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IMPACT OF MANNANOLIGOSACCHARIDES ON PERFORMANCE TRAITS OF RAINBOW TROUT

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Abstract: The effect of mannanoligo saccharides (MOS) as a food additive, applied at a concentration of 0.2% (O-I group of fish) and 0.3% (O-II group of fish) on morphometric characteristics and primary production of the Californian trout was investigated. The experiment was conducted on 450 fish divided into three groups with 150 individuals in each group, and lasted 40 days. The analysis of obtained results established the beneficial effect of the applied additives on morphometric parameters of the growth rate of fish, their final mass and final linear dimensions, and their growth, but no statistically significant differences (p> 0,05) were established. The highest body weight and body length of studied groups was achieved by trout of O-II group (118.49 g, 19.59 cm), followed by trout of O-I group (118.04 g, 19.58 cm) and the lowest K-group fish (115.94 g, 19.56 cm). Adding MOS in the feed mixture for trout had a beneficial effect (p> 0.05) in the exercise of lower feed conversion (FC) and better values of main production indicators: condition factor (FC), protein efficiency ratio (PER), the specific rate growth rate (SGR) and production index (PI) compared to the K group of fish that were fed diets without added mannanoligo saccharides. The best results were achieved by O- II fish group, and expressed in relative terms in comparison to the K group of fish: better feed conversion by 5.61%, a better utilization of protein feed value by 5.94%, a higher value of condition factor by 1.73 %, the specific growth rate by 2.26% and a better value of production index by 8.27%.

Keywords: mannanoligosaccharides, rainbow trout, production indicators

Introduction

Ban of antibiotics as growth promoters and increase in demand for environmentally safe products, modern aquaculture management strategies

in fish nutrition, involve the use of biologically active substances in order to achieve maximum production output. Nowadays, a range of biofunctional preparations are used as feed additives, which exert a positive effect on production traits and health of farmed animals and fish, but do not have direct nutritional effects (*Adams, 2004*).

Prebiotics mannan oligosaccharides (MOS) and supplements based on it are complex carbohydrates derived from the cell wall of yeast *Saccharomyces cerevisiae* and are non-digestible food ingredients. The form present in the cell wall (α-1, 3 and α-1, 6 branched mannans) is particularly effective in binding to pathogens in the digestive tract of animals and fish (*Spring et al., 2000*). Their use contributes to the increased vitality of animals and fish, reduces mortality, stimulates production of immunoglobulins that enhance the immune system, and also improves the conversion and absorption of food, which leads to good production results and positive economic effect (*Ferketi et al., 2002*). mannanoligosaccharides are now the most used in monogastric animal nutrition.

Considering the above facts relating to the applicability of biologically active substances as food additives, the aim of this paper is to show the potential of mannanoligosaccharides as a food additive on the production characteristics of yearling rainbow trout (1 + years).

Material and methods

The experiment was conducted on 450 of sorted and approximately uniform specimens of rainbow trout aged 1 + years of which were formed into three experimental groups of 150 fish each. Studied groups of fish were distributed into 3 individual pools of 20 m^3 volume, with the same water inlet of 24 l/sec, and the flow of water comprising of 69changes within 24 hours. The experiment lasted 40 days.

Fish in all three experimental groups were fed with standard mixture for feeding fattening trout with 40% of the total protein. The control group of fish was fed feed without additives, and other experimental group of fish was fed diets supplemented with either mannanoligo saccharides (MOS) as follows: O-I group was fed mixture containing 0.2% MOS and O-II group mixture containing 0.3% MOS.

The amount of food and number of daily meals were determined on a daily basis according to pre-determined food tables, adjusted to the water temperature and body weight of fish during the test (*Phillips, 1970*). Consumed food was chemically analyzed at the beginning of the experiment using standard testing methods (AOAC, 1990), except that the energy content was obtained by calculation. Ingredients and chemical composition of the mixture used for feeding fish in the experiment is shown in Table 1

Table 1. Ingredients and chemical composition of the used mixture

Component ,%	K	O-I	O-II
Corn	11,30	11,10	11,00
Fish meal	48	48	48
Soybean meal	19	19	19
Sunflower meal 33%	3	3	3
Lime	1,9	1,9	1,9
Mono-Ca-phosphate	0,5	0,5	0,5
Iodized salt	0,3	0,3	0,3
Premix	1	1	1
Soybean oil	15	15	15
Mannanoligo saccharides (BioMos)	-	0,2	0,3
Average chemical composition of used mixtures (%) VSM			
Water	9,33	9,31	9,30
Ash	11,00	11,10	11,14
Proteins	40,39	40,41	40,35
Fibre	2,66	2,64	2,70
Dry matter (DM)	90,67	90,69	90,70
Metabolic energy ME MJ/kg (calculation)	15,06	15,10	15,08

