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Condition factor and identification of amino acid composition of three trout species in the western region of Ukraine

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ABSTRACT

Indicators of the condition factor, growth rate, and quality of the final products of cultivated objects are important parameters for the effective management of cold-water fish farming. These indicators are also used as a way to control the impact of environmental factors on fish, which requires constant research in the context of intensification of the aquaculture sector. The research is aimed at determining the condition factor and the amino acid composition of muscle tissues of *Salmo trutta fario* (Linnaeus, 1758), *Oncorhynchus mykiss* (Walbaum, 1792) and *Salvelinus fontinalis* (Mitchill, 1814) under the conditions of the western region of Ukraine. The results of the condition factor showed that, *S. fontinalis* had the highest value with 1.52±0.0340, and O. mykiss and *S. trutta* showed the lowest value with 1.33±0.0361 and 1.26±0.0181, respectively. Food conversion ratios were similar for S. fontinalis and O. mykiss (1.0), whereas *S. trutta* showed higher values (1.4). The specific growth rate was higher for rainbow trout (1.4) compared to the brook trout (1.32) and brown trout (1.28). The maximum content of protein, total amino acids (TAA), total essential amino acids (TEAA) and nonessential amino acids (TNEAA) were recorded in the brook trout. The muscle tissue of the investigated fish species is a well-balanced source of the nutrition energy in terms of the ratio of total essential to total nonessential amino acids (TEAA:TNEAA ratio).

INTRODUCTION

The flesh of fish is one of products being in the greatest demand all over the world **(FAO, 2014).** According to the data of **Haloyan *et al.* (2017)** the share of salmon in total number of marketable products of the Ukrainian fish-breeding enterprises has rather low

rates; however, some tendencies to increase the amount of this product in recent years exist already. The most cultivated object among salmonids is rainbow trout *Oncorhynchus mykiss* (Walbaum, 1792), the brook trout *Salvelinus fontinalis* (Mitchill, 1814) is breeding somewhat less. However, in recent years, the breeding of the native species namely the brown trout *Salmo trutta* morpha *fario* (Linnaeus, 1758) is becoming more and more popular (**Haloyan, 2017**).

The brook trout fillets contain a higher content of protein, lipids and dry matter than the rainbow trout fillets **(Rasmussen and Ostenfeld, 2000).** According to **Kaya *et al*. (2014)** brown trout fillet is a properly balanced with a high-quality protein source concerning ratio of essential to nonessential amino acids (EAA/NEAA ratio) during all seasons. Besides, brown trout is one of the most preferred wild freshwater fish species in particular due to its nutritional value and palatable aroma as well as being popular for sport fishing **(Kaya and Erdem, 2009)**.

Trout meat contains protein, which is an important item of human nutrition, in particular, the providing human body with protein, which contains all necessary amino acids **(Simeanu, 2012)**. Fish is considered as an important source of animal protein and plays an important role in promoting of the physical and intellectual development of a human being due to its good nutritional values **(Shi *et al*., 2013)**. The nutritional value of the muscles, including the amino acid composition of the protein may have differences between fish species, since muscle nutritional characteristics are influenced by many intrinsic factors (for example, body size and sexual maturity) and extrinsic factors (for example, food resources, water salinity and temperature) **(Børresen, 1992; Wesselinova, 2000).**

The amino acid composition is one of the most important nutritional qualities of protein **(FAO / WHO, 1990)** and the main substrates for metabolism of nitrogenous substances in living organisms. They give rise to proteins, peptide hormones, and many extremely important biologically active compounds **(Джабаров, 2006)**. They also have a high nutritional value and provide a range of health benefits, such as cholesterol reduction in the blood **(Gibbs *et al*., 2004)**. The data on the nutrients content will be helpful in classifying fish quality composition and in assessment of fish market price and human being health profits **(Jabeen and Chaudhry, 2016).**

Therefore, the study was conducted with an aim to identify some fishery indicators, protein content and amino acid composition in three trout species grown under the same conditions.

MATERIALS AND METHODS

The study was conducted 2019 between March and September 2020 in the fish farm “Fish Stream” located in Zakarpatska region (Ukraine), on three species of trout fish: brown trout (*S. trutta*), rainbow trout (*O. mykiss*) and brook trout (*S. fontinalis*).

