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Effect of Dietary Supplementation of Mananoligosaccharide and β-Glucan on the Performance and Feed Utilization of Nile Tilapia Fingerlings

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ABSTRACT

Background and Objective: Prebiotics feed additives can be used as functional feed and applied in aquaculture for improving growth performance and feed utilization. Feeding trail was performed to investigate the effect of different levels of commercial prebiotic (Aqua-Immuostim©) contain Mananooligosaccharide (MOS) and β-glucan on the performance and feed utilization of Nile tilapia (*Oreochromis niloticus*) fingerlings. Methodology: Three hundred of Nile tilapia (4.12 g $fish^{1}$) were randomly allocated into 4 treatments. Treatments were performed in 12 aquaria (25 fish/ aquarium). Nile tilapia were fed basal diet (30.36% crude protein, 3879 kcal gross energy kg^{-1}diet) with different levels of prebiotic (0.0, 2, 4 and 6g kg^{-1} diet). Fish were fed diets twice daily for 56 days. Results: The best values of the final body weight, body weight gain, feed conversion ratio and specific growth rate were obtained with all treatments supplemented with MOS and β-glucan compared with the control group. The best values of feed conversion ratio (FCR), protein efficiency ratio (PER), Protein productive value (PPV) and Energy Retention (ER) were observed in groups fed on diets supplemented with MOS and β-glucan at 2 and 4g/kg, followed by diet supplemented with 6 g/kg, and the worst values of FCR, PER, PPV and ER were observed with the control group. No significant difference was detected among all treatments in body composition. Conclusion: Overall, this study revealed that MOS and β-glucan inclusion in Nile tilapia diets could be more beneficial effects on the growth and utilization of feed. In the current study, the optimal level of the commercial MOS and β-glucan in Nile tilapia fingerlings diets is 2 g/kg^{-1}.

Keywords: prebiotic, Nile tilapia, performance, feed utilization, MOS and β-glucan.

1. Introduction

Using the best feeding system can have a beneficial effect on optimizing profit that is the first goal of commercial aquaculture (Abo-state and Tahoun 2017). Also, capable fish to resist diseases can reduce of the posterior cost of therapy and total production costs would be reduced (Ringø *et al*., 2010). It is just now a deftly-documented truth that there is a clear relation between the nutrition and health status of fish. Application of intensification aquaculture to meet market request causes lead to raise the possibility of the disease breakout (Hoseinifar *et al*., 2015). Several feed additives have been used to enhance growth performance and health status of fish. More natural feed additives like probiotics and prebiotics found that positive effect for enhancing the immune response, feed efficiency, and performance of fish (Kesarcodi *et al*., 2008, Mehdi and Mojtaba, 2009, Guardiola *et al.,* 2016 and Mohsen *et al*., 2016). Beta-glucan and MOS are naturally polysaccharides found in the cell wall of yeast, fungi and algae and used in fish nutrition as prebiotics. Prebiotics prompt growth performance, enhance nutrient utilization and gut growth and modify innate and acquired immunity responses (Andrews *et al*., 2009, Yousefian and Amiri, 2009, Geraylou *et al.,* 2013, Torrecillas *et al.,* 2014 and Selim and Reda, 2015). Prebiotics are beneficially affects the host by selectively stimulating the growth and metabolism of health-promoting bacteria out of prebiotics fermentation (Gibson and

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Roberfroid, 2004, Ringø *et al.,* 2010 and Abo-state *et al*., 2017) gut microbiota (Zhou *et al.,* 2010) resistance against pathogenic bacteria (Talpur *et al.,* 2014) and immuneparameters (Guerreiro *et al.,* 2016).

Several studies have been carried out in fish to evaluate one prebiotic such as inulin (Cerezuela *et al*., 2013 a,b), Mannan-oligosaccharides (MOS) (Torrecillas *et al*., 2013) and fructooligosaccharides (FOS) (Hoseinifar *et al*., 2017 and Guerreiro *et al.,* 2018). Azeredo *et al*., 2017 found that supplementation of FOS in fish diets improved growth performance, feed utilization and immune responses. Addition of 1, 2 or 3 g FOS/kg feed enhanced performance, enzyme activities, feed utilization and immune response of *Lateolabrax japonicas* (Wang and Li, 2020). Therefore, the current study aimed to assess the effects of different levels of MOS and β-glucan as a natural prebiotic on growth, utilization of feed and body composition of fingerlings Nile tilapia (*O. niloticus*).

