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Effect of Dietary Fish Meal Replacement by Poultry By-Product Meal with Different Grain Source and Enzyme Supplementation on Performance, Feces Recovery, Body Composition and Nutrient Balance of Nile Tilapia

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Abstract: The efficacy of replacing Fish Meal (FM) with Poultry By-product Meal (PBM) in Nile tilapia diets on an ideal protein basis with different grain sources and enzyme supplementation was evaluated under condition of cement pond culture. An experimental diet was formulated contain 30% crude protein, 5% ether extract and 3355 Kcal ME/Kg. Four other diets were formulated to be isonitrogenous and isocaloric as the basal diet No. 1, in which FM protein was substituted completely by PBM protein (Basal diet No. 2), while diet No. 3, 4 and 5 sorghum grain replaced 100% of wheat grain (w/w) or 100% of corn grain or 50% of both wheat and corn for the three diets respectively. The fish experimental diets were fed to the fish without or with enzyme supplementation. Statistical analysis of data revealed that inclusion of PBM instead of FM with wheat or sorghum grain plus corn (group 2 and 3) in Nile tilapia diet had no significant ($p>0.05$) effect on Body Weight (BW), Daily Body Gain (DBG), Daily Feed Intake (DFI), Feed Conversion Ratio (FCR), Protein Efficiency Ratio (PER) and Efficiency of Energy Utilization (EEU) when compared with the control. While corn replacement by sorghum (group 4) or 50% of both corn and wheat by sorghum (group 5) had no effect on DFI, but significantly ($p\leq 0.05$) reduced BW, DBG, FCR, PER and EEU when compared with fish group fed on PBM with corn and wheat (group 2). On the other hand nutrient digestibilities were improved with PBM inclusion in Nile tilapia diet. At the end of the experimental period the dressing percent, head weight percent, visceral fat percent and hepatosomatic index were not significantly ($p>0.05$) affected when FM replaced by PBM with different grain sources. Carcass chemical composition data indicated that there is no significant effect of different experimental diets on fish body dry matter, organic matter, crude protein and carbohydrate and phosphorus contents. PBM as FM alternatives has a high potential as feed ingredients replacing FM. Nutrients balances and fecal recovery data showed that PBM with corn + wheat or corn + sorghum results in good fish performance for a similar replacement of FM on protein percent basis. However, they result as well in slightly higher waste loads, in particular of N and C to the system. Sorghum grain as alternative to corn (weight/weight) results in lower fish production and higher nutrient fecal and non fecal losses and prefer to rejected because it has a negative impact on the system. Moreover, enzyme supplementation highly improved the fish performance, nutrient digestibility, carcass traits and fecal recovery and reduces the excessive losses of the nutrient to the environment.

Key words: Nile tilapia, poultry by product, sorghum, enzyme, feces recovery, nutrient balance

INTRODUCTION

Tilapia is the third most important cultured fish group in the world, after carp and salmonids. Tilapia culture is also one of the fastest growing farming activities, with an average annual growth rate of 13.4% during 1970-2002. They are widely cultured in about 100 countries in the tropical and subtropical regions. As a result, the production of farmed tilapia has increased from 383,654 mt in 1990-1505,804 mt in 2003 representing about 6% of total farmed finfish in 2002 (FAO, 2003).

Nutrition is the most expensive component in the intensive aquaculture industry where it represents over 50% of operating costs. Moreover, protein itself represents about 50% of feed cost in intensive culture. Fish Meal (FM) is the major protein source in aquaculture feeds. Moreover, the recent increases in the price of FM necessitate replacing FM with cheaper protein sources. One of the alternative ingredients is Poultry By-product Meal (PBM) is made of ground, rendered, or clean parts of the carcass of slaughtered poultry. PBM has been tested at varying success so far in different fish species (Fowler, 1991; El-Sayed, 1998; Yang *et al*., 2004; Yang *et al*., 2006; Saoud, 2008).

In the past decades several protein sources were tested as alternatives for fish meal in Nile tilapia diets. Results of those studies for different fish species were summarized by Hardy (1996), El-Sayed (1999) and Francies *et al*. (2001). Most conducted studies, which are reported in the literature, focused on growth related factors and feed digestibility. There are very few studies, which are correlating that feces recovery with feed composition (Han *et al*., 1996a,b; Dias *et al*., 1998; Schneider *et al*., 2004). Feces recovery represents a physical measure of feces stability which on its turn is influenced by feed composition (Vens-Cappell, 1985; Han *et al*., 1996a,b; Dias *et al*., 1998; Cripps and Bergheim, 2000) who showed that the solid removal efficiencies are proportionally related to the size and stability of feces particles. Furthermore, if FM replaced by another feed ingredients, the feed nitrogen, phosphorus and carbon will be change, those changes affect the nutrient retention in fish (Machiels and Henken, 1986; Einen *et al*., 1995; Lupatsch *et al*., 2001) and automatically the nutrients released as waste in the rearing system (Brunty *et al*., 1997; Lupatsch and Kissil, 1998; Lupatsch, 2003).

Starch is a cheap source of energy and its inclusion in the feed influences feces stability (Han *et al*., 1996a,b). Moreover, cereal grains differ in its carbohydrate and digestibility which influence the growth and feces recovery in fish culture (Nijhof, 1994; Cho *et al*., 1994; Cho and Burean, 1997). Therefore, it can be hypothesized that the effect of dietary starch on the physical characteristics of digesta and feces and thereby also on fecal stability and its removal efficiency, is dependent on the type of starch. Enzymes provide additional powerful tools that enhance the nutritional value of fish feeds. They provide a natural way to transform complex feed components into absorbable nutrients. Endogenous enzymes found in the fishes digestive system help to break down large organic molecules like starch, cellulose and protein into simpler substances. The addition of enzymes in feed can improve nutrient utilization, reducing feed cost and the excretion of nutrients into the environment (Feord, 1996; Forster *et al*., 1999; Felix and Selvaraj, 2004).

