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Comparison Between Effects of Sinking and Floating Diets on Growth Performance of the Nile Tilapia *(Oreochromis niloticus)*

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ABSTRACT

The present study was conducted over 96 days in order to compare between the effects of floating and sinking diets with different levels of a probiotic on growth performance, food utilization and chemical composition with all-male mono-sex juvenile Nile tilapia (*Oreochromis niloticus*). The treatments were two floating and sinking diets supplemented with three levels of the probiotic PRO-LYNE®, being 0%, 1% and 2% of the diets. Each hapa (measuring 2 × 3 × 1 m^3) was suspended in an earthen pond (4000 m^2). There were 6 treatments, each consisting of 2 replicates, stocked with fish of average initial body weigh 60 g. A total of 366 fish were randomly distributed into 6 experimental groups. The stocking density was 5 fish / m^3 for all the hapas. Fingerlings were fed a commercial diet containing 25.2% crude protein and at feeding rates of 4% of their fresh biomass in each hapa for the first 1.5 month and 3% until the end of the experiment. The results of the present study revealed that performance and production and economic efficiency of Nile tilapia reared in net hapas in earthen ponds significantly increased, when they were fed the floating pellets supplemented with probiotic at level 1%.

INTRODUCTION

Aquaculture is the fastest growing sector of food animal production in the world and supplies an increasing percentage of the total production of fish for human consumption (FAO, 2012). Nowadays, Egyptian fish production from aquaculture contributed by 80% of total fish production which amounted 1.8 million metric tons (Abdelhamid, 2019a). Tilapia in different countries is farmed with fertilization and/or supplementary feeding. Feed is the highest cost-oriented input in aquaculture. Thus, the higher the effective feed the less will be the cost of production. Mono-sex *Oreochromis niloticus* does not breed/multiply, which makes it easy for fish farmers to avoid uncontrolled breeding in their farms. They grow fast and attain market size within a short period than other tilapia forms. This fish is currently considered to be the most important and commonly cultured species around the world and constitutes over 70% of cultured tilapia (Fitzsimmons, 2004), which represent approximately 6% of total farmed fish production (FAO, 2004). Feed is one of the operating costs mostly limiting the expansion of cultured species (Sorensen, 2012).

Feeds commonly accounts for 40-60% of the operating costs depending on the level of intensification and species (Kannadhason *et al*., 2009 and Limbu and Jumanne, 2014). In 2008, global production of Nile tilapia was 2.1 million tons – more than double that recorded in 2000 (FAO, 2012). In addition, tilapia producers have been intensifying their farming practices, thus contributing to higher farm yields (Lim *et al*., 2006). In recent years, probiotics and prebiotics are under extensive investigation for their potential beneficial effects on fish health, growth and survival (Verschuere *et al*., 2000; Irianto and Austin, 2002; Mussatto and Mancilha, 2007; Grisdale-Helland *et al*., 2008 and Yousefian and Amiri, 2009). Consequently, a number of natural and biological products, such as live bacterial suspension and dry concentrates, enzyme preparations, and extracts of plant products are being promoted for use as water and soil quality conditioners in aquaculture ponds (Defoirdt *et al*., 2011 and Cruz *et al*., 2012) and additives to fish feed (El-Rhman *et al*., 2009 and Honsheng, 2010). Although an increasing volume of scientific research from aquatic animals suggests that the establishment, maintenance and enhancement of health promoting bacteria in the intestine can have wide ranging beneficial effects on growth and survival of the host (Verschuere *et al.*, 2000; Irianto and Austin, 2002; Mussatto and Mancilha, 2007; Zhou *et al*., 2007; Burr *et al*., 2008; Grisdale-Helland *et al*., 2008; Yousefian and Amiri, 2009 and El-Rhman *et al.*, 2009), results have been conflicting (Merrifield *et al*., 2010). While some researchers have shown that inclusion of probiotic and/or probiotics in the diet of fish or direct inoculation into the aquatic environment changes gut microbiota, improves growth and survival, or improves water quality (Aly *et al*., 2008; Wang *et al*., 2008 and Merrifield *et al*., 2010). Others have reported no beneficial effects (Shelby *et al*., 2006; Marzouk *et al*., 2008; El-Rhman *et al*., 2009 and Ferguson *et al*., 2010). Hence, the aim of the present study was to compare the effect of commercially produced sinking and floating pellets supplemented with probiotic (PRO-LYNE®) on growth performance, food utilization, body composition and economic efficiency of juveniles Nile tilapia, *O. niloticus*.

MATERIALS AND METHODS

The present work was conducted in a private fish farm (for the owner Hag Aboulenin) in Metubus - Kafr El-Sheikh governorate during season 2017 in order to compare between effects of floating and sinking diets supplemented with graded levels of the commercial probiotic (PRO-LYNE®), being zero, 1 and 2% of the diet on growth performance, food utilization and chemical composition of Nile tilapia (*O. niloticus*), reared in net hapas under Egyptian conditions.

Experimental fish: A total number of 360 Nile tilapia with an average bodyweight of 60 g were obtained from a private fish farm at Metubus area, belonging to Kafr El-Sheikh governorate, Egypt. The experimental period was 96 days (from 23/6 to 26/9/ 2017).