Composition of used premix/kg mixture: Vitamin A 20000 IJ/kg; Vitamin D_3 3000;Vitamin E 80 mg/kg; Vitamin K_3 5 mg/kg; Vitamin B_1 15 mg/kg; Vitamin B_2 25 mg/kg; Vitamin B_6 15 mg/kg; Vitamin B_{12} 0,04 mg/kg; Vitamin C 500 mg/kg; Niacin 100 mg/kg; Ca-pantotenat 50 mg/kg; Biotin 1 mg/kg; folic acid 4 mg/kg; Cholin chloride 100 mg/kg; Fe 40 mg/kg; Cu 10 mg/kg; Mn 40 mg/kg; Zn 40 mg/kg; J 10 mg/kg; Se 0,05 mg/kg; Co 1 mg/kg; Mg 50 mg/kg; Antioxidant BHT 100 mg/kg.

Based on the shown chemical composition of the mixture it can be concluded that the quality of the mixture was such that it meets the optimal nutritional requirements of rainbow trout and meets the requirements that are placed in the design of the experiment (*NRC, 1993, Official Gazette of RS No.4/2010*).

Control measurements of body mass and body length of fish were performed at the beginning, middle and end of the experiment. In order to determine the production characteristics of fish from each group two hours after feeding 20 individuals were cought, according to the method of random sampling. Individual body weight of fish was determined by measuring on a decimal technical scale (accuracy to 10-2 g) and body length using the ihtiometer (accuracy to 0.1 cm).

Based on the determined measurement results in order to determine the effect of mannanoligo saccharides as additive to the mixtures, the following product parameters were analyzed: total body weight gain, average individual weight gain and total body length, feed conversion ratio (FC), condition factor (FC), specific growth rate (SGR), protein efficiency ratio (PER) and production index (PI). In order to determine the hygienic conditions in the pools, indices of fish stocking density (Ig) and flow (Ip) were determined

These parameters were calculated using the following forms:

$HK = H / TM_2 – TM_1$

$FK = TM_2 (g) / L_2^3 (cm)$

$SGR = [(TM_2 - TM_1) / (T_2 - T_1)] \times 100$

PER = Ptm / Up

Where: H-consumed food; TM_2 - Final body weight (g); TM_1 - initial weight (g); L_2 - Final total body length (cm); T_2-T_1 - the number of days the experiment; Ptm - gain of body weight (g); Up - consumption of protein (g).

According to *Piper et al. (1982)* the following was calculated:

Ig = [TM / L] x Q and Ip = [TM / L] x P

Where: TM-weight (g); L - total body length (cm); Q - volume of the fish pool (m^3), P - the water flow (l/sec).

Statistical analysis was performed using analysis of variance with assessment of statistical significance using the t-test.

Results and Discussion

The results on the impact of adding different concentrations of mannanoligo saccharides in the feed mixture of rainbow trout on the performance are presented in Tables 2 and 3

Table 2 Comparative overview of the values of some production traits

Indicator	Groups		
	K	O-I	O-II
Initial body weight (beginning of trial), g	82,30	82,20	82,30
Average total body length (beginning of trial), cm	19,16	19,16	19,16
Production indicators at the end of the trial			
Average body weight (TM), g	115,94	118,04	118,49
Average total body lemngth (L), cm	19,56	19,58	19,59
Total fish weight, kg	17,39	17,71	17,77
Total gain of body weight, kg	5,05	5,38	5,43
Average individual gain of TM, g	33,64	35,84	36,19
Difference (%)		6,54	7,58
Average individual increase of L, cm	0,400	0,420	0,430
Difference (%)		5,00	7,50
Total feed consumption, kg	9,06	9,15	9,20
Average daily feed consumption per fish, g	1,510	1,525	1,533
Difference (%)		0,99	1,55
Feed conversion ratio (FC)	1,795	1,702	1,695
Difference (%)		-5,21	-5,61
Protein efficiency coefficient (PER)	1,392	1,469	1,475
Difference (%)		5,49	5,94
Condition factor (FK)	0,0155	0,0157	0,0158
Difference (%)		1,50	1,73
Specific growth rate (SGR)	2,10	2,24	2,26
Difference (%)		6,54	7,58
Production index (PI)	2,421	2,601	2,622
Difference (%)		7,40	8,27