By combining nutrient balances, improvement of nutrient digestibility with feces recovery rates, the impact of a FM replacement by other feed ingredients on fish and surrounding culture system can be estimated to develop so called “Low pollution diets”. The objective of this study is to determine growth performance, nutrient digestibility, total and recovered amount of feces and some related nutrients balances for PBM as alternative for FM with different cereal grain source and exogenous enzyme supplementation in Nile tilapia.

MATERIALS AND METHODS

The present study was carried out at Al-Qowudey Fish Farm of the middle area in the Kingdom of Saudi Arabia.

Fish and husbandry: One hundred ten thousand Nile tilapia fish were collected from the farm. One week after arrival and adaptation to the facilities, fish were weighed and allotted into 10 cement pond (5×15 m) according to the total mass (880.0 kg/each) and approximately 11000 fish number with averaged body weight (80.0 g). The fish ponds were connected to a recirculation system comprising the pond sedimentation unit, pump and trickling filter. The photoperiod was according to the day length (natural light) which last about 12 h at experimental period. The fish were adapted to the experimental diets and feeding level for another one week before the begun of the experimental period. The fish were fed on the experimental diets during 35 days of the experimental period. On the sampling days (day 0 and 35) fish were not fed. Water quality was checked after the first feeding and the system was monitored for pH and oxygen concentration.

Experimental diets and design: An experimental diet was formulated contain 30% crude protein, 5% ether extract and 3400 Kcal ME/Kg to meet the requirement of Nile tilapia according to NRC (1994). Four other diets were formulated to be isonitrogenous and isocaloric as the basal diet No. 1, in which the Fish Meal (FM) protein was substituted completely by poultry by product (PBM) protein (Basal diet No. 2), while diet No. 3, 4 and 5 sorghum grain replaced 100% of wheat grain (w/w) or 100% of corn grain or 50% of both wheat and corn for the three diets respectively. The fish experimental diets were fed to the fish without or with enzyme supplementation (EniBioCell product "produced by Ameco-Bios Co. USA" contain Amylase 5500000 U/kg, Protease, 200000 U/kg, B. Gluconase 30000 U/kg, Lipase 150000 U/kg, Xylanase 500000 U/kg and Cellulase 15000 U/kg and used at 0.5 Kg/ton feed) Ingredient and proximate composition of the experimental diets are presented in Table 1.

All dietary ingredients were finally ground, well mixed and pelleted in the farm pellet mill through 3.0 mm die. Three diet samples have been collected for proximate analysis. One was taken at the beginning, one in the middle and one at the end of the experimental as grab sample from the feed stocks. Feed samples were stored at -4^{o}C for later analysis.

Experimental procedure: The 10 ponds were randomly assigned to one of the five experimental diets (without and with enzyme supplementation) each diet in one pond. The fish were fed by hand four times a day at 7:00, 10.00, 13.00 and 15:00 h. Fish were fed to apparent visual satiation and utmost care was taken to assure that all feed supplied was consumed.

One thousand fish from each pond (which collected randomly) were weighed at the beginning (W0) and weekly for a continuous 5 weeks (35 days). Weight gain, was calculated as: Weight gain = (Final Body weight-Initial body weight).

Table 1: Composition and chemical analysis of the experimental diets

Ingredient %	Diet No. 1	Diet No. 2	Diet No. 3	Diet No. 4	Diet No.5
Physical composition					
Fish Meal	15.0	0.0	0.0	0.0	0.0
Soybean meal	32.15	32.65	32.65	30.4	31.55
Yellow corn	26.0	23.0	23.0	0.0	11.5
Wheat grain	22.0	22.0	0.0	22.0	11.0
Sorghum grain	0.0	0.0	22.0	25.0	23.5
PBM	0.0	20.5	20.5	20.5	20.5
DCP	1.5	0.5	0.5	0.5	0.5
Durapell[1]	0.3	0.3	0.3	0.3	0.3
Vegetable oil	2.5	0.5	0.5	0.5	0.6
Mineral Premix[2]	0.1	0.1	0.1	0.1	0.1
Vitamin premix[3]	0.1	0.1	0.1	0.1	0.1
Salt (NaCl)	0.25	0.25	0.25	0.25	0.25
Choline chloride.	0.05	0.05	0.05	0.05	0.05
DL-Methionine	0.05	0.05	0.05	0.05	0.05
Chemical composition					
Dry matter %	89.01	89.11	89.11	89.21	89.04
Crude protein%	29.99	29.96	29.97	30.07	30.06
Ether extract %	5.11	5.65	5.91	5.43	5.53
Crude fiber %	2.65	2.59	3.46	3.85	3.42
Ash%	7.32	6.99	6.99	7.06	7.03
NFE %[4]	43.94	43.56	42.78	42.80	43.00
Carbon %[5]	40.85	41.05	41.29	41.16	41.13
Calcium%	0.93	0.95	0.92	0.93	0.96
Phosphorus %	0.85	0.81	0.82	0.81	0.84
Lysine %[6]	1.67	1.87	1.79	1.77	1.75
Methionine[6]	0.52	0.59	0.53	0.51	0.51
ME (Kcal/Kg)[7]	3402.00	3434.00	3457.00	3435.00	3435.00
P/E ratio [8]	88.15	87.25	86.69	87.54	87.51