Experimental design of rearing fish: Each size of fishes was randomly distributed among 12 hapas. Each hapa measuring (2 × 3 ×1 m^3) as width, length, and depth, respectively. Hapas were suspended in an earthen pond of 4000 m^2. The stocking densities were 5 fish/m^3 at a constant rate in all the hapas. Five fishes were kept frozen at -20 ºC for chemical analysis at the beginning of the experiment. The pond was supplied with fresh water from Metubus area. The water exchange rate was 15% of total ponds water volume/day.

Experimental diets and feeding regime: Nile tilapia fingerlings were fed a commercial diet containing 25.2% crude protein and 4625 Kcal/Kg gross energy at feeding rates of 4% of their fresh biomass in each hapa for the first 1.5 month and 3% until the end of the experiment (six days per week). Fish were fed two times daily at 8 a.m. and 2 p.m. with feed amounts adjusted at approximately 14 day-intervals in response to their actual body weight. Ingredients and composition of the experimental diets are presented in Table 1. A sinking diet and floating one was formulated with the aid of a computer program (Winfeed 2.8) using locally available ingredients. The ingredients used were fish meal (Rastrineobola Argentina), whole maize, whole soybean, rice bran, wheat bran, vitamins-minerals premix and commercial probiotic PRO-LYNE®.

Experimental dietary additives: Product name: PRO-LYNE®. It consisting of condensed molasses fermentation solubles (MOS), *Bacillus subtilus*, enzymes (xylanase, hemicellulase, β-glucanase) and sodium bentonite. Arsenic (As) <0.0001 %, Heavy metals (Pb) <0.0005, Product use in animal feeds as a probiotic. Company name: ProByn International Inc. Address: 123 W. St. Charles Road, Unit 200, Lombard, IL 60148, USA.

Table 1: Formulation of the control and experimental diets (%)

Ingredients	Floating 25.2% crude protein			Sinking 25.2% crude protein		
	T1	T2	T3	T4	T5	T6
Fish meal (65%, CP)	20	20	20	20	20	20
Soybean meal	124	124	124	91	91	91
Yellow corn	130	130	130	153	153	153
Wheat bran	412	412	412	416	416	416
Wheat bran red	349	349	349	170	170	170
Rice bran	150	150	150	150	150	150
Poultry by-products meal	145	145	145	151	151	151
Limestone	6	6	6	6	6	6
Vitamins & Minerals premix	3	3	3	3	3	3
Lysine	1.5	1.5	1.5	1.5	1.5	1.5
Methionine	1.5	1.5	1.5	1.5	1.5	1.5
Di-calcium phosphate	4	4	4	4	4	4
Common salt	2	2	2	2	2	2
Vitamin C	0.5	0.5	0.5	0.5	0.5	0.5
Garlic meal	0.3	0.3	0.3	0.3	0.3	0.3
Total	100	100	100	100	100	100
PORO-LYNE®	Zero%	1%	2%	Zero%	1%	2%

The formulation and proximate composition of the diets used in the present study are given in Table 2. Ingredients for the production of sinking diet were purchased from local suppliers at the site based on nutrient composition. During the production of the sinking diet, whole maize and soybeans were processed in order to reduce anti-nutritional factors and improve nutrient bioavailability to the fish (Sinha *et al.*, 2011). Apart from grinding, the other ingredients used in the production of the sinking diet were not subjected to any processing. Thus, whole maize and soybeans were soaked in freshwater for overnight and 8 hours, respectively. They were then boiled for 1.5 hour followed by solar-drying for about a day. Solar-drying was followed by dry cooking (roasting) and finally solar-dried again. Dried ingredients were milled into fine particles using a grinder machine (hammer mill) with a screen size of 0.8 mm, weighed and mixed in the required proportions according to formulation. The mixture was then blended with sufficient hot water to form dough. Pellets were produced by extruding this dough through a meat grinder/mincer with a diameter of 4 mm and subsequent solar-dried for several hours until dry.

Table 2: Chemical analysis (%) of the commercial diet and its ingredients

Ingredients	MO	DM	CP	EE	CF	Ash	Nitrogen-free extract (NFE)*	GE (kcal/kg)**
Fish meal	7	93	65	10	0	15	10	5579
Soybean meal	12	88	48	4.5	2.2	5	40.3	5197.1
Yellow corn	12	88	7.7	3.8	2.3	1.4	84.8	4336.0
Wheat bran	11	89	13	4	8	6	69	4051.6
Wheat bran red	13	87	16	4.2	16	7	56.8	2739.2
Rice bran	11.3	88.7	13.5	15	9.9	9.6	52	4425.5
Gluten	9.6	90.4	62	3	2.1	5	27.9	5457.1
Poultry by-product meal	12	88	58	12	2	16	12	5395
Commercial diet	11	89	25.2	7.5	5.4	6.3	55.6	4625.6

*: Nitrogen free extract (NFE) = 100 - (CP %+EE %+CF %+ash %). **: GE= Gross energy was calculated by multiply the factors 4.1, 6.5 and 9.44 Kilo GE/g DM for carbohydrate, protein and fat, respectively (Jobling, 1983).