At the beginning of the experiment all fish groups were roughly equal in terms of body weight and body length, which is the result of the previous sorting to obtain the more uniformh groups. Upon completion of the experiment, i.e. 40 days, the highest body weight values were recorded in O-II fish group (118.49 g), followed by trout of O-I group (118.04 g), and the lowest in K-group (115.94 g). Average values of body length were highest in fish of O-II group (19.59 cm) and lowest in group K (19.56 cm). The differences of the final body weight and total body length of fish between the groups (Table 3) were not statistically significant ($p > 0.05$). Realized values of morphometric parameters analyzed had directly influenced the results in the gain. Expressed in relative terms, O-II group fish achieved a higher average weight gain compared to fish in K group and 7.58% of the total body length of 7.50%, while the fish of O-I group for the same parameters had better results by 6.54% and 5.00%, respectively. For these two parameters between the groups statistical analysis did not establish a significant difference ($p > 0,05$).

Table 3 Average values of body weight (g) and total body length (cm), 40 days of the experiment

Group	n	$\bar{X}$	min	max	$S_{\bar{X}}$	Sd	t- test
Average values of body weight							
K- group	20	115,94	108,20	124,30	1,040	4,649	p>0,05
O-1 group	20	118,04	113,50	127,60	0,950	4,248	
O-2 group	20	118,49	110,10	128,30	1,032	4,634	
Average values of total body length							
K- group	20	19,56	19,18	19,91	0,061	0,273	p>0,05
O-1 group	20	19,58	19,16	19,93	0,063	0,283	
O-2 group	20	19,59	19,15	19,95	0,066	0,287	

Obtained results are in agreement with the data by researchers who established that the addition of MOS to mixtures for various species of fish, has stimulating effect on the increase in the value of their growth and weight gain, but without statistical significance (*Binh et al., 2008; Dimitroglou et al. , 2011; Sara et al. 2011*). According to other researchers, who have examined the younger fish categories, the positive effects of adding MOS to fish food caused significantly better growth of examined fish (*Staykov et al., 2005; Čuljak et al. 2006; Ognean et al., 2009*).

Based on the obtained production results (Table 2) it can be concluded that the presence of MOS in the mixtures for fattening trout, O-I and O-II group of fish, caused realization of greater feed intake and better feed conversion value and the ratio of protein efficiency. The lowest total food consumption had fish in group K (9.06 kg), and the highest trout in O-II group (9.20 kg) and average daily feed

intake of fish in the O-II group was by 1.55%, and O-I group by 0.99% higher than in the K group.

In the analysis of feed conversion (FC) as the interaction of growth and food consumption, it is evident that the best value for this production parameter was achieved by O-II fish group (1.695), followed by O-I group (1.702), and the worst results of the value of this parameter were established for the fish group K (1.795). As for the relative values of utilization of food protein/protein efficiency (PER), it was found that the O-II group fish performed better for this parameter compared to the group K by 5.94%, while the O-I group of trout by 5.49% in comparison to the K group. Significance test for differences in determined average values for feed intake, conversion and utilization of proteins in food pointed to the absence of a statistically significant difference ($p > 0,05$).

The results in terms of feed conversion are in accordance with the results of *Hossu et al. (2005)* who found that the addition of MOS had positive impact on feed conversion in the experiment with gilthead (*Sparus aurata*), but without significant differences. Similar results have been presented by *Peterson et al. (2010)* in whose research the addition of MOS (0.2% and 0.4%) had no significant effect on feed conversion. However, the results obtained in present study are somewhat lower than the data of *Staykov et al. (2005),* who report that the addition of prebiotics to trout food induced increase of the efficiency of utilization of food by 9.01% and 10.16% ($p < 0,05$). Also, *Čuljak et al. (2006)* indicate that the addition of MOS of 0.6% to carp food contributed to a better feed conversion ratio values by 22.81% ($p < 0.05$) and PER by 22.49% ($p < 0 , 05$).

Average values of condition factor (FC) as an indicator of relations of body weight and total body length of fish, indicate that the groups of fish where the MOS was applied as a dietsupplement, achieved better value of the condition factor. Compared with the K group of fish, O-II group had better values of this parameter by 1.73%, and trout of O-I group by 1.50%, which justifies the above said statement that the application of 0.3% MOS in food achieved the best weight and length gain of the tested fish. The results are lower than the values presented by *Sara et al. (2011).* In their research, adding prebiotic group (0.2% + BioMos SelPlex NuPro 0.03% + 2%) led to improved FC by 5.23%.

