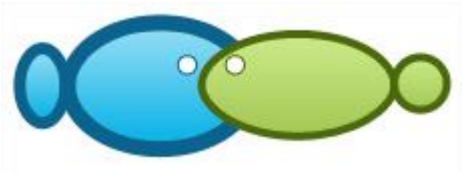

Effect of a prebiotic supplementation of mannan oligosaccharide on growth traits and mortality of rainbow trout (*Oncorhynchus mykiss*)

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Abstract. Use of prebiotics, as dietary supplements, could be beneficial in animal health by improving the non-specific immune system. The objective of this study was to investigate the effect of a diet supplementation of mannan oligosaccharide (MOS) from *Saccharomyces cerevisiae* strain 1026 on mortality and growth traits of rainbow trout *(Oncorhynchus mykiss*). The experiment was conducted at "Reina del Cisne'' fish farm (Cuenca, Ecuador), from October the 7th, 2015 to December the 9th, 2015 (10 weeks). This study involved 30,000 fish allocated in six raceways (5,000 fishes per raceway) with an initial average weight of 170.3±9.7 g. The control treatment group consisted of a standard commercial diet (three raceways), and the MOS treatment group consisted of the control diet supplemented with 0.2% of MOS (three raceways). Growth traits (net body weight [NBW], feed conversion ratio [FCR], and total fish production [TFP]) and mortality were measured. At the end of the fattening period, there were significant differences for NBW, FCR and TFP in favour of the MOS treatment group (p-value <0.05). The mortality observed was 31% and 17% for the control treatment group and the MOS treatment group respectively. The difference between these two groups was statistically significant (p-values <0.05). This study demonstrated that a dietary supplementation of mannan oligosaccharide (MOS) could improve the growth performance and reduce the mortality in rainbow trout (*Oncorhynchus mykiss*) reared in raceways.
Key Words: feed utilization, growth performance, dietary supplement, fish production, *Saccharomyces cerevisiae*.

Resumen. El uso de prebióticos como suplemento en la dieta puede ser beneficioso en la salud animal debido a la mejora del sistema inmunitario. El objetivo de este estudio fue investigar el efecto del suplemento del mannan oligosaccharide (MOS) procedente de la línea 1026 de *Saccharomyces cerevisiae* en una dieta destinada a trucha arcoíris (*Oncorhynchus mykiss*) en caracteres de crecimiento y mortalidad. El experimento se llevó a cabo en la granja piscícola "Reina del Cisne'' (Cuenca, Ecuador), realizado desde el 7 de octubre al 9 de diciembre (10 semanas). El estudio involucró 30000 truchas arcoíris distribuidas en seis estanques (5000 peces por estanque) con un peso inicial medio de 170.3±9.7 g. El grupo de tratamiento control consistió en un pienso comercial (tres estanques) y el grupo de tratamiento MOS consistió en el mismo pienso comercial suplementado con 0.2% de MOS (tres estanques). Se midieron caracteres de crecimiento (peso vivo neto [NBW], índice de conversión [FCR] y producción total de pescado [TFP]) y mortalidad. Al final del periodo de engorde, se observaron diferencias significativas para NBW, FCR y NBW a favor del grupo de tratamiento MOS (p-values <0.05). La mortalidad observada fue de 31% y de 17% para el grupo de tratamiento control y el grupo de tratamiento MOS respectivamente. La diferencia entre estos dos grupos fue estadísticamente significativa (p-values <0.05). Este estudio demostró que una dieta suplementada con mannan oligosacharide (MOS) puede mejorar el crecimiento y reducir la mortalidad in trucha arcoíris *(Oncorhynchus mykiss)* engordadas en estanques.
Palabras Clave: eficiencia alimentaria, caracteres de crecimiento, suplemento nutricional, producción piscícola, *Saccharomyces cerevisiae*.

Introduction. Aquaculture is one of the fastest livestock development activities in the food sector. According to FAO, the average consumption of aquaculture products went from 14% in 1986 to 47% in 2006, and it can be expected to reach 50% in the next years (Desriac et al 2010).

In particular, the rainbow trout (*Oncorhynchus mykiss*) farming industry has been developed intensively in recent decades. The trout world production has passed from 39,671 tonnes in 1965 to 812,939 tonnes in 2014 (FAO 2016). For this reason, there is a

need to increase production efficiency by improving, among other thing, the diet formulation.

Currently, the use of medications as growth promoters in aquaculture is illegal (Mirand & Zemelman 2002) therefore, the addition of various functional additives to a balanced feed formula to achieve better growth is a common practice among the fish and shrimp culturists (Mohapatra et al 2013).

The mannan oligosaccharide (MOS) are a glucomannoprotein complexes derived from the cell wall of yeast *Saccharomyces cerevisiae* (Sohn et al 2000) and it is one of the most widely used prebiotic additive in livestock production. "Mannose-containing molecules induce intracellular signalling that may increase production of proinflammatory cytokines, MOS may possess beneficial features as feed additives to fish and shellfish" (Ringø et al 2010). The benefits of MOS shown in farm animals have produced new researches to evaluate the potential of MOS in aquaculture. Thus, the objective of this study was to estimate the effect a diet with supplementation of MOS on mortality and growth traits in rainbow trout reared in raceways.

Material and Method. The animals were reared and slaughtered in compliance with the regulations for the care and use of animals in research.