Water quality analysis: Water samples were taken monthly for determination of pH, dissolved oxygen (DO), contents of nitrite, nitrate and unionized ammonia. Average values of water quality parameters are illustrated in Table 4. Analytical methods were done according to the American Public Health Association (APHA, 2005). The pH values were determined by digital pH meter (Orient Research Model 201). The water temperature; Seccki disk reading (transparency) and oxygen saturation were measured daily at 8:00 a.m. by an oxygen-meter (model 9070, Scientific Instrument).

Proximate analysis of the experimental diets and fish body: Chemical composition of the control and experimental diets was done at the start and for fish body at the start and at the end of the experiment according to the methods described by A.O.A.C (1990). At the end of the experimental, five fish were derived from each group for drying at 60ºC for 48 hours and then milled through electrical mill and stored frozen until analysis.

Growth performance and efficiency of feed and protein utilization: Average total gain (ATG, g/fish), average daily gain (ADG, g/fish/ day), specific growth rate (SGR, %/d), feed conversion ratio (FCR), feed efficiency, protein efficiency ratio (PER), protein productive value (PPV, %), condition factor (k) and survival rate (SR, %) were calculated according to the following equations:

ATG (g/fish) = [Average finale weigh (g)-Average initial weigh (g)].

ADG (g/fish/ day) =ATG (g)/experimental period (d).

SGR (%/day) = (ln final body weight – ln initial body weight) × 100/ experimental period (d).

FCR = feed intake (g) / live weight gain (g).

Feed efficiency = live weight gain (g) / feed intake (g)

PER = Live weight gain (g) / protein intake (g).

PPV (%) = 100 [final fish body protein (g) – initial fish body protein (g)] / crude protein intake (g).

Condition factor (K) = live body weight (g) / (body length, cm)^3 x 100

SR (%) = 100 [total No. of fish at the end of the experimental period / total No. of fish at the start of the experiment].

Statistical analysis: Numerical data was statistically analyzed as factorial design (2 food types x 3 probiotic levels) using SAS (2006) and Duncan (1955).

RESULTS AND DISCUSSION

Chemical composition of the experimental diet: Chemical composition of the different experimental diets is shown in Table 3. The crude protein (CP) content of the sinking pellets was between 25.2 and 26.0%, and that of the floating ones lay within 25.2- 25.9%. The crude fat and gross energy contents of the floating pellets (7.5 - 8.2% and 4626- 4676 kcal/kg feed, respectively), were higher than in the sinking pellets (being 7.5- 8.1 % and 4626 - 4669 kcal/kg feed, respectively). The ash in sinking pellets was 6.3- 6.7 % and in floating pellets was 6.3 - 6.6%. Chemical analysis of the two types of pellets indicated that the crude protein contents were higher than the guaranteed analysis provided by the manufacturer, while such level was within the range suggested by NRC (1993) for the practical diets for tilapia. However, it was nearly similar to that used by Abdel-Maksoud *et al*. (1998). In this respect, Santiago and Lovell (1988) recommended the optimum protein requirement for growth of Nile tilapia as 25 - 35%, where the dietary protein content level in the present study, agrees with their recommendation.

Table 3: Chemical analysis (% DM basis) of the experimental diets

Ingredients	Floating diet 25.2 % CP			Sinking diet 25.2 % CP		
	T1	**T2**	**T3**	**T4**	**T5**	**T6**
Dry matter (DM)	89	89	90	89	90	91
Crude protein (CP)	25.2	25.7	25.9	25.2	25.8	26.00
Ether extract (EE)	7.5	7.9	8.2	7.5	7.8	8.1
Crude fiber (CF)	5.4	5.3	5.2	5.4	5.4	5.2
Ash	6.3	6.4	6.6	6.3	6.5	6.7
Nitrogen-free extract (NFE)*	55.6	54.7	54.1	55.6	54.5	54
GE (kcal/kg)**	4626	4659	4676	4626	4648	4669
DE (kcal/kg)	304.7	309	311.5	304.7	308.2	310.9
P/E (mg CP/kcal GE)	5.44	5.51	5.54	5.45	5.55	5.57

DM: dry matter, CP: crude protein, EE: ether extract, CF: crude fibers, DE: digestible energy, P/E: protein: energy ratio. * Nitrogen free extract (NFE) =100 - (CP%+EE%+CF%+ash %). **GE= Gross energy was calculated by multiply the Factors 4.1, 6.5 and 9.44 Kilo GE/g DM for carbohydrate, protein and fat, respectively (**Jobling, 1983**). DE (digestible energy) (kcal/g), based on 5.0 kcal/g protein 9.0 kcal/g EE, 2.0 kcal/g NFE, according to **Wee and Shu (1989**).

