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Effects of Replacing Fish Meal with Peanut Meal (*Arachis hypogaea*) on Growth, Feed Utilization and Body Composition of Mozambique Tilapia Fries (*Oreochromis mossambicus*)

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Abstract.- The study was to determine the effects of diets replacing fish meal (FM) with peanut meal (PNM) on feed utilization, growth performance and body composition of Mozambique tilapia (*Oreochromis mossambicus*, initial body weight 0.83±0.17 g). Five isonitrogenous (37% CP) and isolipidic (9% CL) experimental diets with 0% (PNM-0), 10% (PNM-10), 20% (PNM-20), 30% (PNM-30) and 40% (PNM-40) of fish meal replaced with PNM. At the end of a 45 day feeding trial, PNM-10 and PNM-20 diets showed the best growth performance and feed evaluation. Higher dietary FM replacement negatively affected growth performance and feed evaluation. Our results at the end of the experiment showed that the replacement of FM by PNM in Mozambique tilapia diets does not affect body composition. In conclusion, these results indicate that the replacement of 20% dietary FM with PNM had no adverse effect on the growth performance, body composition parameters and general health of Mozambique tilapia fries (mean weight 0.8-3 g).

Keywords: Peanut meal, fish meal, plant protein, growth performance, tilapia.

INTRODUCTION

The aquaculture sector is developing more effectively than other food production sectors. However, economic factors such as feed cost are blocking inhibiting development. Fish meal (FM) is the most attractive protein source for aquaculture diets because of its high protein content, well balanced amino acid and fatty acid composition, high digestibility and palatability, however, the high cost of FM and lack of availability are making it impracticable to use in all aquafeeds. In recent years, a decline in fish stocks on which FM production depends and the increased consumption of fish has promoted the search for alternative protein sources (Akiyama *et al.,* 1995). Consequently, researchers are focusing on replacing fish meal with vegetable protein sources (Yıldırım *et al.,* 2009; González-Félix *et al.,* 2011; Harlıoğlu *et al.*,2011; Yiğit *et al.,* 2012; Bulut *et al*., 2014).

Peanut meal (PNM) contains a lower level of lysine and methionine compared to soybean meal and its protein quality is inferior to soybean meal however, due to its high crude protein content, PNM can be used in the aquafeed industry (Liu *et al.,* 2012). It is the fourth largest oilseed crop in the world and is cultivated in more than 60 countries. The annual global production reaches 35 million tonnes (Liu *et al.,* 2012). Peanut pulp that remain after the extraction oil can be used in animal feeds as a protein source for poultry (Costa *et al.,* 2001), pigs (Adeola, 2009) and fish (Yıldırım *et al.,* 2013).

Tilapias are an important species for fish culture, particularly in Asia. The objective of the present study therefore is to determine the effects of replacing FM with PNM on growth, feed utilization and body composition of Mozambique tilapia fries, *Oreochromis mossambicus.*

MATERIALS AND METHODS

Experimental diets

Peanut pulp was obtained from a local factory (Başpınar Fıstık, Osmaniye, Turkey). The pulp was ground in a hand mill, then in an electric mill with a 590 µm mesh screen and stored in a plastic case at

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Table I.- Proximate analysis of fish meal, soybean meal and peanut meal (as % dry matter)

	Protein	Lipid	Ash	NFE[2]	Arg	His	Ile	Leu	Lys	Met	Phe	Thr	Tyr	Val
FM[1]	70.7	5.3	16.9	7.1	5,9	2,5	4,7	7,7	8	2,9	4,2	4,4	1,2	5,4
Soy meal[1]	52	0.5	4.6	42.9	6,94	2,64	5,01	7,54	6,28	1,38	5,03	4,92	1,18	4,72
Peanut meal	30.6	10.3	7.5	51.53	0,15	N.D	0,45	0,47	0,002	0,023	0,44	N.D	0,2	0,2

[1]Data on proximate composition and amino acid contents of fishmeal and soybean meal are from Hertrampf and Pascual, 2000
[2]Nitrogen–free extracts (NFE) = matter – (crude lipid+crude ash+crude protein).

