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BIOEFFICACY OF RAINBOW TROUT FLESH LIPIDS DEPENDING ON THE LEVEL OF AMINO ACIDS IN COMPOUND FEEDS

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Abstract. *The article examines the effect of complete compound feeds with different lysine and methionine levels on lipid bioefficacy indicators in rainbow trout flesh. The experiment was aimed at determining the effect of different types of amino acid nutrition of commercial rainbow trout on the fatty acid composition of flesh lipids as well as their bioefficacy. For this purpose and by analogy, we formed five experimental groups. The experiment lasted 210 days and consisted of two stages, namely equalizing (10 days) and main (200 days). Throughout the equalizing stage, the experimental fish consumed compound feeds of the control group. Throughout the main stage, lysine and methionine levels in the experimental compound feeds for various experimental trout groups ranged from 2.5 to 2.9% and from 0.8 to 1.0%, respectively. During the study, rainbow trout were fed 4-6 times a day, in the daytime and at regular intervals. The required amount of feeds was calculated based on the indices of individual fish weight and temperature at the time of feeding. Commercial two-year-olds were cultivated in ponds with an area of 100 m^2 at a stocking density of 50 specimens/m^2, and a water level of 1 m. The total number of trout in experimental studies was 25 thousand specimens. It was found that the main share of fatty acids in rainbow trout flesh lipids is saturated and monounsaturated fatty acids. The study demonstrated that the use of compound feeds with an increased lysine and methionine levels for the fish of the 4th experimental group resulted in an increase in the content of saturated fatty acids in the flesh by 5.84% versus control. An increase in the amino acid nutritional value of the compound feeds subsequently let to an increase in the content of linoleic acid in the trout flesh by 0.19-0.24% versus control.*

Keywords: *rainbow trout, fish feeding, compound feeds, lysine, methionine, flesh, lipids, fatty acid composition*

Introduction.

Fish flesh is one of the most vital foodstuffs for humans as well as a source of complete proteins, fat, minerals and vitamins. Its quality and nutritional value depend on both genotypic and phenotypic factors with the latter presupposing rational and balanced fish feeding (Gamigin, 1987; Sherman et al., 2002; Shcherbina and Hamihin, 2006; Kim and Kaushik,1992).

The use of complete compound feeds with different lysine and methionine levels directly affects the bioefficacy of rainbow trout flesh lipids.

Consequently, it is essential to study the influence of different amino acid nutrition types of commercial rainbow trout on the flesh bioefficacy indicators in modern industrial conditions of cold-water fish farms in Ukraine.

Materials and methods.

Experimental studies on two-year-old rainbow trout *Oncorhynchus mykiss* (Walbaum, 1792) were conducted in the Shypot fish farm of Perechyn district in Zakarpattia region.

The scientific and economic experiment was aimed at determining the effect of different types of amino acid nutrition of commercial rainbow trout on the flesh lipid bioefficacy indicators as well as its fatty acid composition.

For this purpose and by analogy, we formed five experimental groups (Table 1).

Throughout the equalizing stage, the experimental fish consumed compound feeds of the control group with equal lysine and methionine levels. Throughout the main stage, fish of all experimental groups received a similar ration except for lysine and methionine levels. The abovementioned amino acids were added in varying proportions as envisaged by the research scheme.

The nutritional value of the experimental grower compound feeds is shown in Table 2.

During the study, rainbow trout were fed 4-6 times a day, in the daytime and at regular intervals. The required amount of compound feeds was calculated based on the indices of individual fish weight and ambient temperature at the time of feeding.