Quality parameters of rearing water: Water temperatures and pH remained fairly stable among all treatments (Table 4). Water temperature (24.9 - 26.2 ºC), pH (6.8 - 6.7), nitrite (0.20 - 0.26 mg/L), total alkalinity (> 300 mg/L $CaCO_3$) and total hardness (> 300 mg/L $CaCO_3$) were within the optimum range recommended for culture of Nile tilapia (Nwanna, 2002). DO ranged from 3.8 ± 0.22 mg/L to 4.1 ± 0.22 mg/L .Unionized ammonia concentration ranged from 0.09 ± 0.017 mg/L to 0.11 ± 0.017 mg/L (Table 4). All the measured water quality parameters did not differ significantly (P>0.05) among the feeding treatments throughout the study. All tested water quality criteria (Table 4) were suitable for rearing Nile tilapia fingerlings as cited by Abdel-Hakim *et al*. (2002). Also, Abdelhamid *et al*. (2002) suggested that these values are acceptable for rearing Nile tilapia. These results pinpoint that, farming Nile tilapia using floating and sinking diets does not cause significant deterioration of water quality parameters providing that the diets were formulated correctly. The unionized ammonia and nitrite levels in the present study remained within safe limits; hence, no remarkable mortality (Table 6) was recorded and no signs of stress were observed. Maximum values of 0.11 mg/L for ammonia and 0.26 mg/L for nitrite were far below the toxic levels. Safe levels of unionized ammonia were indicated as 1.05 mg/L (Hassan, 1992) and 1.0 mg/L for nitrite (Otte and Rosenthal, 1979). Data of the water quality parameters monitored during the study period was within the satisfactory range for tilapia culture given by Boyd (1982), Rahman (1992), Abdelhamid (2019a) and Abdelhamid (1996 & 2019b). The level of DO retention is directly influenced by water temperature. The ability of fresh water to retain an acceptable level of DO hindered water temperature exceeding 24 ºC. The minimum amount of DO that will support a large, diverse fish population is 4-5 mg/L as suggested by numerous scientific studies. Generally, it averages about 9.0 4-5 mg/L for good fishing waters. The fish may die when DO concentration is lower than 3 mg/L. Fish stop eating and become lethargic due to ammonia toxicity. Ammonia is released in the pond when fishes are overfed; uneaten feeds sink to the bottom of the pond and increase the load on the nitrifying bacteria in the pond and filter. Too many fish in the pond or system can also be responsible for ammonia toxicity by producing wastes (Abdel-Hakim *et al*., 2002).

Table 4: Rearing water quality parameters of Nile tilapia fed the floating and sinking diets supplemented with different levels of probiotic

Diets Type	P-L-L* %	Temperature (°C)	Dissolved Oxygen (mg/L)	pH	Unionized Ammonia (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)
Floating	**0**	24.9± 0.1	3.8± 0.22	6.9± 0.103	0.11± 0.017	0.242± 0.82	0.20± 0.038
	1	25.5± 0.0	4.1± 0.22	6.8± 0.103	0.09± 0.017	0.234± 0.82	0.26± 0.038
	2	25.1± 0.0	4.0 ± 0.15	6.9± 0.07	0.10± 0.012	0.240± 0.58	0.23± 0.027
Sinking	**0**	25.5±0 .02	4.0± 0.22	6.9± 0.103	0.09± 0.017	0.250± 0.82	0.26± 0.038
	1	26.2± 0.1	3.9± 0.15	6.8± 0.07	0.09± 0.012	0.250± 0.58	0.20± 0.027
	2	25.5± 0.6	3.8± 0.22	6.9± 0.103	0.10± 0.017	0.260± 0.82	0.26± 0.038

*: P-L-L: PRO-LYNE® level. Mean without a similar small superscript within a column and a group differ significantly (P<0.05). Overall mean without a similar capital superscript within a column differ significantly (P<0.05).

Body weight and length: Table 5 shows mean of fish body weight and length, at the start and the end of the experiment as affected by feed type (floating and sinking pellets). As described in this table, the averages of initial weights of *O. niloticus* were 60 g. While at the end of the experiment, the averages of body weight ranged from 198 ± 1.18 to 163 ± 6.41g, regardless of probiotic levels. As described in this table, the averages of initial length were 14.3 ± 0.15 to 14.0 ± 0.15 cm; while at the end of the experiment, the averages of body length were 21.3 ± 0.33 to 19.2 ± 0.17 cm for the two types, respectively. These results indicated that, the body weight and length for floating feed group were higher than those obtained for sinking feed supplemented with probiotic (0%, 1%, and 2%). Differences between two feeds were significant (P<0.05).

Table 5: Mean ± standard errors of body weight and length of the Nile tilapia fed floating and sinking diets supplemented with different levels of probiotic

