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## **Biological efficiency of rainbow trout meat lipids depending on the levels of amino acids in fodder**

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**Abstract.** In trout farms of Ukraine, when using compound fodder for their production, the question arises of clarifying the requirement of rainbow trout in energy, protein and amino acids to achieve the maximum realisation of its biological productivity potential. Accordingly, the research explored the effect of using complete fodder with various levels of lysine and methionine on the biological efficiency of rainbow trout meat lipids. The purpose of the experiment was to determine the effect of different levels of amino acid nutrition of commercial rainbow trout on the fatty acid composition of meat lipids and their biological efficiency. For this purpose, five experimental groups were established by the method of analogues. The experiment lasted 210 days and was divided into two periods: equalising (10 days) and main (200 days). During the equalisation period, the feeding diet was the same for the fish of the control and experimental groups. During the main period, the level of lysine and methionine in the experimental fodders for different experimental groups of trout ranged from 2.5 to 2.9% and from 0.8 to 1.0%, respectively. Feeding of rainbow trout during the study period was performed 4-6 times a day, during the daytime at regular intervals. The required amount of fodder was calculated according to the individual weight of the fish and the temperature of the environment during feeding. Cultivation of marketable two-year-olds was performed in ponds with an area of 100 m<sup>2</sup> at a planting density of 50 specimens/m<sup>2</sup> and a water level of 1 m. The total number of trout in the experimental studies was 25 thousand specimens. It is established that the main share of fatty acids of lipids of rainbow trout meat is saturated fatty acids and monounsaturated fatty acids. As a result of the research, it was determined that using feed with increased levels of lysine and methionine for fish of the 4th experimental group was accompanied by an increase in the content of the sum of saturated fatty acids in meat by 5.84% compared to the control. With the growth of amino acid nutrition of the fodder, there is an increase

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in the content of linoleic acid in trout meat by 0.19-0.24% compared to the control. The practical value of the scientific work is to substantiate approaches to the technological bases of increasing the efficiency of using fodder nutrients in trout farming to ensure high fish productivity, which is of great economic importance

**Keywords:** rainbow trout, fish feeding, mixed fodder, lysine, methionine, meat, lipids, fatty acid composition

## Introduction

Fish flesh is one of the most vital foodstuffs for humans and 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 [1;2;3].

Using complete compound feeds with different lysine and methionine levels directly affects the bioefficacy of rainbow trout flesh lipids [4;5]. Consequently, it is essential to explore 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 were conducted on two-year-old rainbow trout *Oncorhynchus mykiss* in the Shypot fish farm of Perechyn district in Zakarpattia region. The scientific and economic experiment was designed to determine the effect of different types of amino acid nutrition of commercial rainbow trout on the biological efficiency of meat lipids and its fatty acid composition. For this purpose, were formed five experimental groups by the method of analogues (Table 1).

**Table 1.** The design of scientific and economic experiment

Fish group	Stocking density at the beginning of the experiment, specimen/m <sup>2</sup>	Mean body weight at the beginning of the experiment, g	Experimental periods			
			Equalising (10 days)		Main (200 days)	
			Content per 1 kg of compound fodder, %			
			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

During the equalising period of equalisation, the experimental fish consumed fodders equal to the control group with the same content of lysine and methionine. During the main period, 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 provided by the experimental design. The nutritional value of the experimental grower compound feeds is presented in Table 2.

**Table 2.** Chemical composition of compound fodder

Indicator	Group				
	1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>	4 <sup>th</sup>	5 <sup>th</sup>
Metabolic energy, MJ/kg	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 fibre, %	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 D <sub>3</sub> , thousand IU	3	3	3	3	3
Vitamin E, mg/kg	200	200	200	200	200

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 reared in ponds with an area of 100 m<sup>2</sup> at a stocking density of 50 specimens/m<sup>2</sup>, and a water level of 1 m. The total number of trout in experimental studies was 25 thousand specimens. Conditions for keeping experimental fish correspond the regulatory requirements in salmon farming [6;7].