Three species of fish (10000 of each species) were placed separately in three concrete basins of 120 m^3 in volume in March and were raising as monoculture till September (all fish individuals were fed daily at 08.00h am and 18.00h pm by artificial feeding (Crude protein 43-45%, Crude fat 20-22%, Ash 7%, Fibre 2%) taking into consideration an average weight of fish and water temperature). The basins received water from mountainous river. The physico-chemical parameters were not constant and were changing during the seasons, in particular water temperature was 12.37 ± 2.081, pH 7.1 ± 0,084, dissolved oxygen 8.54 ± 0.3054 ppm.

At the end of the experiment, 20 individuals of each species were taken from the basins and were measured using an electronic dial caliper (measurements of the standard length of body (l_s) and the maximum height of body (H_{max}, measured in the highest area of the body) of fish) and an electronic analytical scales (weight in g).

We calculated the following indices: condition factor (CF), profile index (IP), feed conversion ratio (FCR) and specific growth rate (SGR). Condition factor (CF) expresses the status of fish and is calculated by the formula:

$$CF = \frac{G \times 100}{l^3}$$

Where: G - body weight; 1 - standard length of body.

Profile index (IP) highlights a corporal shape of the fish. This index represents the ratio between standard length and maximum height.

$$IP = \frac{l}{H}$$

Where: l - standard length of body; H - maximum height of body **(Turliu, 2010; Mireşan *et al*, 2012).**

Besides, were calculated the Feed Conversion Ratio (FCR) = Feed consumed/biomass gain and Specific Growth Rate (SGR, % day^{-1}) = $[(\ln W_t - \ln W_0)/t] \times 100$, where W_0 and W_t are the average initial and final body weights, respectively, and (t) is time (days).

Amino acid composition of the muscle tissue was determined in dry matter of the fish muscle tissue from the dorsal part of the body according to the standard protocol (Amino acid analyser AAA400:User manual. Praha:Ingos, 2007), using automated amino acid analyzer AAA 400 (by Ingos a.s., Prague, CR).

The protein content of the fish samples was measured according to the Kjeldahl method using a Kjeltec 2300 autoanalyzer FOSS Tecator (Höganas, Sweden). The results are obtained in % protein. All amino acid samples were subjected to acid hydrolysis with 6 M HCl at 110°C for 24 hours. Amino acids which contain Sulphur were hydrolyzed separately with 6 M HCl after oxidizing (hydrogen peroxide + formic acid 1:10 v / v, 15 h). The tryptophan content was determined by hydrolysis (performed in sealed containers for 24 hours at 110 °C) and was performed with 4 M LiOH. Hydrolysis was performed in sealed containers for 24 hours at 110 °C.

All data are expressed as mean values ± standard deviation (SD). Statistical analyses were performed using the significance value set at 0.05 ($P<0.05$) and ($P<0.01$). All data were analyzed using statistical software Microsoft Excel 2016.

RESULTS AND DISCUSSION

Length, weight and indexes

The juveniles had mean initial weight 11.055 ± 0.091g for brown trout, 15.569 ± 0.192 g for rainbow trout and 22.131 ± 0.030 g for the brook trout.

At the end of study, the average weight of the brown trout was 132.07 ± 0.239 g, rainbow trout was 262.12 ± 2.459 g, and for brook trout it was 288.56 ± 3.640 g (Table 1). The average body length of the studied fish species was 21.88 ± 0.664 cm, 27.03 ± 0.147 cm and 26.64 ± 0.193 cm respectively.

Table 1. Length, weight and indexes of brown trout, rainbow trout and brook trout

Specification	Brown trout	Rainbow trout	Brook trout
Final weights - G (g)	132.07 ± 0.239	262.12 ± 2.459	288.56 ± 3.640
Length of body - l, (cm)	21.88 ± 0.646	27.03 ± 0.147	26.64 ± 0.193
Height of body - H,(cm)	5.10 ± 0.300	7.17 ± 0.082	7.30 ± 0.129
IP	4.29 ±0.091	3.77 ± 0.120	3.65 ± 0.082
CF	1.26 ± 0.02	1.33 ± 0.04	1.52 ± 0.03
FCR	1.4 ± 0.085	1.0 ± 0.066	1.0 ± 0.069
SGR	1.28 ± 0.086	1.45 ± 0.047	1.32 ± 0.071

The condition factor provides information on the maintenance state of fishes and the quality of their feeding. A higher value of this index may be considered as a very good maintenance state of the fish organism and cultivation conditions. In our study, the highest coefficient (1.52) was registered for the brook trout. In other researched species, the CF was slightly lower, in particular in rainbow trout – 1.33, in brown trout – 1.26. However, according to the condition factor standard **(Barnham and Baxter, 2003)** obtained values in our study are between fair and good condition. Consequently, we can conclude that our technological and climatic conditions are favorable for the cultivation of the researched fish species.