Diets type	P-L-L* %	Initial stocking density	Final stocking density	Initial biomass Kg/hapa	Final biomass Kg/hapa	Initial length (cm)	Final length (cm)
Floating	**0**	5	4.40 ± 0.35^{a}	1801 ± 1.00^{a}	4685 ± 346^{b}	14.1 ± 0.10^{a}	19.3 ± 0.33^{c}
	1	5	4.80 ± 0.00^{a}	1800 ± 0.00^{a}	5742 ± 34.7^{a}	14.3 ± 0.17^{a}	21.3 ± 0.33^{a}
	2	5	4.80 ± 0.00^{a}	1803 ± 1.73^{a}	5463 ± 34.4^{a}	14.2 ± 0.09^{a}	20.3 ± 0.17^{b}
Overall		5	4.67 ± 0.12^{A}	1801 ± 0.73^{A}	5297 ± 187^{A}	14.2 ± 0.07^{A}	20.3 ± 0.32^{A}
Sinking	**0**	5	4.43 ± 0.15^{a}	1800 ± 0.00^{a}	4296 ± 60.3^{b}	14.3 ± 0.15^{a}	19.2 ± 0.17^{b}
	1	5	4.67 ± 0.09^{a}	1803 ± 1.73^{a}	5137 ± 108^{a}	14.1 ± 0.10^{a}	20.2 ± 0.44^{a}
	2	5	4.50 ± 0.00^{a}	1800 ± 0.00^{a}	4995 ± 0.00^{a}	14.0 ± 0.15^{a}	20.5 ± 0.29^{a}
Overall		5	4.53 ± 0.06^{A}	1801 ± 0.71^{A}	4809 ± 134^{B}	14.1 ± 0.07^{A}	19.9 ± 0.26^{A}

*: P-L-L: PRO-LYNE® level. Mean without a similar small superscript within a column and a group differ significantly (P<0.05). Overall mean without a similar capital superscript within a column differ significantly (P<0.05).

Improved growth of fish fed extruded floating diet may be due to the presence of pelleted floating diet above the water surface, which enables fish to benefit from it, as well as the fish movement and activity as a result of rise to water surface to feed, which works to improve digestion and absorption of feeds. But, the sinking diet on the feeder lose part of them as a result of movement of fish and a part of this pellets (as a waste that lowering the feed conversion and increases production costs, thus lowering the economic efficiency) download to the bottom of pond and mixed with mud, thus fish will not benefit from it, but even will change the water properties as a result of the accumulation of feed waste analyzed in water causing increased total ammonia concentration in ponds.

As in the present study also, Abou-Zied (2015) found that final mean weight and weight gain were higher of Nile tilapia in commercial farms fed extruded floating diet, while lower values were recorded with sinking diet. With regard to the effect of probiotic level on body weight and length, data in Table 6 showed that final weight was 177, 198, 188, 163, 183 and 185 g/fish for T1, T2, T3, T4, T5 and T6, respectively, while in Table 5 the mean length was 19.3, 21.3, 20.3, 19.2, 20.2, and 20.5 cm. These results indicated that, the average body weight for level of probiotic 1% T2 was higher than other levels. The analysis of variance of these results indicated that, the differences among different levels were significant (P<0.05). These results are in agreement with those reported by Abdoulaye (2013) when studied the effects of dietary protein level and probiotic on growth performance, carcass composition and survival rate of fry mono-sex Nile tilapia. Significantly higher final weight of tilapia was found in T2 (198 g) than those of T1 (177 g), T1 (163 g) and T6 (185g), respectively (Table 6). Results presented in Tables 5 and 6 show that variations were significant (P<0.05) due to the interaction between food type (floating and sinking pellets) and probiotic (0%, 1% and 2%), which indicated that these two factors act dependently on each other and also each of them had its own significant effect.

Table 6: Mean ± standard errors of growth performance parameters, and survival rate of the Nile tilapia fed floating and sinking diets supplemented with different levels of probiotic

Diets type	P-L-L* %	Initial weight (g/fish)	Final weight (g/fish)	Weight gain (g/fish)	Average daily gain (g/fish)	SGR (% /day)	SR (%)
Floating	**0**	60.0 ± 0.03^{a}	177 ± 0.78^{c}	117 ± 0.78^{c}	1.20 ± 0.00^{b}	1.12 ± 0.003^{b}	88.3 ± 6.73^{a}
	1	60.0 ± 0.00^{a}	198 ± 1.18^{a}	138 ± 1.18^{a}	1.43 ± 0.03^{a}	1.24 ± 0.007^{a}	96.7 ± 0.00^{a}
	2	60.1 ± 0.06^{a}	188 ± 1.19^{b}	128 ± 1.21^{b}	1.33 ± 0.03^{a}	1.19 ± 0.006^{a}	96.7 ± 0.00^{a}
Overall		60.0 ± 0.02^{A}	188 ± 3.10^{A}	128 ± 3.11^{A}	1.32 ± 0.04^{A}	1.19 ± 0.018^{A}	93.9 ± 2.39^{A}
Sinking	**0**	60.0 ± 0.00^{a}	163 ± 6.41^{b}	103 ± 6.41^{b}	1.07 ± 0.09^{b}	1.03 ± 0.043^{b}	88.3 ± 2.89^{a}
	1	60.1 ± 0.06^{a}	183 ± 0.09^{a}	123 ± 0.15^{a}	1.30 ± 0.00^{a}	1.16 ± 0.003^{a}	93.3 ± 1.93^{a}
	2	60.0 ± 0.00^{a}	185 ± 0.00^{a}	125 ± 0.00^{a}	1.30 ± 0.00^{a}	1.17 ± 0.000^{a}	90.0 ± 0.00^{a}
Overall		60.0 ± 0.02^{A}	177 ± 4.07^{B}	117 ± 4.07^{B}	1.22 ± 0.05^{B}	1.12 ± 0.025^{B}	90.5 ± 1.25^{A}

*: P-L-L: PRO-LYNE® level. Mean without a similar small superscript within a column and a group differ significantly (P<0.05). Overall mean without a similar capital superscript within a column differ significantly (P<0.05).