2. Materials and Methods

2.1. Fish and culture facilities

Monosex (male) Nile tilapia fingerlings (4.19 g fish^{-1}) were obtained from a commercial tilapia hatchery at Kafr El Sheikh Governorate, Egypt. Fish were randomly distributed in triplicate into four treatment groups in the Fish Nutrition Laboratory, National Research Centre, Egypt. Treatments were performed in twelve glass aquaria (60×30×40 cm^3) at a rate of 25 fish /aquarium. The experimental fish were acclimated to the culture system for 2 weeks. Initially, fifty fish were randomly collected and the average initial weights were recorded then frozen at -20ºC for whole body analysis. Water temperature, dissolved oxygen and pH were adjusted around 26.5 C°, 6 mg/L and 7.5 respectively in all treatments and monitored daily.

2.2. Test diets and feeding regime

A basal diet was formulated to contain (30.36% crude protein, 5.79 ether extract, 6.7 crude fibers, 14.2% ash, and 3879 Kcal gross energy kg^{-1} diet). A commercial prebiotic product (Aqua-Immuostim©, 1 kg contains: Mannan-oligosaccharide and β-glucan 250 g, Vitamin C 25 g and citric Acid (%90) 50 g) was added to the basal diet to represent the levels of 0.0 (control), 2, 4 and 6 g kg^{-1} diet. Fish were fed their respective diets twice a day (at 8 am and 13 pm) for 56 days (at 5% of their body weight for the first 2 weeks then 4% for the last six weeks). The average weight of fish was recorded every 14-day intervals, and the daily rations were readjusted accordingly.

2.3 Chemical analysis of diets and fish

The tested diet and fifteen fish collected from each treatment at the beginning and at the end of the feeding experiment were analyzed for moisture content, protein, fat and ash according to the standard methods of AOAC (2006).

2.4 Calculations of fish performance

The growth performance and feed utilization efficiency were calculated as following:
Weight gain (WG) = final weight – initial weight.
Specific growth rate (SGR) = 100 ($\ln W_2 - \ln W_1$)/ T
where W_1 and W_2 are the initial and final weight, respectively, ln represent Natural logarithm and T is the number of days in the feeding period.
Feed conversion ratio (FCR) = dry feed intake (g) / fish live weight gain (g).
Protein efficiency ratio (PER) = 100 (weight gain (g) / protein intake (g)).
Protein productive value (PPV) = 100 (protein gain (g) /protein fed (g)).
Energy Retention (ER) = Retained energy in carcass (Kcal)/energy intake (Kcal) ×100.

2.5. Statistical analysis

All data were subjected to one-way analysis of variance (ANOVA) at a 95% confidence limit, using SPSS software, version 16 (SPSS, 2007). Duncan's Multiple Range (Duncan, 1955) test was used to compare means when F-values from the ANOVA were significant (P<0.05).

3. Results and Discussion

Mean values of initial body weight (IBW), final body weight (FBW), weight gain (WG) and specific growth rate (SGR) of Nile tilapia fingerlings fed various levels of MOS and β-glucan are shown in Table (1). The IBW was almost similar in all groups without differences ($P<0.05$). Supplementing MOS and β-glucan in Nile tilapia fingerlings diet resulted in significant improvement in FBW, WG and SGR ($P<0.05$) compared to those fed the control diet without supplementation.

The results of feed utilization parameters, feed intake (FI), feed conversion ratio (FCR), protein efficiency ratio (PER), protein productive value (PPV) and energy retention (ER) are shown in Table (2). Results observed enhancing effect of MOS and β-glucan supplementation on feed efficiency. There were, differences ($P<0.05$) of FCR, PER, PPV and ER among the treatments. The superior values of FCR, PER, PPV and ER were observed in groups fed on diets supplemented with MOS and β-glucan at 2 and 4g/kg, followed by diet supplemented with 6 g/kg, and the worst values of FCR, PER, PPV and ER were observed with the control. No differences ($P>0.05$) were observed among various levels of MOS and β-glucan on FCR, PER, PPV and ER.

The results of whole body composition of Nile tilapia are shown in Table (3). Supplementation of MOS and β-glucan did not significant affect ($P>0.05$) in body composition (Dry matter (DM), Crude protein (CP), Ether extract (EE) and Ash) of Nile tilapia.