1-Durapell = pellet binder produced by Intewe Co., USA. 2-Mineral premix produced by Centraly's Co. (contain the following minerals/Kg, Cobalt, 100 mg, Copper, 10000 mg; Iron, 50000 mg; Iodine, 500 mg; manganese, 85000 mg; zinc, 65000 mg and selenium, 200 mg). 3-Vitamin premix produced by Centraly's Co (France) and contain the following vitamins per Kg premix (vitamin A, 10000000, IU; Vitamin D, 2000000 IU; Vitamin E, 20000 mg; Vitamin K, 2000 mg; vitamin 12, 10 mg; Biotin, 200 mg; Folacin, 1000 mg; Niacin, 30000 mg; pantothenic acid, 10000 mg; pyridoxine, 4000 mg; ribroflvin, 5000 mg; thiamin, 2000 mg and proper dose of antitoxidant). 4-NFE: (Nitrogen free extract) % = 100-(Moisture + Crude protein + Crude fiber + Ether extract + ash) 5- Carbon = Protein* 1.18*0.46 + Fat*1*0.76 + Carbohydrates*1.11*0.4, whereby 1.18, 1, 1.11 are the hydration factors of protein, fat and carbohydrates and 0.46, 0.76, 0.4 is the carbon content in the hydrolyzed molecule (Machiels *et al*., 1986). 6-Methionine and lysine content calculated according to NRC (1994). 7-Metabolizable energy: Protein (4.49 Kca/g), Ether extract (8.5 kcal/g), Carbohydrate (3.48 Kcal/g) as reported from Shiau and Hang (1990). 8-P/E ratio calculated as following (Protein to energy ratio in mg protein/Kcal ME)

Feed Conversion Ratio (FCR) was calculated by dividing total feed intake per pond by the total body weight gain per the same pond, Protein Efficiency Ratio (PER) and Efficiency of Energy Utilization (EEU) were calculated. Feces were collected using a mesh size of 1000 µm (Choubert *et al*., 1982). This method was preferred because of its potentially high recovery rate and the low level of nutrient leaching. The feces were transferred from the collectors into plastic containers twice a day (9:30 and 17:30 h) and stored at -4°C for later analysis.

Analytical procedure: An initial sample of ten fish was used to analyze initial body composition. At the end of the experiment, ten fish were randomly selected from each pond during the weighing procedure to analyze final body composition. These fish were immediately stored at -4°C for subsequent analysis. Collected feed, feces and fish samples were analyzed for Dry Matter (DM), moisture and ash contents according to AOAC (1985), crude protein using Kjeldahl method according to Randhir and Pradhan (1981) and ether extract was determined according to Bligh and Dyer (1959) technique as modified by Hanson and Olly (1963). Phosphorus was determined by using spectrophotometer according to (Cockerell and Holliday, 1975). Feed and fecal samples were analyzed for Acid Insoluble Ash (AIA) content by dissolving the obtained ash in hydrochloric acid following the ISO 5985 (1985) procedures. Carbohydrate fraction was determined as DM minus EE, CP and ash I feed and feces.

Digestibility measurements: Apparent Digestibility Coefficients (ADC) of nutrients were determined using an internal marker Acid Insoluble Ash (AIA) in the diets. ADCs for the different nutrients are expressed as the fractional absorption of these nutrients from diets in fish:

$$\text{ADC nutrient} = (AIA_{diet}/AIA_{feces} X nutrient_{feces}/nutrient_{diet}) \times 100$$

where:

AIA_{diet} = The AIA in the diet (%)
AIA_{feces} = The AIA in the faeces (%)
$Nutrient_{feces}$ = The nutrient in the feces (%)
$Nutrient_{diet}$ = Nutrient in the diet (%)

Feces recovery measurements: The recovery % of feces is the percentage of the total amount of feces excreted on a dry matter basis. The amount of excreted feces was calculated from the measured digestibility. To estimated the recovery %, feces in relation the amount of feces produced was to calculated according to Amirkolaie *et al*. (2005) by dividing AIA recovered from the collector by AIA given with the feed:

$$\text{Feces recovery} = (AIA_{recovered}/AIA_{feed}) \times 100$$

where:

$AIA_{recovered}$ = The AIA recovered from the collector (g/Kg)
AIA_{feed} = The AIA given with the feed (g/Kg)

From the measured ADC and recovery%, the amount of feces produced, the amount of feces recovered from the water and the non recovered feces (all expressed in g dry matter per Kg of feed) were calculated.

Nutrient balances: Nutrient balances are derived from the amount of a nutrient in the feed and fish, nutrient digestibility, feed uptake and fish performance:

$$Uptake_{nutrient} = \text{concentration } feed_{nutrient} \times feed_{consumed}$$

where:

$Uptake_{nutrient}$ = The amount of nutrient taken up by the fish (g)
Concentration $feed_{nutrient}$ = The concentration of nutrient in the feed (g/Kg)
$Feed_{consumed}$ = The amount of the feed consumed (g)

The fraction of digested and undigested nutrients is calculated by:

$$Digested_{nutrient} = uptake_{nutrient} \times digestibility_{nutrient}/100$$

$$Undigested_{nutrient} = Uptake_{nutrient} \ (100\text{-}indigestible_{nutrient})/100$$

where:

$Digested_{nutrient}$ = The amount of nutrient digested (g)
$Undigested_{nutrient}$ = The determined digestibility (%)

Digested nutrients are divided into retained nutrients and non fecal loss.

$$Nutrient_{retaind} = W_{final} \times Nutrient_{fish} - W_{initial} X Nutrient_{fish}$$

$$\text{Nutrient non fecal loss} = \text{Digested } nutrient_{retained} - Nutrient_{retained}$$

where:

$Nutrient_{retained}$ = The amount of nutrient retained in the fish (g)
W_{final} = The final wet weight of the fish (g)
$W_{initial}$ = The initial wet weight of the fish (g) and nutrient fish is the amount of the nutrient in the fish in g/Kg wet weight

The obtained values were converted to g/Kg nutrient supplied with the feed.

Statistical analysis: The analysis of variance for the obtained data was performed using Statistical Analysis System (SAS, 1996) to assess significant differences.

RESULTS

Body weight development and growth performance: Effect of FM protein replacement by PBM with different grain source and enzyme supplementation on fish Body Weight (BW) development is presented in Table, 2. Statistical analysis of the data revealed that there was no difference between different groups at the start of the experiment, while there were differences between the different treatments began in the second week and more appeared at the end of the experiment. It was noticed that Nile tilapia fish fed on the PBM as a substitution of 150 g/Kg FM (No. 2) non significantly ($p \leq 0.05$) reduced the average final BW by about 1.3% when compared with the control one (fed on the basal diet "No.1" containing fish meal) with the same grain source (Yellow corn + Wheat).