Average daily weight gain (ADWG): Table 6 shows mean of ADWG during the experimental period as effected by food type (floating and sinking pellets), where ADWGs for floating were (P < 0.05) higher than for sinking pellets. In this regard, Abou-Zeid (2015) also reported that ADWGs were significantly (P<0.05) better with extruded floating diet, while lower values were recorded with sinking diet. The highest growth obtained in T2 might be due to probiotic with floating feed. Final weight of tilapia obtained in the present study is in agreement with the findings obtained by Ahmed *et al*. (2014). Daily weight gain of tilapia varied from 1.43 ± 0.03 to 1.07 ± 0.09 g (Table 6), which is in agreement with the findings of Ahmed *et al*. (2014) who obtained daily weight gain 1.45 - 1.98 g by applying commercial floated feed with probiotics in cages. Ahmed *et al*. (2013) has also found daily weight gain 1.56 g by applying prepared feed and 1.78 g by using commercial feed for tilapia reared for 70 days period. Results presented in Table 6 also showed that differences in DWG were significant (P<0.05) due to the interaction between food type (floating and sinking pellets) and probiotic levels (0%, 1% and 2%) which indicated that these two factors act dependently and also each of them had its own significant effect. As showed in this table, the best DWG was obtained for 2rd treatment in the floating pellets at probiotic level 1%.

Specific growth rate (SGR): Results in Table 6 showed that mean of SGR, during the experimental period as affected by pellets type and probiotic levels. As described in this table, the averages of SGR were 1.24 ± 0.007 to 1.03 ± 0.043 %/ day for floating and sinking pellets, respectively. These results indicated that the SGR for floating pellets was higher (P≤0.05) than obtained in sinking one. Results presented in Table 6 showed that variation was significant due to the interaction between food type (floating and sinking pellets) and probiotic levels (0%, 1%, and 2%), which indicated that these two factors act dependently on each other and also each of them had its own significant effect. As showed in Table 6, the highest (P≤0.05) SGR was obtained for T2 treatment (floating pellets 1.24) at probiotic level 1%, while the lowest in the control group. The SGR values found in other two treatments were also significantly different. Values of SGR observed in the present study are lower than those reported by Diana *et al*. (1996), Ahmed *et al*. (2013) and Kunda *et al.* (2015).

Survival rate: No significant difference was observed in the survival rate of Nile tilapia, it ranged from 88.30 to 96.70% (Table 6). In a previous study, survival rate of caged tilapia had been found to range from 95.76 to 97.54% (Ahmed *et al*., 2014) and 95.39 to 95.87 % (Kunda *et al.*, 2015).

Food and nutrients utilization: Food conversion ratio (FCR) of tilapia in this investigation was 20.05 - 2.63 (Table 7), similar to the findings of Ahmed *et al.* (2013 and 2014) and Kunda *et al*. (2015) who reported that FCR values as 1.40 - 1.51, 1.11 - 1.41 and 1.18 - 1.25, respectively for tilapia. Quality of delivered food and of rearing water are responsible for FCR. Protein efficiency ratio (PER) for tilapia in the present study varied from 1.89 ± 0.02 to 1.52 ± 0.09, which coincided with the finding obtained by Saha and Khatun (2014), who found that PER as 2.81 - 3.97 at stocking density of 5 fish per m^3 for 105 days culture period by applying floating feed supplemented with probiotics.

Table 7: Feed and nutrients utilization parameters* of Nile tilapia fed floating and sinking diets supplemented with different levels of probiotic

Diets type	P-L-L** %	Feed intake g/ fish	Feed conversion ratio	Feed efficiency	Protein efficiency ratio	PPV %	K
Floating	**0**	259 ± 12.7^b	2.21 ± 0.12^a	0.45 ± 0.02^a	1.80 ± 0.10^a	35.2 ± 2.34^a	0.80 ± 0.10^a
	1	284 ± 2.17^a	2.06 ± 0.02^a	0.49 ± 0.01^a	1.89 ± 0.02^a	33.3 ± 1.28^a	0.40 ± 0.06^b
	2	286 ± 6.99^a	2.22 ± 0.05^a	0.45 ± 0.01^a	1.74 ± 0.04^a	28.7 ± 1.30^b	0.53 ± 0.03^{ab}
Overall		276 ± 6.07^A	2.16 ± 0.05^B	0.46 ± 0.01^A	1.81 ± 0.04^A	32.4 ± 1.28^A	0.58 ± 0.07^A
Sinking	**0**	268 ± 1.85^a	2.63 ± 0.16^a	0.38 ± 0.02^b	1.52 ± 0.09^b	26.9 ± 1.41^b	0.90 ± 0.15^a
	1	273 ± 0.23^a	2.21 ± 0.00^b	0.45 ± 0.00^a	1.75 ± 0.01^a	29.9 ± 0.68^{ab}	0.57 ± 0.09^b
	2	273 ± 0.87^a	2.18 ± 0.01^b	0.46 ± 0.00^a	1.76 ± 0.01^a	33.2 ± 1.15^a	0.50 ± 0.12^b
Overall		271 ± 0.98^A	2.34 ± 0.09^A	0.43 ± 0.01^B	1.68 ± 0.05^B	30.0 ± 1.06^A	0.66 ± 0.09^A

*: Values are mean ± standard errors. **: P-L-L: PRO-LYNE® level. Mean without a similar small superscript within a column and a group differ significantly (P<0.05). Overall mean without a similar capital superscript within a column differ significantly (P<0.05).