According to the data presented in Table 2, it can be concluded that the fish of O-II group compared to K group achieved better values of fish specific growth rate (SGR) by 7.58% and O-I group of fish by 6.54%. Statistically significant differences between the groups were not observed ($p > 0,05$). The obtained results were in line with that of other researchers *Binh et al. (2008), Sarah et al. (2011),* while slightly lower in terms of significance were results reached by *Čuljak et al. (2006), Ognean et al. (2009).*

The value of production index (PI) ranged from 2.421 (K group) to 2,622 (O-II group). The highest value of this ratio was observed in fish of O-II group, and as a result more vitality and better feed conversion in this group.

During the experiment there were no disorders in the health status of fish, and the mortality in treated trout was relatively low (K group, 2 fish; O-I group, 1 fish, O-II group, 2 fish). Of the total number of fish with which the experiment was started, by the end of the trial 1.11%died, indicating a good condition of farmed fish and favorable environment conditions. Stocking index values ranged from 0.0044 (K group) to 0.0045 (O-I and O-II group), while flow index values ranged from 0.0556 (K group) to 0.0567 (O-II group). The recorded values of Ip and Ig are in accordance with standards of sanitation for raising trout (*Piper et al. 1982, Klontz, 1991*). From the results of fish mortality in this study, it can be concluded that the use of MOS in the mixtures had no effect on mortality, and that the applied stocking density and carried hygienic measures caused low percentage of deaths and good health of the fish.

Conclusion

Based on the conducted research, it can be concluded that the use of mannanoligo saccharides (MOS) added to mixtures for rainbow trout had a positive effect on the tested production results: morphometric indicators of fish growth rate, feed conversion, condition factor, protein efficiency ratio, specific growth rate and production index.

This especially relates to best production results achieved in the O-II group fish, which used MOS in concentration of 0.3%. Slightly lower values of recorded production parameters of fish in O-I group, which were fed mixture containing 0.2% MOS, while the lowest studied parameters were established in the K group of trout. Despite the favorable effect, the differences in average values of production parameters between studied groups were not statically significant ($p > 0.05$).

For this reason, there is a need for further research in order to find the optimal dose of mannanoligo saccharides as food additive, which would allow a wider application in intensive fish farming.

Uticaj mananoligosaharida na proizvodne osobine kalifornijske pastrmke

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Rezime

Ispitivan je uticaj mananoligosaharida (MOS) kao aditiva hrane, primenjenog u koncentraciji od 0,2% (O-I grupa riba) i 0,3% (O-II grupa riba) na

morfometrijske karakteristike i osnovne proizvodne pokazatelje gajenja kalifornijske pastrmke. Ogled je sproveden na 450 riba podeljenih u tri grupe sa po 150 jedinki u svakoj grupi i trajao je 40 dana. Analizom dobijenih rezultata, ustanovljen je povoljan efekat primenjenog aditiva na morfometrijske pokazatelje tempa rasta riba, kako njihove završne komandne mase i završnih dužinskih mera, tako i njihovog prirasta, ali bez utvrđenih statistički značajnih razlika ($p>0,05$). Najveću prosečnu telesnu masu i dužinu tela kod ispitavanih grupa, ostvarile su pastrmke O-II grupe (118,49 g i 19,59 cm), zatim pastrmke O-I grupe (118,04 g i 19,58 cm), a najmanju K-grupa riba (115,94 g i 19,56 cm).

Dodavanje MOS-a u smeše za ishranu pastrmki je imalo povoljan uticaj ($p>0,05$) na ostvarivanje niže konverzije hrane (HK) i boljih vrednosti osnovnih proizvodnih pokazatelja: faktora kondicije (FK), koeficijenta proteinske efikasnosti (PER), specifične stope rasta (SGR) i proizvodnog indeksa (PI) u odnosu na ribe K grupe, koje su hranjene smešama bez dodatka mananoligosaharida. Najbolje rezultate su ostvarile ribe O-II grupe, a iskazano u relativnim pokazateljima u odnosu na K grupu riba: bolju konverziju hrane za 5,61%; bolju vrednost iskorišćenja proteina hrane za 5,94%; veću vrednost faktora kondicije za 1,73%; specifične stopa rasta za 2,26% i bolju vrednost proizvodnog indeksa za 8,27%.

References

ADAMS C.A. (2004): Nutricines in poultry production: focus on bioactive feed ingredients. Nutrition abstracts and reviews: Series B 74, Nutritional Services department, Kemin Europa, Belgium. 1-12.

AOAC - Association of Official Analytical Chemists (1990): Official Methods of Analysis. Washington, DC: AOAC. p. 246.