Table II.- Formulation and proximate composition of the experimental diets containing supplement of different PNM rate

		Experimental diets				
		PNM–0	PNM–10	PNM–20	PNM–30	PNM–40
Ingredients (%)						
Fish meal		30.00	27.00	24.00	21.00	18.00
Soybean meal		33.00	33.00	33.00	33.00	33.00
Fish oil		5	5	5	5	5
Peanut meal		-	6	12.8	19.1	25.3
Corn starch		28	25	21.2	17.9	14.7
Vitamin–mineral mix[1,2]		4.0	4.0	4.0	4.0	4.0
Total		100	100	100	100	100
Chemical analyses (%, DM)						
Protein		36.70	36.60	36.70	36.70	36.60
Lipid		8.19	8.51	8.91	9.26	9.60
Ash		6.02	6.02	6.08	6.1	6.12
NFE[3]		47.70	47.50	46.90	46.70	46.30
Gross energy, Kj/kg[4]		19.90	20.07	20.15	20.25	20.30
EAA (g 100 g^{-1} DM)[5]	**Tilapia***					
Arginine	1.18	4.06	3.89	3.73	3.56	3.39
Histidine	0.48	1.62	1.55	1.47	1.40	1.32
Isoleucine	0.87	3.06	2.95	2.84	2.73	2.61
Leucine	0.95	4.80	4.60	4.40	4.19	3.99
Lysine	1.43	4.47	4.23	3.99	3.75	3.51
Methionine	0.75	1.33	1.24	1.15	1.07	0.98
Phenylalanine	1.05	2.92	2.82	2.72	2.63	2.53
Threonine	1.05	2.94	2.81	2.68	2.55	2.42
Tyrosine	0.28	0.75	0.73	0.70	0.68	0.66
Valine	0.78	3.18	3.02	2.88	2.73	2.58

[1]Vitamin Mix: Vit. A, 18000 IU; Vit. D3, 2500 IU ; Vit. E, 250 mg/kg; Vit. K3, 12 mg/kg; Vit. B1, 25 mg; Vit. B2, 50 mg; Vit. B3, 270 mg; Vit. B6, 20 mg; Vit. B12, 0.06 mg; Vit. C, 200 mg; Folic acid, 10 mg; Calcium d–pantothenate, 50 mg; Biotin, 1 mg; Inositol, 120 mg; Choline chloride, 2000 mg.
[2]Mineral Mix: Fe, 75.3 mg; Cu, 12.2 mg; Mn, 206 mg; Zn, 85 mg; I, 3 mg; Se, 0.350 mg; Co, 1 mg.
[3]Nitrogen–free extracts (NFE) = matter – (crude lipid+crude ash+crude protein).
[4]Energy calculated according to 23.6 kJ g^{-1} protein, 39.5 kJ g^{-1} lipid, and 17.0 kJ g^{-1} NFE.
[5]Essential amino acid contents calculated from data in Table 1.
*As a percent of diet essential amino acid requirements of tilapia to Jauncey *et al.* (1982)

–20°C until used. The pulp was added to the feed at a rate of 0%, 10%, 20%, 30% and 40% for diets PNM–10, PNM–20, PNM–30 and PNM–40, respectively. The chemical composition of main protein sources is presented Table I. The feed components of the diets are presented in Table II. The ingredients were mixed in a blender. The pellets (2 mm diameter) were prepared with a mincing machine, and the pellets were dried in a drying cabinet (40°C until moisture levels dropped to around 10%). The pellets were crushed into desirable particle sizes (250-400 µm) and stored at –20°C until used.