The profile index reflects the pronounced convexity of the upper line of the fish body, which has a curved dorsum. Fish with the lowest profile index is preferred for selection practice because the curved shape of the dorsum correlates with the rich

muscular mass (Mireşan *et al.*, 2010). The rainbow trout and the brook trout had almost identical results for this index and rather low, indicating their fleshiness.

It has been discovered that brook trout and rainbow trout had good FCR, but a slightly higher value was observed for the brown trout. Similar results were found in the works of other authors, as **Başçinar (2011)** for *Salmo trutta fario* FCR was 1.19; **Karataş *et al.*, (2017)** for *Oncorhynchus mykiss* which amounted to - 1.1; **Başçinar *et al.*, (2010)** for *Salvelinus fontinalis* – 0.909.

The specific growth rates were marked as the highest for rainbow trout due to the water temperature regime in basins during summer, but for brook trout this temperature was higher optimal one though it did not reach critical levels (> 20 °C) **(Delihasan Sonay and Başçınar, 2017).**

Protein and Amino acid profiles

In the present study, the protein content was the highest in the brook trout, followed by rainbow trout ($P<0.05$) and brown trout ($P<0.05$).

According to **Tidballb *et al* (2017),** wild brook trout has higher protein content than domesticated and wild rainbow trout. Some scientists also indicated that the brook trout had a higher protein content than the rainbow trout **(Rasmussen and Ostenfeld, 2000; Köse *et al.*, 2001; Coroian *et al.*, 2015).**

Table 2. The protein and amino acid content in the muscle tissue of brown, rainbow and brook trout, g kg^{-1}

Specification	Brown trout	Rainbow trout	Brook trout
Protein, %	71.83 ± 0.389	73.09 ± 0.410	76.12 ± 0.196ab
Aspartic acid (Asp)	71.42 ± 0.439	73.79 ± 0.427	76.63 ± 0.364ab
Threonine (Thr)E	32.11 ± 0.382	33.93 ± 0.443	34.16 ± 0.551
Serine (Ser)	24.67 ± 0.419	26.24 ± 0.308	25.96 ± 0.454
Glutamic acids(Glu)	113.06 ± 0.694	111.53 ± 0.891	118.75 ± 0.899ab
Proline (Pro)	25.49 ± 0.534	25.69 ± 0.562	25.02 ± 0.624
Glycine (Gly)	32.35 ± 0.385	32.74 ± 0.362	33.47 ± 0.569
Alanine (Ala)	43.24 ± 0.681	43.06 ± 0.614	44.89 ± 0.569
Valine (Val)E	35.33 ± 0.122	37.25 ± 0.690	37.98 ± 0.677a
Isoleucine (Ile)E	31.79 ± 0.303	32.50 ± 0.687	33.52 ± 0.326
Leucine (Leu)E	56.54 ± 0.410	56.95 ± 0.450	59.70 ± 0.395ab
Tyrosine (Tyr)	22.96 ± 0.397	23.83 ± 0.246	26.05 ± 0.124a
Phenylalanine (Phe)E	30.17 ± 0.461	32.12 ± 0.499	33.47 ± 0.591a
Histidine (His)	22.50 ± 0.222	25.05 ± 0.543a	25.40 ± 0.435a
Lysine (Lys)E	59.68 ± 0.532	58.71 ± 0.470	60.61 ± 0.311b
Arginine (Arg)	42.28 ± 0.339	41.45 ± 0.443	45.95 ± 0.466aab
Cystine (Cys)	5.57 ± 0.115	6.93 ± 0.176a	6.26 ± 0.132a
Methionine (Met)E	22.11 ± 0.184	22.86 ± 0.429	24.0 ± 0.157a
Tryptophan (Try)E	6.36 ± 0.141	6.45 ± 0.242	6.36 ± 0.039
TAA	677.63	691.08	718.18
TEAA	316.37	322.22	335.75
TNEAA	361.26	368.86	382.43
TEAA / TNEAA	0.875	0.873	0.878

Note. ^{E} – Essential amino acid for humans (Sirakov, 2015), TAA – Total amino acid; TEAA – Total essential amino acid; TNEAA – Total nonessential amino acid.