Commercial two-year-olds were cultivated in ponds with an area of 100 m^2 at a stocking density of 50 specimens/m^2, and a water level of 1 m. The total number of trout in experimental studies was 25 thousand specimens. Conditions for keeping experimental fish met the regulatory requirements in salmon

1. Scientific and Economic Research Scheme

Group of Fish	Stocking Density at the Beginning of the Experiment, specimen/m^2	Average Weight at the Beginning of the Experiment, g	Research Stages			
			Equalizing (10 days)		Main (200 days)	
			Content in 1 kg of Compound Feed,%			
			Lysine	Methionine	Lysine	Methionine
1- control	50	53.9±3.17	2.7	0.9	2.7	0.90
2- experimental	50	53.4±2.86			2.5	0.80
3- experimental	50	54.2±3.74			2.6	0.85
4- experimental	50	52.7±3.29			2.8	0.95
5- experimental	50	54.0±3.06			2.9	1.00

2. Content in 1 kg of Compound Feed, %

Indicator	Group				
	1st	2nd	3rd	4th	5th
Metabolic energy, MJ	17.00	17.00	17.00	17.00	17.00
Crude protein	48.00	48.00	48.00	48.00	48.00
Crude fat	18.00	18.00	18.00	18.00	18.00
Crude fiber	2.40	2.40	2.40	2.40	2.40
Calcium	1.80	1.80	1.80	1.80	1.80
Total phosphorus	1.20	1.20	1.20	1.20	1.20
Lysine	2.70	2.50	2.60	2.80	2.90
Methionine	0.90	0.80	0.85	0.95	1.00
Vitamin A, thousand IU	10	10	10	10	10
Vitamin D3, thousand IU	3	3	3	3	3
Vitamin E, mg	200	200	200	200	200

farming (Kanydev, 1985; SOU–05.01-37-385:2006).

The mass fraction of lipids was determined by the Soxhlet extraction method in accordance with DSTU 8717 (2017). The fat was weighed after its solvent extraction from a dry sample using a Soxhlet apparatus based on the determination of the sample mass change after the solvent extraction rendering.

The content of fatty acids was determined using the chromatographic technique on a Kupol 55 chromatograph. The peaks in the chromatogram were identified by calculating the "carbon numbers" as well as by using chemically pure standard solutions and fatty acid methyl esters. The content of individual fatty acids based on the results of gas chromatographic analysis, i.e. chromatograms, was calculated according to the formula including correction factors for each of such acids. The above correction factors were defined as the ratio of the peak areas (namely peak heights) of heptadecanoic acid (internal standard) and test acids at a concentration of 1:1 and isothermal operation of the gas-liquid chromatograph.

Mass fraction of polyunsaturated fatty acids (PUFA) was determined by the chromatographic technique on an HRGC 5300 chromatograph (Baidalinova et al., 1977); lipids were extracted by the Folch and Bligh-Dyer extraction method (Blight and Dyer, 1959); lipid efficiency coefficient was determined by the calculation method (Rogov et al., 2007); lipid biological significance coefficient (BSC) was calculated as the ratio of the sum of eicosapentaenoic and docosahexaenoic PUFAs to the mass fraction of fat in the product (Baidalynova et al., 2006).

The research results were processed by the variation statistics (Plohinskij, 1969) technique using the STATISTICA 7.0 software as well as MS Excel with the built-in statistical functions.

Results of the research and their discussion.

The research results have revealed that different levels of limiting amino acids in compound feeds for commercial rainbow trout entail certain changes in the fatty acid composition of the flesh (Table 3).

