THE INFLUENCE OF DIFFERENT NUTRITION LEVELS ON THE GROWTH CHARACTERISTICS AND MEAT TEXTURE OF THE RAINBOW TROUT (*ONCORHYNCHUS MYKISS* WAL.)

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UTICAJ RAZLIČITIH NIVOA ISHRANE NA KARAKTERISTIKE RASTA I TEKSTURU MESA DUŽIČASTE PASTRMKE (*ONCORHYNCHUS MYKISS* WAL.)

Apstrakt

Eksperiment je realizovan u laboratoriji za akvakulturu Poljoprivrednog fakulteta Univerziteta u Banjoj Luci. Ukupno je naseljeno 100 jedinki u 5 eksperimentalnih grupa, prosječne individualne mase 91.09±1.37 g, totalne dužine tijela 20.08±0.10 cm i dužine tijela do račve repnog peraja 19.37±0.10 cm (M±SEM). Cilj rada je bio praćenje efekata različitih nivoa ishrane na karakteristike rasta i teksturu (tvrdoću) mesa dužičaste pastrmke (*Oncorhynchus mykiss*). Dužičasta pastrmka u svim eksperimentalnim grupama hranjena je istom hranom, sa različitim nivoima ishrane: 20% (G_{-20}) i 10% manje (G_{-10}) u odnosu na standardni nivo ishrane, standardni nivo ishrane (G_{100}) (preporuka proizvođača hrane), 10% (G_{+10}) i 20% više (G_{+20}) u odnosu na standardni nivo ishrane. Statistički značajna razlika sredina ($p<0.05$) mase i dužine tijela između posmatranih eksperimentalnih grupa javlja se u drugom periodu. Najmanja potrebna sila (kg) za presijecanje mesa dužičaste pastrmke konstatovana je na početku eksperimenta kod jedinki prosječne mase oko 90 g. Najtvrđe meso je kod riba iz eksperimentalnih grupa G_{+10} i G_{-10}. Između posmatranih eksperimentalnih grupa konstatovana je statistički značajna razlika sredina ($p<0.05$) potrebne sile za presijecanje mesa.

Ključne riječi: ishrana, rast, tekstura, meso, dužičasta pastrmka
Keywords: nutrition, growth, texture, meat, rainbow trout

INTRODUCTION

Rainbow trout (*Oncorhynchus mykiss*) is widely farmed in many countries around the world due to its rapid growth and high nutritional value (Fallah et al., 2011). The feeding cost of farmed rainbow trout is high, over 50% of total production costs (Hardy & Barrows, 2002). Therefore, there is a need of continued research in the field of salmonid's nutrition and study of the effects of different types of feed and nutrition level in different environmental conditions on the growth characteristics of rainbow trout (Savić et al., 2013).

In addition, an important issue is the quality of meat of farmed trout in terms of chemical composition and texture of meat (Andersen et al., 1997). The texture of fish meat depends on the physical factors (fish species; age and size etc.), chemical factors (the content and arrangement of the water etc.) and the applied treatment (freezing, cooling, etc.) (Cheng et al., 2014).

The aim of the study was to analyze the effects of different diets on growth performance and meat texture of the rainbow trout (*Oncorhynchus mykiss*) starting with initial weight around 90 g and final weight of approximately 200 g.

MATERIALS AND METHODS

The experiment was carried out at the laboratory of Aquaculture, Faculty of Agriculture, University of Banja Luka. It lasted 48 days. A total of 100 individuals were placed in five experimental groups. The average weight was 91.09 g, total body length 20.08 cm and fork length 19.37 cm. The fish were distributed in 5 experimental groups, 20 fish per experimental group. Each aquarium had a volume of 55 l with constant water flow. Rainbow trout was fed with the same feed in all the experimental groups with different levels of nutrition: 20% (G_{-20}) and 10% less (G_{-10}) than the standard level of the diet, a standard diet level (G_{100}) (recommended by the feed producers), 10% (G_{+10}) and 20% higher (G_{+20}) than the standard level of the diet. Fish were fed twice a day, with feed having the following composition: crude protein 42%, crude fat 24%, fiber 3%, ash 6%, total phosphorus 0.9% and digestible energy of 19.4 MJ/kg.