Analysis of variance of the data revealed that sorghum addition in Nile tilapia diet non significantly ($p>0.05$) improved final BW by about 0.3% when replaced 100% of wheat grain (group, 3) while significantly ($p \leq 0.05$) reduced by about 9.1 and 8% when replaced 100% of corn and 50% of wheat plus 50% of corn grain amount of the basal diet No. 2.

The data indicated that fish groups fed on the basal diets supplemented with 0.5 Kg enzyme/Ton non significantly ($p>0.05$) improved BW by about 2% and 4.4% when compared with the fish groups fed on the same diet without enzyme supplementation (groups 1 and 3 respectively), while enzyme supplementation showed significant ($p \leq 0.05$) increase in fish BW by about 14.5, 8.5 and 4.8% when compared with the fish groups fed on the same diet without enzyme (group 2, 4 and 5) respectively.

At the end of the experiment, the highest average BW was recorded in fish group which fed on the basal diet 2 (FM was substituted by PBM) with enzyme supplementation (137.60 g) followed by fish group which

Table 2: Effect of fish meal replacement by poultry by product with different grain sources and enzyme supplementation on body weight development (g/fish) of Nile tilapia fish

Group No.	Body weight (g/fish) Without enzyme supplementation	With enzyme supplementation
W0		
1	79.77 ± 2.55^{ax}	80.64 ± 2.23^{ax}
2	79.47 ± 1.78^{ax}	78.06 ± 1.98^{ax}
3	78.31 ± 1.69^{ax}	80.31 ± 1.51^{ax}
4	79.99 ± 2.40^{ax}	78.17 ± 2.13^{ax}
5	79.33 ± 1.64^{ax}	79.98 ± 1.81^{ax}
W1		
1	85.18 ± 2.59^{ax}	85.42 ± 2.22^{ax}
2	84.92 ± 1.83^{ax}	83.36 ± 1.93^{ax}
3	83.87 ± 1.68^{ax}	87.38 ± 1.69^{ax}
4	84.87 ± 1.96^{ax}	82.78 ± 1.98^{ax}
5	82.04 ± 2.24^{ax}	85.34 ± 1.68^{ax}
W2		
1	90.01 ± 2.17^{ax}	92.98 ± 1.79^{ax}
2	90.43 ± 1.65^{ay}	98.23 ± 2.44^{ax}
3	90.97 ± 2.86^{ax}	95.01 ± 2.52^{ax}
4	85.23 ± 1.77^{ax}	86.11 ± 1.78^{bx}
5	85.76 ± 2.74^{ax}	91.43 ± 1.79^{abx}
W3		
1	99.01 ± 2.07^{ax}	102.33 ± 1.43^{ax}
2	99.85 ± 1.9^{acy}	116.38 ± 1.09^{bx}
3	103.05 ± 4.00^{acx}	107.11 ± 3.62^{ax}
4	90.01 ± 1.51^{by}	92.60 ± 0.90^{cx}
5	93.17 ± 3.50^{ay}	101.20 ± 2.08^{ax}
W4		
1	115.86 ± 1.13^{ax}	116.02 ± 1.86^{ax}
2	113.61 ± 0.64^{ax}	129.45 ± 1.87^{bx}
3	117.75 ± 2.40^{ax}	121.51 ± 1.46^{cx}
4	104.34 ± 0.73^{bx}	108.78 ± 2.98^{dex}
5	98.13 ± 2.11^{cy}	112.53 ± 1.18^{aex}
W5		
1	121.75 ± 1.63^{ax}	124.21 ± 1.00^{ax}
2	120.19 ± 1.69^{ay}	137.60 ± 1.50^{bx}
3	120.55 ± 1.15^{ax}	125.84 ± 2.03^{ax}
4	109.22 ± 0.73^{by}	118.55 ± 4.84^{cx}
5	110.52 ± 0.82^{by}	115.86 ± 0.68^{cx}

Values are means±standard error. Mean values with different letters at the same column (a-d letters) or row (x-y letters) and period differ significantly at ($p\le0.05$)

fed on PBM and corn plus sorghum with enzyme supplementation (125.84 g), while the lowest BW were recorded in fish groups which fed PBM when sorghum substituted 100% of corn or 50% of both corn and wheat.

Table 3, show the effect of different dietary treatment on Daily Body Gain (DBG), Daily Feed Intake (DFI), Feed Conversion Ratio (FCR), Protein Efficiency Ration (PER) and Efficiency of Energy Utilization (EEU) in Nile tilapia. Data analysis of variance revealed that inclusion of PBM instead of FM with wheat or sorghum grain plus corn (group 2 and 3) in Nile tilapia diet had no significant effect on DBG, DFI, FCR, PER and EEU when compared with the control. While substitution of corn by sorghum (group 4) or 50% of both corn and wheat by sorghum (group 5) had no effect on DFI, but significantly ($p\le0.05$) reduced DBG, FCR, PER and EEU when compared with fish group fed on PBM with corn and wheat (group 2).