Condition factor (k): Table 7 shows mean of condition factor (k), at the start and at the end of the experiment affected by food types (floating and sinking pellets). As described in this table, the averages of initial (k) of *O. niloticus* were 0.58 and 0.66, respectively. These results indicated that, the condition factor was decreased with extruded floating diet. It is advantageous to feed a floating food, because the farmers can directly observe the feeding intensity of their fish. Regarding to the effect of tested levels of probiotic on (k), means of condition factor (k), were 0.80, 0.40 and 0.53 for three levels of probiotic 0%, 1% and 2% floating diet, respectively (Table 7). While, at the end of the experiment, the mean of k were 0.90, 0.57 and 0.50, for three levels of probiotic 0%, 1% and 2% sinking diet, respectively. The analysis of variance of these results indicated that, the differences among different levels were significant (p<0.05). These results are in agreement with those obtained by Abdoulaye (2013) who reported that k of fish was significantly improved with increasing dietary levels 0%, 1% and 2% of tested probiotic. Results presented in Table 7 due to the interaction effects between food type (floating and sinking pellets) and probiotic levels (1%, 2% and 3%).

Chemical composition: The changes in chemical composition during development and in response to studied factors are shown in Table 8. Proximate analysis showed significant (P<0.05) effects in the six treatments. Sinking diet released the highest values of fat and ash. This closely met with remarks of Abou-Zaid (2015) who emphasized that floating diet is commonly considered the most desirable for aquaculture, because it is usually consistent in quantity and quality. Data refers to fish carcass protein and lipid content that significantly (P<0.05) increased with increasing dietary protein levels and probiotic levels. Pedro *et al*. (2001), Tidwell *et al*. (2005), and Abdoulaye (2013) reported the increase in carcass protein content with the increase in dietary protein levels. In contrast, in the present study there was not any significant difference in body protein content of tilapia. While, there were significant differences between treatments in ether extract and crude fiber composition. This is in contrast with the findings obtained by Ahmed *et al*. (2012). Yet, carcass lipid content exhibited positive relation with dietary lipid levels in rainbow trout (Yamamoto *et al*., 2000 and Gumus and Ikiz, 2009). Laterally, other scientists reported similar results of different tilapia spp. (Davis and Stickney, 1978; Mazid *et al*., 1979; Winfree and Stickney, 1981 and Jauncey, 1982). Once the protein requirement of the fish was met; the excess protein was used for other bodily processes as indicated by the significantly higher crude fat content of the carcass of juveniles fed with sinking pellets. Dietary protein is the source of amino acids used for protein synthesis that represents normal growth (Shul'man, 1974). However, certain proportions of absorbed amino acid are used to obtain energy (Pfeffer, 1982) or stored as fat or glycogen (Shul'man, 1974 and Cowey and Sargent, 1979) and the amount depends mainly on the amino acid composition of dietary protein relative to fish needs, and the amount of energy provided by lipids and carbohydrates relative to that need to cover metabolic requirements (Pfeffer, 1982 and Wilson *et al*., 1985).

Table 8: Chemical composition* of Nile tilapia fed floating and sinking diets supplemented with different levels of probiotic

Diets type	**P-L-L** %**	**% On Dry matter basis**					
		DM	**CP**	**EE**	**CF**	**Ash**	**CHO**
Initial analysis		25.55 ± 2.68	56.97± 4.05	11.87 ± 1.13	2.88 ± 0.05	19.87± 0. 38	8.42 ± 0.097
Final analysis							
Floating	**0**	32.00±0.00a	55.65±1.11a	22.53±1.08a	3.08±0.02b	14.25±0.69b	4.40±0.23a
	1	29.06±0.00c	57.30±1.73a	20.46±0.53a	0.67±0.07c	17.42±0.78a	4.60±0.23a
	2	29.17±0.00b	54.59±2.33a	20.25±0.23a	4.26±0.15a	17.00±0.58a	3.84±0.20a
Overall		30.08±0.48A	55.85±0.98B	21.08±0.51A	2.67±0.53A	16.23±0.60A	4.28±0.16A
Sinking	**0**	26.06±0.00b	63.64±0.39a	15.34±0.91b	1.56±0.20a	16.15±1.21ab	3.24±0.09b
	1	24.64±0.00c	65.96±1.08a	10.43±0.58c	1.00±0.06b	19.65±1.04a	3.36±0.24b
	2	30.30±0.00a	57.54±1.40b	22.05±1.16a	1.50±0.17ab	13.85±0.87b	4.51±0.29a
Overall		27.00±0.85B	62.38±1.36A	15.94±1.74B	1.35±0.12B	16.55±0.99A	3.70±0.23B

*: Values are means ± standard errors. **: P-L-L: PRO-LYNE® level. Means without a similar small superscript within a column and a group differ significantly (P<0.05). Overall means without a similar capital superscript within a column differ significantly (P<0.05).

