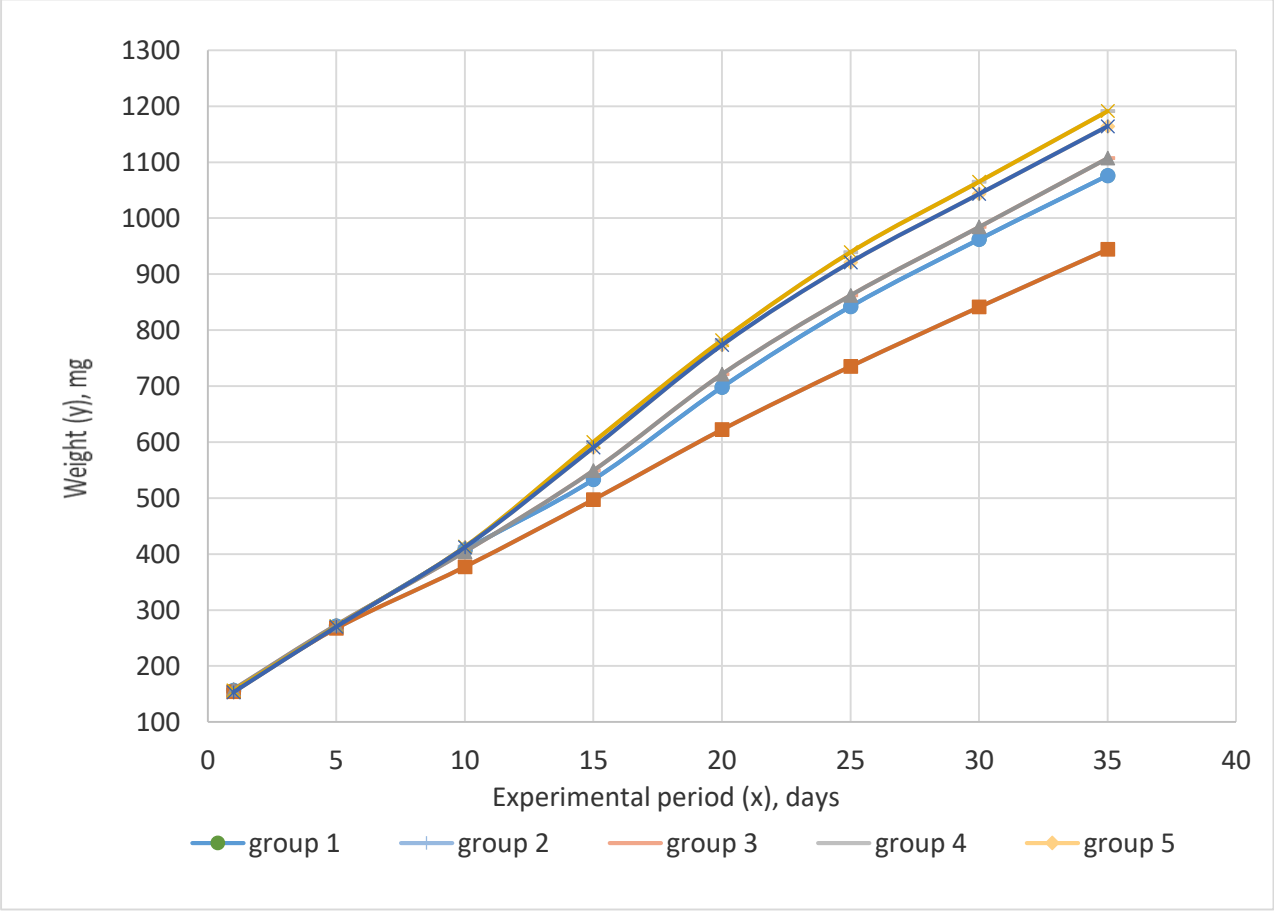

Fig. Graphic model of trout larvae and juveniles growth at different amino acid nutrition

The growth of juvenile trout was further described by a mathematical model with a nonlinear characteristic. According to the age of larvae and juveniles (experiment period - x), depending on the level of lysine and methionine in the feed, we can predict their weight (function - y):

Group 1 (3.1 % lysine - L, 1,05 % methionine - M):

$$y = -0.0004x^4 + 0.0198x^3 - 0.2593x^2 + 28.446x + 129.6 \ (R^2 = 0.9996);$$

Group 2 (2.9 % L, 0.95 % M):

$y = -0.0002x^4 + 0.0159x^3 - 0.4006x^2 + 27.976x + 128.75$ ($R^2 = 0.9998$);