Experimental design and feeding trial

The experiment was designed in triplicate for each diet. Fifteen 50 L glass aquariums were stocked with 150 fry (10 fry/aquarium of *O. mossambicus*). The fry were fed at satiety three times a day for 45 days. During the experiment, water was exchanged daily at a rate of ~10% of the total volume. The fry averaging about 0.83±0.17 g were produced in Muğla Sıtkı Koçman University, Faculty of Fisheries, Muğla, Turkey. The physical qualities (mean ± SD) of fresh water during the experiment were as follows: temperature was 28.1±0.2 °C, pH was 7.0±0.1, dissolved oxygen was 7.0±0.2 mg/L, total NH_3 was 0.09±0.02 mg/L, nitrite was 0.03±0.01 mg/L and nitrate 0.8±0.2 was mg/L throughout the experiment.

Proximate composition

Feedstuffs and fish samples were analyzed for proximate composition according to AOAC (2000). All the samples were frozen at -20 °C until analyzed. Dry matter was detected after drying at 105 °C until a constant weight was achieved. Ash content was measured in a muffle furnace at 525 °C for 12 hour. The amount of crude protein was analyzed by the Kjeldahl method. Lipid extractions were determined by the SOXTEC system. For essential amino acid analysis (excluding tryptophan), 50 mg of the diet was hydrolyzed in 10 ml 6 N HCl at 110°C for 24 h. After removal of the HCl by evaporation under vacuum, the amino acids were separated by ion-exchange chromatography on a Shimadzu RF-10AXL sodium column and detected following postcolumn derivatization with ninhydrin, by measuring absorbance at 350-450 nm.

Statistical analysis

Statistical analysis included one-way analysis of variance (ANOVA) and Tukey's multiple significant difference tests using the software program (Minitab 16 for Windows). Differences were regarded as significant when P<0.05 level.

RESULTS

Survival, growth performance and feed efficiency results are shown in Table III. Survival was high with no significant differences between the treatment groups (P>0.05). The highest weight gain (WG%) occurred in fish fed with the PNM-10 diet, but these were not significantly different from the PNM-20 diets (P>0.05). Fish fed with the PNM-30 and PNM-40 diet had lower final weight compared to the other PNM groups (P<0.05). Similar results were observed in the final weight. Specific growth rate (SGR) was significantly higher in PNM-10 diet compared to PNM-0 diet (P>0.05). Feed conversion rates (FCR) showed a similar pattern to SGR and WG, the best FCR value was obtained in PNM-10 diet (P>0.05). The growth parameters were affected negatively by increasing PNM level in the diets.

At the end of the 45 day trial, proximate composition of tilapia fed with the experimental diets is offered in Table IV. Fillet protein content was similar between the groups and no differences were observed. Moisture content was not influenced by any treatment.

DISCUSSION

The usages of peanut products as a raw material for fish feed have not been widely investigated. Lack of information exists about the usability of peanut meal instead of fish meal in aquafeeds. The level of acceptance or rejection of feed is a common problem when plant based protein sources are used in aquafeed as an alternative feed stuff (Rodriguez *et al.,* 1996). In the present study all diets were accepted by the fish. Therefore, dietary inclusion of PNM did not affect the palatability of test diets. Otherwise, the low level lysine and methionine levels in the diets with increasing PNM have led to poor growth performance. The present study showed that peanut meal can substitute up to 20% of the dietary fish meal without adverse effect on growth performance. The results obtained in the present study agree with previous aquatic animal studies. Garduño-Lugo and Olvera-Novoa (2008), successfully replaced 20% of the fish meal diet with peanut leaf meal for Nile tilapia without negative effects on growth

Table III.- Survival, weight gain, specific growth rate (SGR) and feed conversion rate (FCR) in tilapia fed the experimental diets.