Water temperature (°C) and dissolved oxygen (mg/l) in water were measured every day before the first feeding with digital oxy-meter (Oxi 330i/SET 2B20-0011 WTW), and the pH value with digital pH-meter (pH 330i/SET 2A20-1011 WTW). Body mass of each individual was measured by scales Denver DL-501, capacity of 0.5 kg. The body length of each individual was determined with ichthyometer. The following formulas were used to analyze the growth characteristics and other parameters: The growth of body mass (%)=((FBW-IBW)/IBW)x100; CF=(BW/L^3)x100; SGR=((lnFBW-lnIBW)/D)x100; Survival (%)=(N_t/N_0)x100; TGC=((FBW$^{1-3}$-IBW$^{1-3}$)/Σ(TxD))x100; FCR=F/G. (FBW-final body weight (g); IBW-initial body weight (g); CF-condition factor; BW-body weight (g); L–fork length (cm); SGR-specific growth ratio; ln-natural logarithm; D-the number of feeding days; N_0-the number of fish at the beginning (n); N_t-the number of fish at the end (n); TGC-thermal-unit growth coefficient; T-water temperature (^oC); FCR-feed conversion ratio; F-feed consumption; G-gain weight).

The texture of fresh raw fish meat was determined by sampling the muscle *Musculus lateralis maior*. Eight fish from each experimental group, a total of 40 fish, were taken for determination of the meat texture at the end of the experiment. The thickness of meat

samples was 10 mm and length about 60 mm. Measurements of hardness of fish meat were carried out using instrument for analysis of textures, Texture Analyser TA.XT Plus (Stable Micro Systems, England) with the help of Warner-Bratzler knife and HDP/BSK platform. The load cell of the instrument was 25 kg, the speed of the knife was 5.0 mm/s during the test and distance 20 mm.

The statistical program SPSS-17 was used to calculate the average value, the SEM, CV, the univariate analysis of variance and LSD test.

RESULTS AND DISCUSSION

Basic physical and chemical water quality parameters (Table 1) for fish farming were in a narrow range of variation and there were no significant differences between the experimental groups.

Table 1. Average values (Mean±SEM) and the coefficients of variation of water temperature, dissolved oxygen, and pH values during the experimental period

Experimental groups	Water temperature (°C)		Dissolved oxygen (mg/l)		pH value	
	Mean±SEM	CV	Mean±SEM	CV	Mean±SEM	CV
G_{-20}	16.29±0.03	1.10	7.17±0.08	6.72	7.32±0.02	1.57
G_{-10}	16.32±0.02	0.80	6.73±0.11	9.58	7.27±0.02	1.48
G_{100}	16.33±0.02	0.74	6.62±0.10	8.63	7.22±0.01	0.90
G_{+10}	16.31±0.02	0.69	7.08±0.11	9.14	7.28±0.02	1.11
G_{+20}	16.34±0.01	0.53	6.96±0.14	12.35	7.18±0.02	1.31

A statistically significant difference ($p < 0.05$) of weight and body length in the observed experimental groups appeared in the second period (Table 2). The largest variations in body mass were presented in the experimental group G_{+10} with a tendency of growth, and variations of body weight in the group G_{+20} a continuous upward trend. This is understandable, considering that the group was given the largest amount of feed per day.