These results are agreement with the previous results of several studies that reported improvement in growth performance of fish fed diet supplemented with prebiotics (Ringø *et al*., 2014 and Romero *et al*., 2014). Addition of prebiotic improved growth performance of hybrid striped bass (Gatlin and Li, 2004). Mazurkiewiez *et al*. (2008) addition different levels (0.0, 1, 2 and 3g/kg feed) of a commercial prebiotic (Fermacto) to carp fry diets improved ($P\leq 0.05$) body weight compared with the control. Also, the higher improvements of SGR, FCR, PER and coefficients of feed protein retention have been obtained in the treatment with 3g prebiotic /kg of feed. Similar results, fed rainbow trout diet containing 2g Kg^{-1} MOS improved growth performance and feed utilization compared with those fed on the basal diet (Staykov *et al*., 2007 and Grisdale-Helland *et al*., 2008). Staykov *et al.* (2007) reported that fed rainbow trout diet supplemented with 2g Kg^{-1} MOS improved lyzozyme activity. Dietary 2g Kg^{-1} MOS remarkably improved the growth and feed utilization in gilthead sea breem (Gültepe *et al.,* 2011). Ebrahimi *et al.* (2012) studied the effect of dietary MOS on feed efficincy, performance, immunity stimulation and body composition analysis of the Common carp fingerlings (11.12g) different levels (0, 0.5, 1, 1.5 and 2.5 g Kg^{-1}diet).

Results indicated that addition of MOS from 1 to 1.5 g Kg^{-1} improved feed efficiency and growth performance. Ganguly *et al*. (2013) found that MOS can be used as alternative to growth promoters with combination with organic acid to achieve good health and growth performance. These improvements related to improved nutrients utilization due to changes in digestive enzymes activity and thus enhance performance (Merrifield *et al*., 2010 and Anguiano *et al.,* 2013). Higher growth performance of Caspian roach (*Rutilus rutilus*) and blunt Shout breum (*Megalobrameambly cephala*) fed prebiotic was correlated with enhanced digestive enzyme activity (Soleimani *et al*., 2012 and Wu *et al.,* 2013). Talpur *et al*. (2014) reported that dietary supplemented with 2 g kg^{1} MOS for three month increased lyzozyme activity of Snakehead (*Channa striata*). Incorporation of 1g/kg MOS was suggested to enhance growth and feed utilization of Sea bass (*Dicentrarchus labrax*) (Salem *et al*., 2016). The improvement of growth performance may be related to several factors, such as improved gut morphology or modifications in intermediary metabolism, improved digestive enzymatic activity (Hoseinifar *et al*., 2013 and Ringø *et al*., 2016). Utilization of nutrients mainly depends on the activities of digestive enzyme in alimental tract which reflects on feed efficiency and nutrient utilization (Fountoulaki *et al.,* 2005). Furthermore, short-chain fatty acids (SCFA) produced in prebiotics fermentation reducing gut pH and provide nutrients for the fish which improved growth, disease resistance and immunity (Guerreiro *et al*., 2018). Improved digestive enzymes activities that were detected in fish fed prebiotics may be a reason for bacterial digestive enzyme production (Hu *et al.,* 2019).

Furthermore, Cechim *et al*. (2012) reported that MOS supplementation (0.2, 0.4 and 0.8 g kg^{-1}) in Nile tilapia diet (12.62 g) did not show a positive effects on Juvenile Nile tilapia growth. Dietary supplementation of MOS at various levels did not have an effect on moisture and crude ash content of

Japanese flounder (*Paralichthys olivaceus*) (Ye *et al*., 2011), in contrast reducing body fat was found of fish fed MOS and inulin in sherpsnout Sea bream (*Diplodus puntazzo*) (Apperbossard *et al.,* 2013). General it seems that the high body protein content reveals the ingested feed was converted extra beneficially into synthesis protein in turn enhance growth performance (Kumar *et al*., 2018).

Contradictory results of prebiotic may be imputed to the addition level and duration of experiment (Dawood and Koshio 2016 and Hoseinifar *et al.,* 2017). Munir *et al*. (2016) revealed a positive effect of dietary prebiotic and probiotic as feed supplements for Snake head (*Channa striata*) fingerlings. Effects prebiotic depend on many items such as addition level and fish species, dietary supplementation of different feed additives like prebiotics in low level have been reported to enhance growth performance feed utilization and immunity fish (Ganguly and Prasad, 2012).