The mass fraction of lipids was determined by the Soxhlet extraction method in accordance with DSTU 8717 [8]. 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 fatty acid content was determined using the chromatographic technique on a Kupol 55 chromatograph. The peaks in the chromatogram were identified by calculating the “carbon numbers” and 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 tested acids at a concentration of 1:1 and isothermal operation of the gas-liquid chromatograph.

The mass fraction of polyunsaturated fatty acids (PUFA) was determined by the chromatographic technique on an HRGC 5300 chromatograph; lipids were extracted by the Folch and Bligh-Dyer extraction method; lipid efficiency ratio was determined by the calculation method; 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 [9;10;11].

The research results were processed by the variation statistics [12;13;14] technique using the STATISTICA 7.0 software, and MS Excel with the built-in statistical functions.

## Research and Discussion

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

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 and monounsaturated acids where oleic acid predominates.

Linolenic and linoleic acids occupy a unique position among PUFA since they are essential for human nutrition and the treatment and prevention of many diseases.

Experimental studies indicate that different types of rainbow trout amino acid nutrition do not significantly affect the fatty acid composi-

tion of flesh lipids [15;16]. Thus, using compound fodders 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. It is explained by an increased content of palmitic (by 5.42%), stearic (by 0.59%), and arachidic (by 0.21%) acids in the flesh versus control.

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

**Table 3.** Fatty acid composition of commercial rainbow trout flesh lipids (n=5)

Fatty acids	Fatty acid code	Groups				
		1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>	4 <sup>th</sup>	5 <sup>th</sup>
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 <sup>o</sup>	23.4±1.27 <sup>o</sup>
stearic	18:0	3.15±0.63	3.12±0.41	3.55±0.74	3.74±0.68	3.66±0.47
arachidic	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
ω <sub>9</sub> oleic	18:1	14.08±1.44	14.93±1.24	14.62±2.12	15.10±2.39	15.31±2.69
ω <sub>9</sub> elaidic	18:1	1.21±0.09	1.38±0.06	1.44±0.02 <sup>o</sup>	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 ω <sub>6</sub>	18:2	1.74±0.09	1.78±0.12	1.78±0.11	1.93±0.09	1.98±0.05 <sup>o</sup>
linolenic ω <sub>3</sub>	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 <sup>o</sup>	0.88±0.04 <sup>o</sup>	0.83±0.07
Not identified		16.42	12.05	9.85	8.86	11.09

Note: <sup>o</sup>p < 0.05 compared to the 1<sup>st</sup> group

A similar pattern was inherent with MUFA. In particular, an increase in the content of limiting amino acids in diets for commercial rainbow trout resulted in an increase in the content of MUFA in meat by 1.14-2.18% relative to control analogues. It was explained by an increase in the content of oleic and elaidic acids.

In addition, it was discovered that using compound fodders with high levels of amino

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

Additionally, there were significant differences between two-year-old trout of different groups in terms of PUFA content in the flesh such as linoleic and linolenic amino acids. Thus,

an increase in the amino acid nutritional value of the compound fodders 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 4<sup>th</sup> experimental group fed with compound fodders 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. Based on this, it was important to explore the biological efficiency of lipids of meat of two-year-old rainbow trout depending on the growing conditions (Table 4).

**Table 4.** 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	$\omega_6$ : $\omega_3$
Ideal lipid	1:1:1	0.2:0.4	>0.25	10:1
1 <sup>st</sup>	1:0.79:0.07	0.07:1	1:8.09	1:2.10
2 <sup>nd</sup>	1:0.81:0.07	0.07:1	1:8.39	1:2.03
3 <sup>rd</sup>	1:0.75:0.07	0.07:1	1:8.21	1:1.91
4 <sup>th</sup>	1:0.73:0.07	0.07:1	1:7.82	1:2.05
5 <sup>th</sup>	1:0.75:0.08	0.08:1	1:7.73	1:2.36

The experimental data obtained indicate that the growth of rainbow trout on fodder with different amino acid compositions contributed to the increase of biological efficiency of meat.