Table 2. Growth of weight and body length (Mean±SEM) and coefficients of variation (CV) of rainbow trout

Parameter	Eksperimental groups									
	G_{-20}		G_{-10}		G_{100}		G_{+10}		G_{+20}	
	Mean±SE	CV	Mean±SE	CV	Mean±SE	CV	Mean±SE	CV	Mean±SE	CV
Mass (g)										
Beginnig	91.6±2.78^{ns}	13.56	89.7±3.55^{ns}	17.69	94.3±2.78^{ns}	13.18	91.2±2.89^{ns}	14.19	88.8±3.42^{ns}	17.22
I period	115.1±3.13^{ns}	12.16	114.1±4.37^{ns}	17.14	122.6±3.35^{ns}	12.21	118.7±3.87^{ns}	14.58	118.0±4.66^{ns}	17.68
II period	142.6±4.44^{a}	13.93	145.2±6.81^{ab}	20.98	160.4±5.01^{b}	13.98	155.0±6.40^{ab}	18.45	157.7±6.30^{ab}	17.87
III period	176.3±5.64^{a}	14.31	183.3±8.41^{a}	20.52	208.7±6.22^{b}	13.34	209.0±8.70^{b}	18.14	209.5±9.12^{b}	19.47
Totall lenght (cm)										
Beginnig	20.1±0.16^{ns}	3.64	19.8±0.29^{ns}	6.67	20.2±0.19^{ns}	4.20	20.2±0.20^{ns}	4.38	20.2±0.26^{ns}	5.74
I period	21.6±0.18^{ns}	3.63	21.3±0.37^{ns}	7.86	21.9±0.20^{ns}	3.99	21.7±0.24^{ns}	4.95	21.8±0.29^{ns}	6.06
II period	22.8±0.21^{ab}	4.11	22.6±0.41^{a}	8.18	23.5±0.23^{b}	4.36	23.1±0.33^{ab}	6.34	23.3±0.34^{ab}	6.45
III period	24.1±0.24^{a}	4.36	24.3±0.46^{a}	8.56	25.4±0.24^{b}	4.15	25.3±0.34^{b}	5.78	25.3±0.40^{b}	7.16
Fork length (cm)										
Beginnig	19.5±0.18^{ns}	4.01	19.0±0.29^{ns}	6.74	19.5±0.21^{ns}	4.77	19.5±0.19^{ns}	4.32	19.4±0.27^{ns}	6.17
I period	20.7±0.18^{ns}	3.99	20.4±0.37^{ns}	8.13	21.0±0.20^{ns}	4.33	20.7±0.25^{ns}	5.39	20.9±0.30^{ns}	6.51
II period	21.9±0.21^{a}	4.23	21.8±0.40^{a}	8.30	22.8±0.23^{b}	4.61	22.3±0.32^{ab}	6.40	22.4±0.35^{ab}	6.91
III period	23.4±0.24^{a}	4.65	23.5±0.46^{a}	8.74	24.7±0.25^{b}	4.47	24.5±0.34^{b}	6.06	24.5±0.39^{b}	7.06

Values with different superscripts are significantly different ($p<0.05<$) ^{ns}not significant

In general it can be said that the CF was fairly uniform during the observation period in all experimental groups and it had a growth trend from the beginning to the end of the experiment.

Total FCR is the same in experimental groups G_{100} and G_{-20}, unlike experimental groups with higher consumption (G_{+10} and G_{+20}) which had higher FCR. This is in accordance to the research of Savić et al. (2013). Bitaraf et al. (2012) suggests that the FCR in rainbow trout with similar size, diet with a protein content of 36% and 14% fat, grown in brackish water (salinity 8.5 gl^{-1}, temperature 10-15^{o}C, O_2 5.2-6.6 mg/l) ranged from 1.27 to 1.70.

Table 3. Characteristics of growth, conversion coefficient and survival of rainbow trout