Statistical significance was established at $P<0.05$ for: [a] — $P<0.05$, [aa] — $P<0.01$ for brown trout / rainbow trout, brown trout / brook trout; [b] — $P<0.05$, for rainbow trout / brook trout.

The content of amino acids in the dry matter of the muscle tissue of the three species of trout (Table 4) revealed that the main amino acids for those fish species were aspartic acid, glutamic acid and lysine. Other authors have reported similar data on those amino acids in trout muscles **(Ozyurt and Polat, 2006; Kaya *et al*., 2014; Sirakov, 2015).** However, according to **Sarma *et al*., (2015),** the amino acid proline was the main one in the muscles of the rainbow trout.

The highest content of aspartic acid and glutamic acid was reported for brook trout with 3.85% and 6.47% more than for the rainbow trout and 7.3% and 5.03% more than for brown trout respectively. Glutamic acid is considered to be one of the most important amino acids for body systems **(Christina *et al.*, 1999)**. Lysine quantity in brook trout was 1.56% higher than in brown trout and 3.24% higher than in rainbow trout.

The contents of histidine, methionine, valine and leucine in brook trout were higher than in brown trout by 11.41%, 7.87%, 6.98% and 5.29%, respectively. In rainbow trout, the amounts of cystine, proline and serine were higher comparatively with brook and brown trout. The contents of histidine, phenylalanine and valine in rainbow trout and brook trout exceeded the brown trout's values. The content of tryptophan was somewhat higher in the rainbow trout compared with brook trout and brown trout. The two last ones had the same content of tryptophan. Tryptophan is one of the most important amino acids in food, because it is nutritionally important as a precursor for important metabolites such as serotonin and nicotinamide, in the latter case giving it the vitamin-like properties through its ability to replace dietary niacin **(FAO / WHO, 2007).** Some amino acids like tyrosine, methionine, histidine, lysine and tryptophan are considered to act as antioxidants **(Saito *et al*., 2003).**

The total amount of amino acids (TAA) in brook trout exceeded the same one in brown trout and rainbow trout for 5.64 % and 3.77% respectively.

The content of nonessential amino acids (TNEAA) and essential amino acids (TEAA) was higher in brook trout for 3.68% and 4.2% comparatively with rainbow trout and for 6.12% and 5.86% comparatively with brown trout.

Muscle tissue of trout has a well-balanced and high-qualitative protein source. According to our research, the value of the ratio of the essential amino acid to nonessential amino acids (TEAA / TNEAA) in these three fish species is almost the same, although in the brook trout it was slightly higher and was equal 0.878. Similar data are indicated for the brown trout 0.86 and for the rainbow trout 0.73 **(Sirakov, 2015)**. According to the Kaya *et al*., (2014) researches, who cultivated brown trout in September, the ratio of TEAA / TNEAA was equal to 0.896.

Furthermore, according to the results of **Sabetian (2012)** this number was equal 0.75 for rainbow trout. According to the studies of **Iwasaki and Harada (1985)**, the correlation of TEAA / TNEAA in chum salmon (*Oncorhynchus keta*) was equal 0.75, in sea bream (*Pagrus major*) and in pacific flounder (*Paralichthys olivaceus*) it amounted 0.77; in wild and cultured sea bass (*Dicentrarchus labrax*) it made 1.198 and 1.096 respectively **(Baki *et al.*, 2015).** Also according to the data of **Özyurt and Polat (2006)** in the sea bass (*Dicentrarchus labrax*) fillets the ratios of essential / nonessential amino acids were observed to be 0.76 for autumn, 0.77 for both spring and summer.

CONCLUSION

Different indices were calculated for three species of salmonid fish: the brown trout (*Salmo trutta m. fario* L.), the rainbow trout (*Oncorhynchus mykiss* W.) and the brook trout (*Salvelinus fontinalis* M.), such as final weight, length, condition factor and specific growth rates. We observed a significant difference in values between the studied species. Feed conversion ratios were similar in brook and rainbow trouts, while brown trout showed higher values.

It has been estimated that according to the results the quality of muscle tissues of brook trout by protein content is higher comparatively with rainbow and brown trout. moreover, brook trout has better indices of amino acid composition (TAA, TEAA and TNEAA) comparatively with rainbow and brown trout. It may be asserted that these three salmon species are characterized by properly balanced amino acid composition, including all necessary essential amino acids.

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