3. Fatty Acid Composition of Commercial Rainbow Trout Flesh Lipids, n = 5

Fatty Acids	Fatty Acid Code	Groups				
		1st	2nd	3rd	4th	5th
Saturated fatty acids (SAFA)		44.73	46.80	49.55	50.57	48.60
myristic	14:0	2.31±0.78	2.18±0.68	2.42±0.95	2.38±0.87	2.36±0.36
palmitic	16:0	19.08±1.24	21.6±2.84	23.1±2.04	24.5±1.02*	23.4±1.27*
stearic	18:0	3.15±0.63	3.12±0.41	3.55±0.74	3.74±0.68	3.66±0.47
arachic	20:0	0.88±0.08	0.81±0.06	0.93±0.09	1.09±0.08	1.06±0.06
nonadecanoic	19:0	19.31±2.13	19.09±2.31	19.55±2.14	18.86±2.58	18.12±2.69
Monounsaturated fatty acids (MUFA)		35.52	37.70	36.98	36.82	36.66
palmitoleic	16:1	6.12±0.96	7.08±0.87	7.83±0.94	6.31±0.81	6.10±0.79
ω9 oleic	18:1	14.08±1.44	14.93±1.24	14.62±2.12	15.10±2.39	15.31±2.69
ω9 elaidic	18:1	1.21±0.09	1.38±0.06	1.44±0.02*	1.28±0.04	1.32±0.06
gadoleic	20:1	14.11±1.69	14.31±3.01	13.09±1.97	14.13±2.14	13.93±2.33
Polyunsaturated fatty acids (PUFA)		3.33	3.45	3.62	3.75	3.65
linoleic ω3	18:2	1.74±0.09	1.78±0.12	1.78±0.11	1.93±0.09	1.98±0.05*
linolenic ω6	18:3	0.83±0.04	0.88±0.09	0.93±0.06	0.94±0.07	0.84±0.05
eicosadienoic	20:2	0.76±0.02	0.79±0.06	0.91±0.06*	0.88±0.04*	0.83±0.07
Not identified		16.42	12.05	9.85	8.86	11.09

*p< 0.05 compared to the 1st group

As can be seen from the above data, the bulk of fatty acids in rainbow trout flesh lipids are saturated fatty acids, mainly palmitic and nonadecanoic acids as well as monounsaturated acids where oleic acid predominates.

Linolenic and linoleic acids hold a unique position among polyunsaturated fatty acids since they are essential for human nutrition as well as for the treatment and prevention of many diseases.

The above experimental studies indicate that different types of rainbow trout amino acid nutrition do not significantly affect the fatty acid composition of flesh lipids. For instance, the use of compound feeds with an increased level of lysine and methionine for fish of the fourth experimental group throughout rearing entailed an increase in saturated fatty acids in the flesh by 5.84% versus control. This is due to an increased content of palmitic (by 5.42%), stearic (by 0.59%) and arachic (by 0.21%) acids in the flesh versus control.

The value of nonadecanoic acid concurrently decreased. For instance, the content of the indicated acid in the fourth group trout flesh was 0.45% lower versus control.

A similar pattern was inherent with monounsaturated fatty acids. In particular, an increase in the content of limiting amino acids in the rations of commercial rainbow trout led to an increase in monounsaturated fatty acids in the flesh by 1.14-2.18% versus control analogues. This was due to an increase in the content of oleic and elaidic acids.

It was also discovered that the use of compound feeds with high levels of

5. Bioefficacy Indicators of Flesh Lipids in Two-Year-Old Rainbow Trout, n=5

Group	Ratio of Fatty Acid Types			
	SAFA:MUFA:PUFA	PUFA:SAFA	C 18:2:C:18:1	ω6: ω3
Ideal Lipid	1:1:1	0.2:0.4	>0.25	10:1
1st	1:0.79:0.07	0.07:1	1:8.09	1:2.10
2nd	1:0.81:0.07	0.07:1	1:8.39	1:2.03
3rd	1:0.75:0.07	0.07:1	1:8.21	1:1.91
4th	1:0.73:0.07	0.07:1	1:7.82	1:2.05
5th	1:0.75:0.08	0.08:1	1:7.73	1:2.36

amino acid nutrition when feeding rainbow trout of the 4th and 5th experimental groups entailed a decrease in the content of monounsaturated fatty acids in the flesh, namely palmitoleic and elaidic acids, compared to the indicators of the 2nd group specimens.

Additionally, there were significant differences between two-year-old trout of different groups in terms of polyunsaturated fatty acids in the flesh such as linoleic and linolenic amino acids. For instance, an increase in the amino acid nutritional value of the compound feeds evoked an increase in the content of linoleic acid in the trout flesh by 0.19-0.24% versus control.