BINH V., TRUC N., HUNG L. (2008): Effects of BioMos (mannan oligosaccharide) on growth performances and fish health improvement of tra catfish (*Ictalurus punctatus*). Faculty of Fisheries. Nong Lam University Ho Chi Minh city. Vietnam. Presentation Alltech.

ČULJAK V., BOGUT I., HAS-SCHON E., MILAKOVIĆ Z., CANECKI K. (2006): Effect of Bio-Mos on performance and health of juvenile carp. Proceedings of Alltech's 22 Annual Symposium. Abstracts of posters presented Lexington. April 23-26, 2006. Lexington, KY, USA.

DIMITROGLOU A., REYNOLDS P., RAVNOY B., JOHNSEN F., SWEETMAN J.W. JOHANSEN J., DAVIES S. (2011): The Effect of Mannan Oligosaccharide Supplementation on Atlantic Salmon Smolts *(Salmo salar L.*) Fed Diets with High Levels of Plant Proteins. Journal of Aquaculture & Research Development. Special section S1-011., 1-6.

FERKET P.R., PARKS C.W., GRIMES J.L. (2002): Mannan oligosaccharides *versus* antibiotics for turkeys. Nutritional Biotechnology in the Feed and Food

Industries. Proc. of Alltech's 18th International Symposium. T. P. Lyons and K. A. Jacques, eds. Nottingham University Press, Nottingham, UK., 179-184.
HOSSU B., SALNUR S., GULTEPE N. (2005a): The effects of yeasts derivatives (Bio-Mos®) on digestibility of Gilthead sea bream (*Sparus aurata*). In: Nutritional Biotechnology in the Feed and Food Industries: Proceedings of Alltech's 21th Annual Symposium (Suppl., Abstracts of Posters presented). May 23-25, Lexington, KY, USA, pp 5.
HOSSU B., SALNUR S., GULTEPE N. (2005b): The effects of yeasts derivatives (Bio-Mos®) on growth of Gilthead sea bream (*Sparus aurata*). In: Nutritional Biotechnology in the Feed and Food Industries: Proceedings of Alltech's 21th Annual Symposium (Suppl., Abstracts of Posters presented). May 23-25, Lexington, KY, USA, pp 5.
KLONTZ G.W. (1991): Fish for the Future: Concepts and Methods of Intensive Aquaculture. Text Number 5, Idaho Forest, Wildlife and Range Experiment Station, University of Idaho., 28-39.
NRC (1993): Nutritien requirements of fish. National Academy Press. Washington DC.
OGNEAN L., BARBU A. (2009): The estimation of biostimulator potential of some fodder additives based on the main hematological and biometrical indices of brook trout (Salvelinus fontinalis M.). Annals of Romanian Society for cell biology. Vol. XIV, Issue 2., 292-296.
PETERSON C.b., BRAMBLE S.T., MANNING B.B. (2010): Effects of Bio-Moşon Growth and Survival of Channel Catfish Challenged with *Edwardsiella ictaluri*. Journal of the world aquaculture society. Vol. 41, No. 1, 149-155.
PHILIPS, A.M. (1970): Trout feeds and feeding. Manual of fish culture.U.S.Department of the Interior,Washington. DC., 1- 49.
PIPER, R.G., MCELWAIN I.B., ORME L.E., MCCRAREN J.P., FLOWER L.G., LEONARD J.R. (1982): Fish hatchery management. U.S. Fish and Wildlife Service, Washington, D.C. p.517.
PRAVILNIK O KVALITETU HRANE ZA ŽIVOTINJE (Službeni glasnik RS br.4/2010)
SARA A., BARBU A., GABOR E., BENTEA M. (2011): Researches regarding the combined fodder additives (Bio-Mos+Nupro+Selplex) effects on the productive performances and health of rainbow trout (Oncorhynchus Mykiss W.). Animal Science and Biotechnologies. 44 (2)., 61-66.
SPRING P., WENK C., DAWSON K.A., NEWMAN K.E. (2000): The effects of dietary mannanoligosaccharides on cecal parameters and the concentrations of enteric bacteria in the ceca of Salmonella-challenged broiler chicks. Poult. Sci. 79., 205-211.
STAYKOV Y., DENEV S., SPRING P. (2005): Influence of dietary Bio-Mos on growth, survival and immune status of rainbow trout (Salmo gairdneri irideus G.) and common carp (*Cyprinus carpio L.*). Nutritional Biotechnology in the Feed and

Food Industries. Proceedings of Alltech's 21st Annual Symposium, Lexington, Kentucky, USA, 22-25 May 2005. Edition: First Edition, Publisher: Nottingham University Press, United Kingdom, 333-343.

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