Table 3: Effect of fish meal replacement by poultry by product with different grain sources and enzyme supplementation on growth perform-ance of Nile tilapia fish

Group No.	Without enzyme supplementation	With enzyme supplementation
Daily body gain		
1	1.20 ± 0.03^{ax}	1.25 ± 0.04^{ax}
2	1.16 ± 0.02^{ay}	1.70 ± 0.02^{bx}
3	1.21 ± 0.02^{ax}	1.30 ± 0.03^{adx}
4	0.83 ± 0.05^{by}	1.16 ± 0.09^{aex}
5	0.89 ± 0.03^{by}	1.03 ± 0.03^{cy}
Daily feed intake		
1	2.27 ± 0.0^{ax}	2.27 ± 0.0^{ax}
2	2.27 ± 0.0^{ay}	2.73 ± 0.0^{bx}
3	2.27 ± 0.0^{ay}	2.55 ± 0.0^{cx}
4	2.27 ± 0.0^{ax}	2.27 ± 0.0^{ax}
5	2.27 ± 0.0^{ax}	2.27 ± 0.0^{ax}
Feed Conversion Ratio (FCR)		
1	1.91 ± 0.04^{ax}	1.85 ± 0.05^{ax}
2	1.96 ± 0.03^{ay}	1.61 ± 0.02^{ax}
3	1.90 ± 0.04^{ax}	1.97 ± 0.18^{ax}
4	2.96 ± 0.18^{by}	2.23 ± 0.78^{bx}
5	2.59 ± 0.09^{cy}	2.26 ± 0.36^{bx}
Protein Efficiency Ratio (PER)*		
1	1.77 ± 0.04^{ax}	1.84 ± 0.05^{ax}
2	1.71 ± 0.02^{ay}	2.08 ± 0.03^{bx}
3	1.78 ± 0.03^{ax}	1.71 ± 0.03^{ax}
4	1.21 ± 0.08^{by}	1.70 ± 0.13^{ax}
5	1.31 ± 0.04^{by}	1.51 ± 0.05^{cx}
Efficiency of Energy Utilization (EEU)**		
1	6.41 ± 0.15^{ax}	6.21 ± 0.17^{ax}
2	6.65 ± 0.09^{ay}	5.46 ± 0.07^{cx}
3	6.37 ± 0.15^{ax}	6.73 ± 0.14^{acx}
4	10.04 ± 0.60^{by}	7.55 ± 0.59^{bcx}
5	8.75 ± 0.29^{cy}	7.67 ± 0.27^{bx}

Values are means ± standard error. Mean values with different letters at the same column (a-d letters) or row (x-y letters) and period differ significantly at ($p\le0.05$) *PER = weight gain (g)/protein intake (g). **EEU = Energy consumed (Kcal)/Body weight gain (g)

DFI was significantly increased when FM replaced by PBM with enzyme supplementation, however, enzyme supplementation had no effect on DFI wit other treatment. Enzyme supplementation non significantly ($p\le0.05$) improved DBG, FCR, PER and EEU in fish groups fed on the basal diet with FM or PBM with complete replacement of wheat grain by sorghum when compared with fish groups fed on the same diet without enzyme supplementation (group 1 and 3), while significantly ($p\le0.05$) improved the mentioned growth performance parameters when FM replaced by PBM with out sorghum or when whole corn substituted by sorghum or 50% of both corn and wheat substituted by sorghum when compared with the fish group fed on the same diet without enzyme (groups 2, 4 and 5) respectively.

Table 4: Effect of fish meal replacement by poultry by product with different grain sources and enzyme supplementation on apparent nutrient digestibility of Nile tilapia fish

Group No.	Without enzyme supplementation	With enzyme supplementation
Dry matter digestibility %		
1	75.47±3.83^{ax}	76.17±2.84^{ax}
2	81.37±1.02^{ax}	87.96±0.99^{by}
3	80.60±0.93^{ax}	86.23±0.58^{bx}
4	81.07±2.36^{ax}	87.77±1.24^{by}
5	80.33±2.57^{ax}	83.23±1.76^{bx}
Organic matter digestibility %		
1	78.50±3.93^{bx}	78.10±3.03^{ax}
2	83.03±1.24^{abx}	89.37±0.58^{by}
3	84.87±0.52^{ax}	87.70±0.40^{bx}
4	83.03±1.83^{abx}	89.23±0.79^{by}
5	82.83±2.09^{abx}	85.17±1.48^{bx}
Crude protein digestibility %		
1	80.90±2.43^{ax}	82.23±2.43^{ax}
2	84.00±1.12^{abx}	90.20±0.61^{by}
3	86.13±0.49^{bx}	88.80±0.73^{bx}
4	83.23±1.73^{abx}	88.90±1.23^{by}
5	85.60±2.98^{abx}	86.57±0.84^{abx}
Ether extract digestibility %		
1	84.67±2.19^{ax}	85.60±1.70^{ax}
2	90.70±0.46^{bcx}	93.33±0.75^{bx}
3	89.97±0.38^{bcx}	92.90±0.93^{bx}
4	87.77±1.34^{acx}	92.00±1.34^{bx}
5	89.23±2.96^{bcx}	90.50±0.87^{bx}
Carbohydrate digestibility %		
1	68.27±7.17^{ax}	71.50±2.34^{ax}
2	79.60±1.35^{bx}	85.67±2.78^{bx}
3	78.23±4.02^{bx}	82.80±1.32^{bx}
4	79.97±1.89^{bx}	86.80±1.56^{bx}
5	80.63±0.09^{bx}	83.03±1.65^{bx}
Phosphorus digestibility%		
1	60.27±6.17^{ax}	55.83±2.63^{ax}
2	66.33±2.59^{ax}	78.10±2.37^{bx}
3	68.33±5.57^{ax}	72.70±2.92^{bx}
4	63.50±4.08^{ax}	76.03±4.08^{bx}
5	61.67±9.00^{ax}	71.53±0.92^{bx}

Values are means±standard error. Mean values with different letters at the same column (a-d letters) or row (x-y letters) and period differ significantly at ($p \leq 0.05$)

Nutrient digestibility: Apparent Digestibility Coefficient (ADC) of dry matter (DM) (Table 4) non significantly ($p>0.05$) improved when FM protein replacement by PBM protein with different gain sources (groups 2-5) by about 7.8, 6.8, 7.4 and 6.4% respectively when compared with fish group fed on FM protein. In regard to Organic Matter (OM) and Crude Protein (CP) digestibility the data indicated that FM protein replacement by PBM without sorghum or when sorghum substituted 100% of corn quantity and 50% of both corn and wheat (groups 2, 4 and 5) non significantly improved ADC of DM, OM and CP when compared with control, while sorghum substitution of wheat (group 3) significantly ($p \leq 0.05$) improved digestibility of the mentioned nutrients. On the other hand enzyme supplementation non significantly improved DM, OM and CP digestibility in Nile tilapia fish fed on the basal diet No. 1 or when FM replaced by PBM with sorghum substitution of whole wheat and 50% of both corn and wheat when compared with fish group fed on the same diet without enzyme, while diets contain PBM without sorghum or with sorghum as substitute of whole corn significantly improved the ADC of DM, OM and CP (groups 2 and 4).