Overall, the highest content of fatty acids in the flesh inhered in commercial trout of the 4th experimental group fed with compound feeds with a lysine and methionine content of 2.8% and 0.95%, respectively.

Fish lipids are basic labile components affecting the nutritional and biological value of fish products. Fish oil is mainly distinguished by the predominance of unsaturated fatty acids (up to 84%), including fatty acids. Following this line of reasoning, it was essential to study the bioefficacy of flesh lipids in two-year-old rainbow trout flesh depending on the rearing conditions (Table 4).

The above experimental data indicate that the cultivation of rainbow trout on compound feeds with different amino acid composition has improved the flesh bioefficacy.

The C18:2:C18:3 ratio of fatty acids has proved to be consistent with the literature reports and is indicative of a high bioefficacy of rainbow trout flesh lipids. The ratio of the above fatty acids in flesh with predominantly ω_3 valuable fatty acids is of considerable interest.

The calculations demonstrate that the increase in the number of limiting amino acids (lysine and methionine) in grower compound feeds for commercial trout (3rd and 4th groups) has been accompanied by the accumulation of ω3, ω6 valuable fatty acids in the flesh.

Conclusion

The conducted study demonstrates the influence of different levels of amino acid nutrition of commercial rainbow trout on the fatty acid composition of flesh lipids as well as their bioefficacy.

It has been established that an increase in the content of limiting amino acids in the rations of commercial rainbow trout leads to an increase in monounsaturated fatty acids in the flesh by 1.14-2.18% versus control.

The obtained results suggest that the highest content of fatty acids can be found in the flesh of commercial trout of

the 4th experimental group fed with compound feeds containing 2.8% and 0.95% lysine and methionine, respectively.

It has been proved that an increase in the amino acid nutritional value of compound feeds results in an increase in the content of linoleic acid in trout flesh by 0.19-0.24% versus control.

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Анотація. *У статті досліджено вплив використання повнораціонних комбікормів з різними рівнями лізину і метіоніну на показники біологічної ефективності ліпідів м'яса райдужної форелі. Метою досліду передбачалося встановити вплив різних рівнів амінокислотного живлення товарної райдужної форелі на жирнокислотний склад ліпідів м'яса та їх біологічну ефективність. Для цього за методом аналогів було сформовано п'ять піддослідних груп. Дослід тривав 210 діб та поділявся на два періоди: зрівняльний (10 діб) та основний (200 діб). У зрівняльний період піддослідна риба споживала комбі-*

корм контрольної групи. В основний період рівень лізину і метіоніну в експериментальних комбікормах для різних піддослідних груп форелі коливався від 2,5 до 2,9 % і від 0,8 до 1,0 % відповідно. Годівлю райдужної форелі в період досліджень проводили 4–6 раз на добу, в денний час через рівні проміжки. Необхідну кількість корму розраховували відповідно до показників індивідуальної маси риб та температури середовища на момент годівлі. Вирощування товарних дволітків проводили в ставах площею 100 м^2 за щільності посадки 50 екз./м^2, та рівня води в них 1 м. Загальна кількість особин форелі в експериментальних дослідженнях становила 25 тис. екз. Встановлено, що основну частку жирних кислот ліпідів м›яса райдужної форелі складають насичені жирні кислоти та мононенасичені. В результаті досліджень виявлено, що використання комбікормів з підвищеним рівнем лізину та метіоніну для риб 4-ї дослідної групи супроводжувалося збільшенням вмісту у м'ясі суми насичених жирних кислот, порівняно з контролем на 5,84%. За зростання амінокислотної поживності комбікорму спостерігається збільшення у м'ясі форелі вмісту лінолевої кислоти - на 0,19-0,24 %, порівняно з контролем.

Ключові слова: *райдужна форель, годівля риб, комбікорми, лізин, метіонін, м'ясо, ліпиди, жирнокислотний склад*