Group 3 (3.0 % L, 1.0 % M):

$y = 0.0001x^4 - 0.016x^3 + 0.5801x^2 + 22.606x + 138.4$ ($R^2 = 0.9995$);

Group 4 (3.2 % L, 1.10 % M):

$y = 0.0005x^4 - 0.0536x^3 + 1.6063x^2 + 16.903x + 141.47$ ($R^2 = 0.9997$);

Group 5 (3.3 % L, 1.15 % M):

$y = 0.0005x^4 - 0.0489x^3 + 1.4447x^2 + 18.257x + 137.34$ ($R^2 = 0.9996$).

Data of the variance analysis indicate that different levels of lysine and methionine in feeds intended for feeding trout larvae and juveniles, reliably ($p < 0.01$) affected the weight of the experimental fish. The share of this factor's influence is 56.5%, which is by 13% more than the influence of other factors.

Calculations showed that during the growing period the nature of changes in the average daily weight gain of trout larvae and juveniles depended on the content of lysine and methionine in the feed and the corresponding change in fish weight (table 3).

3. Average daily weight gain of trout larvae and juveniles at different amino acid nutrition, mg

Experimental periods, days	Groups of fish				
	1	2	3	4	5
1-5	23.0	22.6	23.0	23.0	23.4
6-10	27.2	22.0	26.2	28.4	28.4
11-15	25.2	24.0	29.0	37.4	35.6
16-20	33.0	25.0	34.4	36.4	36.6
21-25	28.8	22.6	28.2	31.4	29.6
26-30	24.0	21.2	24.4	25.2	24.4
31-35	22.8	20.6	24.6	25.2	24.2
Average for the main experimental period (6- 35 days)	26.8	22.6	27.8	30.7	29.8

It should be noted that in general, during the main experimental period, the juveniles of experimental groups 3, 4 and 5 were characterized by higher indices of average daily weight gain, which exceeded the control ones by this index, respectively by 1.0; 3.9 and 3.0 mg. Trout juveniles of group 2 in the main period of the experiment were inferior to the control index by 4.2 mg.

It should be noted that the survival of experimental fish throughout the experiment was high enough, close in value and ranged within 83.9 to 85.1% (table 4).

4. Survival rate of trout larvae and juveniles with different amino acid nutrition,%

Day of experiment	Groups of fish				
	1	2	3	4	5
5	98.1	97.9	98.0	97.9	97.6
10	96.0	95.4	95.8	95.3	94.7
15	93.5	93.0	93.1	92.4	91.8
20	91.2	90.2	90.9	90.1	89.3
25	88.0	88.1	88.4	88.5	87.3
30	86.4	86.2	86.7	86.2	85.5
35	84.3	84.0	85.1	84.2	83.9

Analyzing the indices of economic efficiency of rearing trout larvae and juveniles, it can be stated that at different levels of introducing the studied amino acids into the feed, these indices changed differently (table 5).

5. Economic efficiency of growing trout larvae and juveniles with different amino acid nutrition

Index	Group				
	1	2	3	4	5
Ichtyomass at the beginning of the main experimental period, kg	5,32	5,23	5,35	5,31	5,27
Survival rate, %	84,3	84	85,1	84,2	83,9
Ichtyomass at the end of experiment, kg	18,14	15,86	18,84	20,06	19,53
Ichtyomass gain for the main experimental period, kg	12,82	10,63	13,49	14,75	14,26
Feed costs per 1 kg of ichtyomass gain, kg	0,744	0,791	0,734	0,715	0,723
Feed costs for the total ichtyomass gain, kg	9,54	8,41	9,90	10,55	10,31
Production cost per 1 kg of compound feed, UAH	87,3	87,12	87,21	87,39	87,48
Cost of feed fed for the total ichtyomass gain, UAH	832,67	732,53	863,52	921,64	901,92
Cost of feed consumed per 1 kg of ichtyomass gain, UAH	64,95	68,91	64,01	62,48	63,25
Net cost per1 kg of ichtyomass gain, UAH	92,79	98,45	91,45	89,26	90,35

Note: in prices of 2017.