Statistical analysis of the obtained data indicated FM protein replacement by PBM protein with or without sorghum grain (groups 2-5) non significantly improved ADC of ether extract, carbohydrate and phosphorus when compared with the control.

Moreover, enzyme supplementation non significantly ($p>0.05$) improved ether extract, carbohydrate and phosphorus digestibility when compared with fish group fed on the same diet without enzyme supplementation. Generally enzyme supplementation more effective on different nutrient digestibility's with inclusion of PBM with different grain sources in Nile tilapia diet than basal diet containing fish meal protein.

Carcass traits and chemical composition: At the end of the experimental period the dressing percent, head weight percent, visceral fat percent and hepatosomatic index (Table 5) were not significantly ($p>0.05$) affected when FM replaced by PBM with different grain sources. Moreover, enzyme supplementation had no significant effect on the carcass traits parameters when compared with fish group fed on the same diet without enzyme supplementation.

Carcass chemical composition data (Table 6) indicated that there is no significant effect of different experimental diets on fish body dry matter, organic matter, crude protein and carbohydrate and phosphorus contents. However, non significantly reduction of body ether extracts percent of fish was observed when fish fed on diet containing PBM as a complete replacement of FM protein (group 2) or PBM with replacement of wheat or corn by sorghum grain (groups 3 and 4) respectively when compared with control, while replacement of 50% of both corn and wheat by sorghum non significantly increased by ether extracts content. Analysis of variance of the obtained data indicated that FM protein replacement by PBM protein with wheat or sorghum grains (group 2 and 3) non significantly increased ash in the fish body by about 19 and 3.8% respectively when compared with control, while sorghum substitution of corn or 50% of corn and sorghum (group 4 and 5) non significantly reduced ash content by about 10.8% and 15.7% when compared with control. Enzyme supplementation had no significant effect on chemical body composition of the fish when compared with the fish group fed on the same experimental diet without enzyme supplementation.

Table 5: Effect of fish meal replacement by poultry by product with different grain sources and enzyme supplementation on some carcass traits of Nile tilapia fish

Group No.	Without enzyme supplementation	With enzyme supplementation
Dressing % (Without head)		
1	65.05±1.15^{ax}	64.91±1.78^{ax}
2	62.33±2.47^{ax}	67.75±1.11^{ax}
3	63.11±3.72^{ax}	64.52±1.48^{ax}
4	63.11±0.74^{ax}	64.93±2.40^{ax}
5	64.39±2.60^{ax}	64.82±1.16^{ax}
Head weight %		
1	24.72±1.56^{ax}	22.09±1.58^{ax}
2	25.60±1.25^{ax}	22.55±1.29^{ax}
3	25.30±3.00^{ax}	22.24±2.74^{ax}
4	26.19±1.21^{ax}	24.71±2.72^{ax}
5	23.53±2.69^{ax}	24.25±1.40^{ax}
Visceral fat %		
1	2.12±0.10^{ax}	2.05±0.12^{ax}
2	2.00±0.15^{ax}	2.20±0.17^{ax}
3	2.03±0.11^{ax}	2.13±0.09^{ax}
4	1.90±0.14^{ax}	2.13±0.17^{ax}
5	1.89±0.06^{ax}	1.93±0.06^{ax}
Hepatosomatic Index (HSI)		
1	1.33±0.07^{ax}	1.31±0.05ax
2	1.35±0.10^{ax}	1.48±0.06^{abx}
3	1.25±0.06^{ax}	1.30±0.18^{ax}
4	1.25±0.06^{ax}	1.20±0.08^{acx}
5	1.23±0.13^{ax}	1.28±0.10^{ax}

Values are means±standard error. Mean values with different letters at the same column (a-d letters) or row (x-y letters) and period differ significantly at ($p \leq 0.05$)

Fecal matter recovery: The percent of feces recovered per Kg of feed (Table, 7) was significantly ($p \leq 0.05$) improved when PBM protein included in the Nile tilapia diet as a replacement of FM protein with or without replacement of wheat grain by sorghum (group 2 and 3 respectively) when compared with the control. While PBM diet without corn grain or with 50% of corn only (group 4 and 5) non significantly affect the amount of feces recovery.

Moreover, enzyme supplementation non significantly improved fecal matter recovery by about 8.8, 21.7, 8.3, 39.2 and 47.3% when compared with the fish group fed on the same diet without enzyme. However, the amount of total feces produced per Kg feed were non significantly ($p \leq 0.05$) reduced in fish fed on PBM with or without sorghum (groups 2–5) by about 23.9, 19.5, 22.7 and 19.7%, respectively when compared with control. Moreover, enzyme supplementation non significantly reduced fecal matter production by fish fed on FM protein or fed on PBM with 50% of corn and wheat quantity replacement by sorghum when compared with fish group fed on the same diet without enzyme supplementation. However, enzyme supplementation significantly reduced fecal matter quantity when PBM substituted FM protein without sorghum or with wheat and corn replaced by sorghum when compared with fish groups fed on the same diet without enzyme supplementation (groups 2-4).