Parameter	Experimental groups				
	G_{-20}	G_{-10}	G_{100}	G_{+10}	G_{+20}
Condition factor (CF)					
Beginning	1.23	1.31	1.28	1.24	1.22
I period	1.30	1.34	1.32	1.33	1.30
II period	1.36	1.41	1.36	1.40	1.39
III period	1.37	1.42	1.38	1.41	1.43
The level of nutrition (%)	-20	-10	100	+10	+20
Feed conversion ratio (FCR)					
I period	0.77	0.81	0.80	0.87	0.87
II period	0.87	0.86	0.84	0.93	0.93
III period	0.87	0.89	0.86	0.95	0.95
Total FCR	0.84	0.86	0.84	0.89	0.92
Specific growth ratio (SGR)					
I period	1.53	1.60	1.75	1.76	1.89
II period	1.43	1.61	1.79	1.78	1.93
III period	1.41	1.55	1.76	1.99	1.89
Total SGR	1.46	1.59	1.77	1.84	1.91
Thermal-unit growth coefficient (TGC)					
I period	0.122	0.127	0.142	0.141	0.151
II period	0.147	0.166	0.190	0.187	0.203
III period	0.157	0.174	0.205	0.231	0.220
Total TGC	0.141	0.154	0.176	0.183	0.189
Weight gain - WG (%)					
I period	25.72	27.22	30.01	30.17	32.83
II period	23.89	27.27	30.79	30.64	33.66
III period	23.60	26.25	30.15	34.84	32.86
Total weight gain	92.52	104.41	121.31	129.29	135.87
Survival (%)	100.00	100.00	100.00	95.00	100.00

SGR and TGC are expected and in accordance with levels of nutrition. SGR ranged from 1.46 to 1.91, which is significantly higher compared to the results obtained from Guler & Yildiz (2011) in their study, carried out in five treatments (SGR was ranged from 0.82 to 0.92), at a temperature between 10°C and the experiment duration of 60 days. Ustaoğlu & Alagille (2009) reported that rainbow trout of similar weight, for a period of 60 days, at a similar temperature, with a slightly lower content of dissolved oxygen in water and fed different diet frequencies achieved a SGR of 1.02 and 1.07.

Table 4. The hardness of fresh raw meat of rainbow trout

Period	Experimental group	The maximum force (kg) required for cutting of fish meat			
		Mean±SEM	CV	Min.	Max.
Initial		0.75^{a}±0.039	28.29	0.47	1.22
Final	$\mathbf{G_{-20}}$	1.15^{bd}±0.030	13.85	0.75	1.39
	$\mathbf{G_{-10}}$	1.25^{d}±0.038	17.23	0.92	1.84
	$\mathbf{G_{100}}$	1.12^{b}±0.041	20.59	0.77	1.73
	$\mathbf{G_{+10}}$	1.34^{c}±0.031	13.73	1.06	1.71
	$\mathbf{G_{+20}}$	1.17^{bd}±0.024	11.49	0.90	1.37

Values with different superscripts are significantly different (P<0.05)

Minimum needed force (kg), for cutting the meat of rainbow trout was found at the beginning of the experiment when the average weight of the fish was about 90 g. This is to be expected considering the size of the fish and the water content, according to the results of Hultmann & Rustad (2002). They reported that higher water content in muscle reduces the required force for cutting the meat. Cheng et al. (2014) also suggested that meat texture depends of the physical and chemical factors. Among the observed experimental groups was found statistically significant differences ($p<0.05$) required maximum force for cutting meat. The biggest variations in needed force for cutting fish meat were found in experimental group G_{100} (from 0.77 to 1.73 kg). Hardest meat is found in fish from experimental groups G_{+10} and G_{-10} (G_{+10} = 1.34 kg and the G_{-10} = 1.25 kg).

CONCLUSION

The effects of different levels of nutrition on growth characteristics demonstrate the presence of a statistically significant difference. Significant differences were found in the groups fed with 10 and 20% less feed, and groups fed with standard and higher (10 and 20%) feed. Age or size of the fish had a significant influence on the texture (hardness) of meat, which means that less force is required for cutting meat of fish with smaller mass. There is a statistically significant difference of meat texture in fish with larger mass as a direct consequence of the different levels of nutrition.

Analysis of the growth performance of rainbow trout during the breeding cycle was significant, particularly in terms of achieving optimal or maximal mass growth while preserving the good health status of farmed fish, good feed consumption and better results, and consequently achieving good quality of meat in reared rainbow trout.

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