Dietary treatment (% PNM)	Initial weight (g)	Final weight (g)	Weight gain (%)	SGR	FCR	Survival (%)
0	0.83±0.02	3,06±0,29[ab]	266,25±29,78[a]	2,88±0,18[a]	1,48±0,04[a]	100±0,00[a]
10	0.82±0.01	3,74±0,13[b]	354,42±8,67[b]	3,36±0,04[bc]	1,35±0,12[a]	100±0,00[a]
20	0.83±0.01	3,43±0,31[b]	313,51±38,63[b]	3,15±0,21[abc]	1,40±0,02[a]	86,67±23,09[a]
30	0.83±0.02	2,71±0,29[a]	228,67±24,65[a]	2,64±0,16[a]	2,17±0,48[b]	93,33±5,77[a]
40	0.81±0.02	2,42±0,24[a]	198,80±28,63[a]	2,43±0,22[a]	2,83±0,43[b]	83,33±15,28[a]

Values are mean ± SD (n=3). Values for each parameter with different superscript letters are significantly different as determined by ANOVA ($p < 0.05$).
Weight gain (g) = final biomass – initial biomass
Weight gain (%) = 100 (final fish weight – initial fish weight)/initial fish weight
Specific growth rate (SGR) = 100 (ln final fish weight) – (ln initial fish weight)/experimental days
Feed conversion ratio (FCR) = feed intake/weight gain + weight of death fish

Table IV.- Fillet proximate composition of tilapia fed the experimental diets.

Dietary treatment (% PNM)	Moisture	Ash	Protein	Lipid
0	74,05±0,20	2,97±0,07[b]	16,96±0,90[a]	3,61±0,05[a]
10	73,04±0,24	2,79±0,05[ab]	17,87±0,95[a]	3,78±0,04[a]
20	76,00±0,25	2,46±0,17[a]	16,61±0,08[a]	3,89±0,12[ab]
30	74,97±0,50	2,80±0,11[ab]	16,97±0,62[a]	4,06±0,08[b]
40	75,59±0,08	2,60±0,19[ab]	16,23±0,92[a]	3,77±0,01[a]

Values are mean ± SD (n=3). Values for each parameter with different superscript letters are significantly different as determined by ANOVA ($p < 0.05$).

performance. Lim (1997) and Liu *et al.* (2008) said that low PNM inclusion level is possible (104-120 g kg^{-1}) in the diet for Pacific white shrimp. Heat treatment of peanut meal at 60°C during dehydration inactivated its tripsin inhibitor content (Rivas, 1993). Peres *et al.* (2003) reported that autoclaving defatted raw soybean meal using the dry cycle at 130 ˚C for 40 min lowered the trypsin inhibitor and improved the growth performance and feed utilization for channel catfish. Accordingly, the amino acid composition of diets used in the present study was to meet the requirements of the fish, although, growth decrease can be explained by the lower quality proteins in plants compared to that in fish meal (Olvera-Novoa *et al.*, 1998). A study conducted to determine the effect of *Spirulina maxima* as a protein source in diets for *Oreochromis mossambicus* reported that increasing the (algae) content in the diets significantly decreased the growth and feeding performance (Olvera-Novoa *et al.*, 1998). Similar result was reported by Liu *et al.* (2012) who replaced FM with PNM in the diet of shrimps and recommended a maximum level of 14% PNM in the diet. On the contrary, soybean meal can replace 100% with PM in poultry diets (Pesti *et al.*, 2003). The high survival in the present study indicates that PNM can be used for long periods as an alternative to the FM protein source in tilapia diets. Martinéz-Palacios *et al.* (1988) reported high mortality in *O. mossambicus* fed with Jack bean (*Canavalia ensifomis*) seed meal.

The inclusion of peanut meal does not affect the proximate analyses of diets. The protein, lipids level and amino acid content in all experimental diets were within requirements recommended for tilapia (Jauncey *et al.*, 1982). The lipid contents of the fish showed differences but it is difficult to attribute this to the inclusion of PM in the diets. Addition of PM had no adverse effect on the composition of flesh protein and ash content. These results overlap with (Wee and Wang, 1987; Garduño-Lugo and Olvera-Novoa, 2008).

In conclusion, PNM can be used as a replacement source of protein in fish meal for tilapia feeds without negative effects on fish performance. On the basis of these results, we recommended that a maximum inclusion level of 20% PNM can be used as a replacement for fish meal in Mozambique tilapia fries (mean weight 0.8-3 g) diets.

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