Economic study: The economic efficiency parameters of the tested diets are presented in Table 9. The calculations depended on the average price of dietary ingredients of year 2017; where local marked prices of their ingredients were as fish meal 16400 LE, soybean meal 7350 LE, Yellow corn 3800 LE, oil 31550 LE, Vit. &Min. 25000 LE and black seed meal 1450 LE. The calculated figures showed the high cost of one ton of all diets included the probiotic. However, the control diet recorded the lowest price. The diets containing 1% and 2% floating diet showed the hifgest fish gain compared with the other diets. Therefore, 1% floating diet showed the lowest feed cost / kg gain. However, diet No. 2 and 6 (including 1% PRO-

LYNE®-floating and 2% PRO-LYNE-sinking diets) reflected the best fish body gains. Thus, these low levels (1% and 2% PRO-LYNE®) gave the best feed cost / kg gain being (16.71 and 17.34 LE).

Table 9: Data of the economic efficiency parameters of Nile tilapia fed floating and sinking diets supplemented with different levels of probiotic

Diets type	P-L-L** %	Feed intake (g/fish)	Cost of one-ton diet (LE)	Decrease feed cost (LE)	Total fish gain (g/fish)	Feed Cost / kg gain (LE)
	0	258.50	8100	0.00	116.8	17.92
Floating	1	283.53	8137.5	37.5	138.0	16.71
	2	285.60	8152.5	52.5	128.3	18.14
	0	268.20	7900	0.00	102.5	20.67
	1	273.10	7937.5	37.5	123.4	17.66
Sinking	2	272.60	7952.5	52.5	125.0	17.34

Feed cost / kg (LE) = feed intake *cost of ton feed *1000/ total gain. **: P-L-L: PRO-LYNE® level.

CONCLUSION

In conclusion, the present study revealed that performance and production of Nile tilapia reared in net hapas in earthen ponds significantly increased, when fed the floating pellets supplemented with PRO-LYNE® probiotic at level 1% (T2). This is confirmed in Table 9 regarding the economic assessment, where the best economic efficiency return was observed for T2.

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ARABIC SUMMARY

مقارنة العليقتين الطافية والغاطسة على أداء النمو لأسماك البلطي النيلي

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٢- المعمل المركزى لبحوث الثروة السمكية بالعباسة شرقية (وحدة بحوث سخا – كفر الشيخ) – مركز البحوث الزراعية – وزارة الزراعة - مصر.

تم إجراء هذه الدراسة فى مزرعة سمكية خاصة بمنطقة مطوبس، غرب بحيرة البرلس، محافظة كفر الشيخ شمال دلتا النيل بجمهورية مصر العربية. وتهدف الدراسة إلى مقارنة العليقتين الطافية والغاطسة مع إضافة مستويات مختلفة من بروبيوتك على أداء النمو ومعدلات الاستفادة الغذائية في أسماك البلطي النيلي. تضمنت الدراسة اختبار مجموعة علف طافية بأخرى غاطسة. وداخل كل مجموعة علف تم اختبار ثلاث مستويات مختلفة من بروبيوتيك (٠% ، ١% و ٢%). تمت التجربة فى هابات مثبته فى الأحواض الترابية، أبعاد كل هابه (٢ × ٣ × ١ م٣)، كل معامله مُثلت فى٢ مكررة بإجمالي ١٢هابه. وتم البدء بعدد إجمالى أسماك ٣٦٦ سمكة بوزن إبتدائى ٦٠ جراما، وكانت مدة التجربة ٩٦ يوما، وتمت تغذية الأسماك علي عليقه صناعية ذات بروتين خام ٢٥.٢%. تم تقديم العليقة المحسوبة على أساس الوزن الحى على وجبتين يومياً الأولى الساعة العاشرة صباحاً والثانية بعد ظهر نفس اليوم بمعدل تغذية ٤% لمدة شهر ونصف ثم ٣% حتي نهاية التجربة، وتم أخذ عينة من الأسماك من كل معاملة مرة كل ١٥ يوما، وذلك لحساب كمية العلف المأكول للفترة القادمة بناء على الوزن الفعلى. أيضاً تم تقدير مقاييس جودة المياه لمعرفة مدى ملاءمتها للاستزراع السمكي، تم التحليل الكيميائي لأجسام أسماك البلطي النيلي في بداية التجربة وفى النهاية.

وخلُصت نتائج الدراسة إلى زيادة معدلات النمو، والاستفادة الغذائية والكفاءة الإقتصادية لأسماك البلطي النيلي المرباه فى هابات شبكية في الأحواض الترابية والتي تم تغذيتها على العليقة الطافية مع إضافة البروبيوتك بمستوى (١%).