Studies focused on effects of using β-glucan in fish diets reported that β-glucan improved performance, utilization of feed and immune response (Brogden *et al*., 2012, Dobšíková *et al*., 2013, Al-Faragi 2014, Falco *et al*., 2014 and Jung- Schroers *et al*., 2016). Gu *et al.* (2011) found that supplementation of 0.15% β-glucan and 0.1% MOS improved specific growth rate values compared with the control ($P < 0.05$) and had the best effects on enhancing disease resistance of sea cucumber (*Apostichopus japonicas)*. Kühlwein *et al.* (2013) reported that dietary β-glucan positive effects on intestinal villi length and density of carp. These effects might be contributory factors to improve growth performance. Kühlwein *et al*. (2014) suggested that addition of β-glucan to mirror carp diet improved performance without effects on carcass body composition intestinal histo-morphology or the hemato-immunological parameters. Selim and Reda (2015) found that dietary supplementation of a combination of β- glucan and MOS at 1.5 and 3g/kg feed improved growth performance and feed utilization in Nile Tilapia and the best growth and feed utilization were observed with group fed on 3g prebiotic/kg feed. Soares *et al.* (2017) found that supplementation of 0.1% combined of Glucan and MOS produced from yeast, to juvenile pacu (*Piaractus mesopotamicus*) diet enhanced body weight gain, feed and protein efficiency compared to the control diet. Abu-Elala *et al.* (2018) reported that dietary addition of β-glucan and mannan oligosaccharide to Nile tilapia diet at 0.1 or 0.2% significantly increased growth parameters ($P \leq 0.05$) white blood cell count, total protein, and globulin level.

Table 1: Growth performance of Nile tilapia fed the experimental diets

Item	Initial Weight (g)	Final Weight (g)	Weight gain (g)	Specific growth rate
Control	4.21	12.47^b	8.25^b	1.94^b
2 g/kg prebiotic	4.20	13.51^a	9.31^a	2.09^a
4 g/kg prebiotic	4.23	13.38^a	9.15^a	2.06^a
6 g/kg prebiotic	4.19	13.59^a	9.40^a	2.10^a
SE of means	±0.02	±0.16	±0.016	±0.02
Significances	NS	**	*	*

Means designated with the same letter within the same column are not significantly different at 0.05 level of probability, **: (p<0.01), *: (p<0.05), NS: Not significant (P>0.05).

Table 2: Feed utilization of Nile tilapia fed the experimental diets

Item	FI (g)	FCR	PER	PPV	ER
Control	15.09	1.83^a	1.80^b	22.66^b	23.61^b
2 g/kg prebiotic	15.69	1.69^b	1.96^a	27.10^a	26.97^a
4 g/kg prebiotic	15.55	1.70^b	1.94^a	25.54^a	26.47^a
6 g/kg prebiotic	15.73	1.67^b	1.97^a	26.08^a	27.08^a
SE of means	±0.14	±0.02	±0.02	±0.85	±0.71
Significances	NS	**	*	**	*

Means designated with the same letter within the same column are not significantly different at 0.05 level of probability, **: (p<0.01), *: (p<0.05), NS: Not significant (P>0.05).
Whereas: Feed intake (FI), Feed conversion ratio (FCR), Protein efficiency ratio (PER), Protein productive value (PPV), Energy Retention (ER).

Table 3: Body composition of Nile tilapia fed the experimental diets.

Item	DM	Crude Protein	Ether Extract	Ash
Initial	22.11	53.70	16.20	14.83
Control	24.68	49.94	32.33	10.21
2 g/kg prebiotic	26.09	50.84	31.57	10.42
4 g/kg prebiotic	25.99	49.20	32.10	10.28
6 g/kg prebiotic	26.10	48.98	32.54	9.95
SE of means	±0.30	±0.82	±0.89	±0.25
Significances	NS	NS	NS	NS

Means designated with the same letter within the same column are not significantly different at 0.05 level of probability, NS: Not significant ($P>0.05$).

4. Conclusions

It can be concluded that the use of prebiotic (MOS and β-glucan) at the levels examined is capable of affecting the growth performances of fish. Feeding of Nile tilapia fingerlings on feeds with an addition of the MOS and β-glucan improved growth performance and feed utilization. The perfect addition of the prebiotic (MOS and β-glucan) in the fish diet is 2 g/ kg feed. Further studies are needed to investigate the underlying mechanistic pathways behind these findings, and explore other efficient nutritional strategies to improve growth performance and feed utilization of Nile tilapia fish in eco-friendly production system.

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