Both experimental diets and enzyme supplementation had no significant effect on recovered fecal matter quantity (g DM/Kg feed). On the other hand the analysis of variance of the obtained data indicated that replacement of FM protein by PBM without sorghum (group 2) or with sorghum as substitute to whole wheat grain quantity in the diet (group 3) significantly ($p \leq 0.05$) reduced unrecovered fecal matter quantity (g DM/Kg feed) by about 28.7 and 27.7% when compared with control, while unrecovered fecal matter quantity non significantly reduced when sorghum substitute whole quantity or 50% of corn (groups 4 and 5) by about 23.9% and 20.1%, respectively when compared with control. Enzyme supplementation had no significant effect on quantity of unrecovered fecal matter when fish fed on diet containing FM protein while, significantly reduced with FM protein replacement by PBM with different grain sources.

Nutrient balance: The highest C retention and lowest non fecal C loss (Table 8) were found of fish fed on FM protein diet (group 1) while replacement of FM by PBM with different grain sources non significantly reduced C retention, significantly decreased C fecal loss, while significantly increased C non fecal loss. FM protein replacement by PBM had no significant effect of Nitrogen (N) retention in the fish body, however using PBM without corn or 50% of corn quantity of the basal diet No. 1, only (groups 4 and 5) significantly ($p \leq 0.05$) reduced nutrient retention and increase non fecal losses of C, N, CHO and P when compared with the control.

DISCUSSION

PBM seems to be a good source of dietary protein for Nile tilapia fish and those data are in agreement with the results obtained by Yang *et al*. (2004) They reported that PBM could replace 150 or 500 g/Kg of fish meal protein in diets for gibel Carp without negative effects on growth. Also, Yigit *et al*. (2006) and Muzinic *et al*. (2006) they indicated that there were no significant differences in final mean weight of hybrid striped bass when fed diets with decreasing levels pf fish meal (300, 200, 100 and 0.0 gKgG^{1}) and increasing levels of turkey meal (0.0, 97, 175 and 264 gKgG^{1}). These results are in agreement with Saoud *et al*. (2008) they concluded that growth of crayfish were not significantly different when FM in the basal diets was replaced with PBM at various levels so that the diet contained 150, 120, 90, 60, 30 and 0.0 g FM KgG^{1} and 78, 105, 132, 185 and 212 g PBM KgG^{1} diet respectively.

Moreover, FM replacement by PBM had no significant effect on feed intake, FCR, PER and EEU. These data are in agreement with that obtained by Steffens (1994)

Table 6: Effect of fish meal replacement by poultry by product with different grain sources and enzyme supplementation on chemical body composition of Nile tilapia fish

	Initial body composition	Final Body composition: Without enzyme	With enzyme
Moisture %			
1	72.68	71.17±1.07^{ax}	68.90±2.21^{ax}
2		70.43±1.41^{ax}	71.81±2.91^{ax}
3		71.13±0.97^{ax}	72.77±1.63^{ax}
4		71.73±1.83^{ax}	7.70±1.02^{ax}
5		72.20±1.53^{ax}	71.50±2.80^{ax}
Dry matter %			
1	27.32	28.83±1.07^{ax}	31.17±2.23^{ax}
2		29.57±1.41^{ax}	28.20±2.92^{ax}
3		28.87±0.97^{ax}	27.23±1.63^{ax}
4		28.27±1.83^{ax}	29.60±1.02^{ax}
5		27.83±1.53^{ax}	28.53±2.77^{ax}
Organic matter %			
1	20.78	23.53±0.34^{ax}	25.73±1.58^{ax}
2		23.20±1.35^{ax}	23.10±1.49^{bx}
3		23.30±0.60^{ax}	23.40±0.79^{abx}
4		23.57±1.18^{ax}	23.97±0.95^{abx}
5		23.37±1.20^{ax}	25.27±1.23^{abx}
Crude protein%			
1	15.14	17.30±0.75^{ax}	18.10±1.58^{ax}
2		17.27±0.90^{ax}	17.27±1.07^{ax}
3		17.07±0.52^{ax}	16.97±0.55^{ax}
4		17.21±1.42^{ax}	17.77±0.47^{ax}
5		16.50±1.22^{ax}	17.67±0.77^{ax}
Ether extract%			
1	5.43	6.03±0.72^{ax}	7.60±0.24^{ay}
2		5.90±0.32^{ax}	5.70±0.45^{bx}
3		6.10±0.20^{ax}	6.33±0.35^{cdx}
4		6.16±0.55^{ax}	6.03±0.48^{cx}
5		6.67±0.24^{ax}	7.40±0.52^{adx}
Carbohydrate%			
1	0.21	0.21±0.02^{ax}	0.21±0.01^{ax}
2		0.20±0.01^{ax}	0.17±0.02^{ax}
3		0.16±0.01^{ax}	0.18±0.01^{ax}
4		0.19±0.01^{ax}	0.16±0.02^{ax}
5		0.15±0.01^{ax}	0.19±0.02^{ax}
Ash %			
1	6.54	5.30±0.91^{ax}	5.37±0.73^{ax}
2		6.33±0.49^{ax}	5.10±1.48^{ax}
3		5.53±0.87^{ax}	3.83±0.87^{ax}
4		4.73±0.62^{ax}	5.63±0.12^{ax}
5		4.47±0.34^{ax}	4.57±0.44^{ax}
Phosphorus %			
1	1.04	0.96±0.14^{ax}	0.93±0.19^{ax}
2		1.11±0.09^{ax}	0.89±0.17^{ax}
3		0.93±0.07^{ax}	0.81±0.11^{ax}
4		0.88±0.06^{ax}	1.04±0.08^{ax}
5		0.91±0.04^{ax}	0.98±0.09^{ax}

Values are means±standard error. Mean values with different letters at the same column (a-d letters) or row (x-y letters) and period differ significantly at ($p \leq 0.05$)

and Bras (2002). The highest feed intake was recorded in fish group fed on PBM diet (No. 2 and 3) supplemented with enzyme and that may be related to the higher body weight gain of that groups when compared with fish fed on the same diet without enzyme. Dietary inclusion of sorghum grain instead of corn or 50% of both corn and wheat quantity in the diet (Groups 4 and 5) significantly deteriorated FCR, PER and EEU when compared with other fish groups. The data indicated that sorghum grain can be effectively substitute wheat grain without any detrimental effect on Nile tilapia growth, while corn grain is more suitable than sorghum for fish. These data are disagreement with Castro *et al*. (1998) verified no significant differences for protein efficiency rate, when diets containing 20 and 40% sorghum for Nile tilapia were used in comparison with