In particular, ichtyomass at the end of the experiment was the highest in fish

of group 4, which outperformed analogues from all other groups by this index, respectively (according to the experimental design) by 10.6; 26.5; 6.5 and 2.7%. Similarly, the ichtyomass gain changed during the main period of the experiment - group 4 trouts outperformed analogues of groups 1, 2, 3 and 5 by 15.1; 38.8; 9.3 and 3.4%, respectively. As a result, the cost of 1 kg of ichtyomass gain was the highest in fish that consumed compound feed with lysine and methionine content of 2.9 and 0.95%, respectively (group 2). According to this index, they were inferior to their peers of all other groups, respectively (according to the experimental design) by 6.1; 7.7; 10.3 and 9.0%.

Thus, the lowest cost of ichtyomass was characteristic of fish in group 4, which consumed compound feed with a content of lysine and methionine at the level of 3.2 and 1.1%, respectively. Rearing trout larvae and juveniles at the above levels of these amino acids is the most economically feasible.

Conclusions

1. It is proved that increasing the content of lysine and methionine in feed for larvae and juveniles of rainbow trout to the levels of 3.2 and 1.1%, respectively, contributes to an increase in their weight by 10.7% ($p < 0.01$) and growth intensity - by 6.4-11.1%, while further increase in the content of these amino acids in the feed reduces the productivity indices of fish.

2. Description of rainbow trout larvae and juveniles growth by means of mathematical methods confirmed the ascending form of their growth curve. Polynomial equations for determining the weight of fish at any stage of rearing at a high level of determination for each of the experimental groups are calculated.

3. It is established that with the increase of lysine and methionine content in feed to the levels of 3.2 and 1.1%, respectively, feed costs per 1 kg of weight gain in trout larvae and juveniles decrease by 4.1%, and further increase in levels of these amino acids to 3.3 and 1.15%, respectively, increase this index value by 1.1%. Survival of the experimental fish ranged from 83.9 to 85.1% and no significant difference was observed in this index.

4. As a result of the trout production analysis according to the criteria of maximum productivity and to economic optimization criteria, it is recommended to use complete feeds with the level of lysine - 3.2% and that of methionine - 1.1% for feeding trout larvae and juveniles.

Prospects of further research

Prospects for further research are related to the study on the use of compound feeds with different levels of lysine and methionine and the patterns of changes in physiological, biochemical and morphological parameters in this year juveniles and commercial rainbow trout.

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ВИРОЩУВАННЯ ЛИЧИНОК І МАЛЬКІВ РАЙДУЖНОЇ ФОРЕЛІ ЗА РІЗНОГО АМІНОКИСЛОТНОГО ЖИВЛЕННЯ

В. М. Кондратюк

Анотація. *У статті розглянуто питання ефективності використання повнораціонних комбікормів з різними рівнями лізину і метіоніну за вирощування личинок і мальків райдужної форелі. Метою досліду передбачалося встановити вплив різних рівнів амінокислотного живлення молоді форелі на показники її продуктивності. Для цього за методом аналогів було сформовано п'ять піддослідних груп. Дослід тривав 35 діб і поділявся на два періоди: зрівняльний (5 діб) та основний (30 діб). У зрівняльний період піддослідна риба споживала комбікорм контрольної групи. В основний період рівень лізину і метіоніну в експериментальних комбікормах для різних піддослідних груп форелі коливався від 2,9 до 3,3 % та від 0,95 до 3,15 % відповідно. Доведено, що збільшення вмісту лізину і метіоніну у комбікормі для личинок і мальків райдужної форелі до рівнів 3,2 і 1,1 % відповідно сприяє збільшенню їхньої маси на 10,7 % ($p<0,01$) та інтенсивності росту – на 6,4-11,1 %, тоді як подальше підвищення вмісту у кормі цих амінокислот зменшує показники продуктивності риб. Розраховані поліноміальні рівняння визначення маси молоді риб на будь-якому етапі вирощування за високого рівня детермінації для кожної з піддослідних груп. Встановлено, що зі збільшенням вмісту лізину і метіоніну у кормі до рівнів 3,2 і 1,1 % відповідно зменшуються витрати корму на 1 кг приросту маси у личинок*

і мальків форелі на 4,1 %, а подальше підвищення рівнів цих амінокислот до 3,3 і 1,15 % відповідно збільшують цей показник на 1,1 %. При цьому збереженість піддослідних риб знаходилась у межах від 83,9 до 85,1 %. За виробництва продукції форелівництва за критеріями максимальної продуктивності та економічними критеріями оптимізації рекомендується для годівлі личинок і мальків форелі використовувати повнораціонні комбікорми з рівнем лізину 3,2 % та метіоніну 1,1 %.

Ключові слова: *райдужна форель, молодь, годівля риб, комбікорми, лізин, метіонін, продуктивність, економічна ефективність*