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 these fatty acids in flesh with predominantly  $\omega_3$  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 fodders for commercial trout (3<sup>rd</sup> and 4<sup>th</sup> groups) has been accompanied by the accumulation of  $\omega_3$ ,  $\omega_6$  valuable fatty acids in the flesh.

## Conclusions

1. The conducted research demonstrates the influence of different levels of amino acid nutrition of commercial rainbow trout on the fatty acid composition of flesh lipids and their bioefficacy.
2. It has been established that an increase in the content of limiting amino acids in the diets for commercial rainbow trout results in an increase in monounsaturated fatty acids in the flesh by 1.14-2.18% compared to the control.
3. The obtained results suggest that the highest content of fatty acids can be found in the flesh of commercial trout of the 4<sup>th</sup> experimental group fed with compound fodders containing 2.8% lysine and 0.95% methionine.
4. 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% compared to the control.

## References

- [1] Archibisova, D., & Suslov, V. (2018). Ecological and economic efficiency of aquaculture development in the Black Sea region of Ukraine. *Bulletin of KhNAU. Series: Economic Sciences*, 4, 52-60. <https://doi.org/10.31359/2312-3427-2018-4-52>.

- [2] Brooks, J.L., Chapman, J.M., Barkley, A.N., Kessel, S.T., Hussey, N.E., Hinch, S.G., & Nguyen, V.M. (2019). Biotelemetry informing management: case studies exploring successful integration of biotelemetry data into fisheries and habitat management. *Canadian Journal of Fisheries and Aquatic Sciences*, 76(7), p. 1238-1252.
- [3] Crank, K., Voorhees, J., & Barnes, M.E. (2019). Predator avoidance of rainbow trout reared with environmental enrichment. *Journal of Fisheries and Aquaculture Development*, 3(1), p. 1-6.
- [4] De Sá, L., Oliveira, M., Ribeiro, F., Rocha, T., & Futter, M. (2018). Studies of the effects of microplastics on aquatic organisms: what do we know and where should we focus our efforts in the future. *Science of the Total Environment*, 645, 1029-1039.
- [5] Kondratiuk V., Slobodyanyuk, N., & Ivaniuta A. (2021). Effect of feeding conditions on the quality traits of rainbow trout. *Acta Fytotechnica et Zootechnica*, 24, 256-264.
- [6] GOST 7635-81. (1985). Fish, marine mammals, marine invertebrates and products of their processing. Acceptance rules, organoleptic methods for quality control, sampling methods for laboratory test. Quality management systems – Requirements. Retrieved from <https://docs.cntd.ru/document/1200022220/titles>.
- [7] FAO. (2016). El estado mundial de la pesca y la acuicultura. Contribución a la seguridad alimentaria y la nutrición para todos. Roma: FAO (Food and Agriculture Organization of the United Nations).
- [8] DSTU 8717. (2017). “Fish and fish products. Methods for fat determining”. Quality management systems – Requirements. Retrieved from [http://online.budstandart.com/ua/catalog/doc-page?id\\_doc=73417](http://online.budstandart.com/ua/catalog/doc-page?id_doc=73417).
- [9] Kondratiuk V.M., & Ivaniuta A.O. (2021). Morphological composition of the body and chemical composition of trout meat depending on amino acid levels in feed. *Taurian Scientific Bulletin*, 119, 188-195.
- [10] Kondratiuk V.M. (2021). *Hematological and biochemical indicators of rainbow trout blood depending on lysin and methionine levels in combined feed*. Retrieved from <http://journals.nubip.edu.ua/index.php/Dopovidi/article/view/15134/13448>.
- [11] Voorhees, J., Barnes, M., Chipps, S., & Brown, M. (2019). Effects of exercise and bioprocessed soybean meal diets during rainbow trout rearing. *The Open Biology Journal*, 7(1), p.1-13.
- [12] Holembovska, N., Tyshchenko, L., Slobodyanyuk, N., Israelian, V., Kryzhova, Y., Ivaniuta, A., Pylypchuk O., Menchynska, A., Shtonda, O., & Nosevych, D. (2021). Use of aromatic root vegetables in the technology of freshwater fish preserves. *Potravinarstvo Slovak Journal of Food Sciences*, 15, 296-305.
- [13] Kondratiuk, V., & Otchenashko, V. (2021). Investigation of dependences of the morphological composition of body and amino acid composition of trout meat proteins (*Oncorhynchus mykiss*) on levels of the energy value of feeds. *Potravinarstvo Slovak Journal of Food Sciences*, 15, 497-505.
- [14] Ivaniuta, A., Menchynska, A., Nesterenko, N., Holembovska, N., Yemtcov, V., Marchyshyna, Y., Kryzhova, Y., Ochkolyas, E., Pylypchuk O., & Israelian, V. (2021). The use of secondary fish raw materials from silver carp in the technology of structuring agents. *Potravinarstvo Slovak Journal of Food Sciences*, 15, 546-554.
- [15] Carozza, D., Bianchi, D., Galbraith, E. (2019). Metabolic impacts of climate change on marine ecosystems: Implications for fish communities and fisheries. *Global Ecology and Biogeography*, 28(2), 158-169.