Animals. The present study involved approximately thirty-thousand trout with an initial mean body weight of 170.3±9.7 g, randomly distributed in six raceways (450 m^3), giving three replicate per dietary treatment. They were located at the ''Reina del Cisne'' fish farm (Cuenca, Ecuador), from October the 7^{th}, 2015 to December the 9^{th}, 2015 (10 weeks). The farm was fed by a local river, so temperature (8 to 14°C) and pH (~7 to 8) fluctuated naturally with seasonality. No serious health problems were observed throughout the experiment.

Diet preparation. Trouts were subjected to two dietary treatments. The control group were fed with a standard commercial feed (S400 Extruso, GISIS, Ecuador) normally used on the farm. The MOS group were fed with the same standard commercial fed supplemented with a commercial MOS product (Bio-Mos; Alltech, USA) at 0.2%. The MOS was added before the extrusion process. Bio-Mos are derived from the outer cell wall of *S. cerevisiae* strain 1026. Due to space restrictions, it was not possible to make a comparison of different levels of dietary MOS. Furthermore, the diet supplemented with 0.2% of MOS was generally observed in rainbow trout. Supplementation level of 0.2% was chosen based on previous studies focused on improving growth traits, immune status, intestinal microbial ecology and gut morphology (Staykov et al 2007; Salze et al 2008; Dimitroglou et al 2009). For both trials feed rations were supplied in six equal meals per day at 07.00, 09.00, 11.00, 13.00, 15.00 and 17.00 h.

The basal diet composition is shown in Table 1. The main dietary components were fishmeal, fish oil, corn gluten meal, soybean meal, wheat, vitamins, minerals, and lysine.

Table 1

Diet composition used in trout trials

Composition	*Control*	*MOS*
Protein	43%	43%
Lipid	26%	26%
Ash	8%	8%
Nitrogen-free extract	16%	16%
Moisture	7%	7%
MOS	-	0.2%

MOS - Mannan oligosaccharide.

Data recording. Body weight gain (NBW, g) and the feed conversion ratio (FCR) calculated by the use of the formula NWB = final weight (g) - initial weight (g); and FCR = feed given (kg)/fish weight gain (kg), respectively. In addition, total fish production (TFP, kg) and mortality (%) were recorded. The raceway was the experimental unit.

Statistical analyses. Estimates of the differences between diets were obtained by an independent samples 2-tailed t-test. Mortality were evaluated by a Chi Square test (X^2) to compare percentages. The program R-Project (R Core Team 2013) was used for the statistical analysis. If p-value was lower than 0.05 the difference was assumed significant.

Results and Discussion. Summary statistics for the total period of the experiment were 443.2±17.51 g, 1.47±0.02, 14490±626.55 g and 19.8 % for NBW, FCR, TFP and mortality, respectively. These values are within the range of commercial fish farms in Ecuador (Nancy Cardoso, personal communication).

Table 2 shows the effect of MOS on growth traits and mortality. Significant differences were found for NBW, FCR and TFP in favour of the diet with supplementation of MOS. In addition, the inclusion of MOS in the diet had a lower mortality rate. These results are in agreement with previous studies in rainbow trout growth (Staykov et al 2007; Yilmaz et al 2007; Rodrigues-Estrada et al 2008).

Table 2

Effect of a dietary supplementation with mannan oligosaccharide (MOS) on growth traits and mortality of *Oncorhynchus mykiss*

Specification	*Control*	*MOS*	*P value*
Net Body Weight (g)	320.33±2.53	432.47±3.03	<0.05
Feed Conversion Ratio	1.51±0.03	1.44±0.03	<0.05
Total Fish Production (g)	6,408.92±683.22	8,157.60±636.52	<0.05
Mortality	31 %	17%	<0.05

Values are means ± SE.

In other fish species, the use of MOS has reported improvement on growth performance and a reduction on mortality. The MOS studies on Atlantic salmon (*Salmo salar*) (Grisdale-Helland et al 2008), cobia (*Rachycentron canadum*) (Salze et al 2008), Prussian carp (*Carassius gibelio*) (Akrami et al 2012), striped catfish (*Pangasianodon hypophthalmus*) (Akter et al 2016), European sea bass (*Dicentrarchus labrax*) (Torrecillas et al 2007), hybrid *Oreochromis niloticus x O. aureus* (Genc et al 2007a), European lobster (*Homarus gammarus*) (Daniels et al 2010), red drum (*Sciaenops ocellatus*) (Burr et al 2008) and *Penaeus semisulcatus* (*Penaeus semisulcatus*) (Genc et al 2007b) have reported significant differences on growth and mortality in favour of MOS-supplemented diets. This positive effect could be due to MOS, acting as prebiotic, have a positive effect on the immune system and on the intestinal microbiota, which subsequently improve gut morphology and epithelial brush border (Dimitroglou et al 2009). These positive effects were also demonstrated for other farm animals as on swine (Miguel et al 2004), bovine (Franklin et al 2005), poultry (Baurhoo et al 2007) etc.

Conclusions. In conclusion, under the current experimental conditions, the supplementation of 2% of MOS in the diet of rainbow trout can improve body weight in more than 100 g and decrease the FCR around 0.07 ($P<0.05$). In addition, MOS supplementation reduce the mortality (from 31% in the control treatment to 17% in the MOS treated group; $P<0.05$). The significant reduction in mortality could be an indicator of the improvements of immune status, which indicates that MOS can improve disease prevention in rainbow trout. The utilization of MOS could increase the production cost but the used dose is very low. For this reason, the extra cost arising of MOS supplementation

(≈0.01 $/kg feed) is not significant in contrast with the benefits on growth performance and the reduction on mortality.

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