- [16] Crank, K., Voorhees, J., Barnes, M.E. (2019). Predator avoidance of rainbow trout reared with environmental enrichment. *Journal of Fisheries and Aquaculture Development*, 3(1), 1-6.

## **Біологічна ефективність ліпідів м'яса райдужної форелі залежно від рівнів амінокислот у комбікормах**

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**Анотація.** У форелевих господарствах України за використання комбікормів власного виробництва постає питання щодо з'ясування потреби райдужної форелі в енергії, протеїні та амінокислотах з метою досягнення максимальної реалізації її біологічного потенціалу продуктивності. Відповідно, у статті досліджено вплив використання повнораціонних комбікормів із різними рівнями лізину й метіоніну на показники біологічної ефективності ліпідів м'яса райдужної форелі. Метою дослідження передбачалося встановити вплив різних рівнів амінокислотного живлення товарної райдужної форелі на жирнокислотний склад ліпідів м'яса та їхню 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 раціон годівлі був однаковим для риб контрольної та експериментальних груп. В основний період рівень лізину й метіоніну в експериментальних комбікормах для різних піддослідних груп форелі коливався відповідно від 2,5 до 2,9 % і від 0,8 до 1,0 %. Годівлю райдужної форелі в період досліджень проводили 4-6 раз на добу, у денний час через рівні проміжки. Необхідну кількість корму розраховували відповідно до показників індивідуальної маси риб та температури середовища на момент годівлі. Вирощування товарних дволіток проводили в ставках площею 100 м<sup>2</sup> за щільності посадки 50 екземплярів/м<sup>2</sup>, та рівня води в них 1 м. Загальна кількість особин форелі в експериментальних дослідженнях становила 25 тис. екземплярів. Встановлено, що основну частку жирних кислот ліпідів м'яса райдужної форелі складають насичені жирні кислоти та мононенасичені. У результаті досліджень виявлено, що використання комбікормів із підвищеним рівнем лізину та метіоніну для риб 4 дослідної групи супроводжувалося збільшенням вмісту суми насичених жирних кислот у м'ясі на 5,84 % порівнюючи з контролем. За зростання амінокислотної поживності комбікорму спостерігається збільшення у м'ясі форелі вмісту лінолевої кислоти на 0,19-0,24 % порівнюючи з контролем. Практична цінність наукової роботи полягає в обґрунтованні підходів до технологічних основ підвищення ефективності використання поживних речовин комбікормів у форелівництві з метою забезпечення високої рибопродуктивності, що мають важливе народногосподарське значення

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