Table 7: Effect of fish meal replacement by poultry by product with different grain sources and enzyme supplementation on fecal matter production and fecal recovery of Nile tilapia fish

Group No.	Without enzyme supplementation	With enzyme supplementation
Fecal matter recovery %		
1	11.67±3.08^{bx}	12.70±0.31^{bx}
2	16.60±2.94^{ax}	20.20±0.64^{ax}
3	18.83±0.27^{ax}	20.40±2.19^{ax}
4	12.84±2.71^{bx}	17.87±6.47^{ax}
5	11.90±1.23^{bx}	17.53±2.02^{ax}
Fecal matter quantity produced (g DM/Kg feed)		
1	245.27±38.53^{ax}	245.07±26.29^{ax}
2	186.73±10.15^{ax}	120.27±10.09^{by}
3	197.40±5.99^{ax}	137.77±5.61^{by}
4	189.57±23.51^{ax}	122.60±12.36^{by}
5	196.87±25.71^{ax}	167.47±17.67^{bx}
Recovered fecal matter quantity (g DM/Kg feed)		
1	27.43±6.63^{ax}	30.77±3.04^{ax}
2	31.37±6.56^{ax}	24.43±2.74^{ax}
3	36.47±1.53^{abx}	28.43±2.15^{ax}
4	24.00±4.92^{acx}	20.33±5.29^{ax}
5	22.77±1.30^{acx}	28.77±1.95^{ax}
Unrecovered fecal matter quantity (g DM/Kg feed)		
1	217.83±37.48^{ax}	214.00±23.33^{ax}
2	155.37±7.27^{bcx}	95.83±7.40^{by}
3	157.57±7.72^{bcx}	109.33±6.21^{bx}
4	165.57±22.06^{acx}	102.27±17.57^{by}
5	174.10±25.03^{acx}	138.70±17.11^{bx}

Values are means±standard error. Mean values with different letters at the same column (a-d letters) or row (x-y letters) and period differ significantly at ($p \leq 0.05$)

Table 8: Effect of fish meal replacement by poultry by product with different grain sources and enzyme supplementation on nutrient balance of Nile tilapia fish (based on g per Kg nutrient supplied)

	With out enzyme supplementation			With enzyme supplementation		
	Fish g/Kg nutrient	Fecal loss g/Kg nutrient	Non fecal loss g/Kg nutrient	Fish g/Kg nutrient	Fecal loss g/Kg nutrient	Non fecal loss g/Kg nutrient
Carbon balance						
1	365.4±11.3^{ax}	269.6±56.4^{ax}	365.0±45.2^{ax}	463.8±38.1^{ay}	223.9±25.4^{ax}	312.2±14.1^{ax}
2	357.1±36.2^{ax}	177.4±11.7^{bx}	465.5±37.2^{bx}	427.1±58.1^{acx}	147.1±2.9^{bx}	425.7±55.6^{bx}
3	349.6±14.9^{ax}	175.5±22.6^{bx}	473.3±31.9^{bx}	386.1±4.5^{acx}	138.9±7.6^{bx}	474.9±6.5^{bdx}
4	234.5±2.7^{ax}	182.5±17.2^{bx}	583.1±38.4^{cx}	351.2±26.6^{bcy}	121.2±13.9^{bx}	527.6±37^{cdx}
5	255.0±25.1^{ax}	166.7±14.6^{bx}	578.2±34.1^{cx}	353.2±32.4^{bcy}	151.2±13.6^{bx}	495.6±24.2^{bdx}
Nitrogen balance						
1	557.7±47.2^{ax}	192.3±23.9^{ax}	250.0±64.6^{ax}	642.3±102^{ax}	177.6±24.22^{ax}	246.7±44.8^{ax}
2	535.1±54.3^{acx}	161.0±11.2^{acx}	303.9±53.8^{acx}	728.8±68.9^{acy}	94.6±7.3^{bcx}	176.6±62.8^{ax}
3	571.1±31.3^{ax}	138.7±4.9^{bcx}	290.2±29.9^{ax}	538.3±32.9^{adx}	112.4±7.5^{bcx}	349.3±25.7^{acx}
4	362.0±72.2^{bcx}	167.9±16.7^{acx}	469.9±83.2^{bcx}	528.1±28.8^{adx}	111.1±12.6^{bcx}	360.8±32.9^{acx}
5	335.7±63.3^{bx}	144.4±29.8^{bcx}	519.9±85.9^{bx}	401.2±101^{bdx}	135.6±9.3^{acx}	463.2±96.9^{bcx}
Phosphorus1 balance						
1	764.1±299^{ax}	398.0±60.5^{ax}	-162.1±31^{ax}	736.8±458^{ax}	466.7±46.6^{ax}	-203.2±43^{ax}
2	982.8±187^{ax}	365.2±39.9^{ax}	-348.3±15^{abx}	939.7±381^{ax}	205.4±16.9^{by}	-145±38.8^{ax}
3	654.7±119^{ax}	355.3±20.1^{ax}	-10.0±11.5^{ax}	417.4±203^{ax}	267.4±29.2^{bx}	315.2±18.3^{ax}
4	198.1±114^{ax}	363.2±38.8^{ax}	438.7±12.5^{acx}	868.1±157^{ax}	238.9±39.5^{bx}	-106.9±15.3^{ax}
5	297.9±73^{ax}	414.9±99.6^{ax}	320.5±16.5^{ax}	571.7±187^{ax}	289.7±8.3^{bx}	138.5±19.0^{ax}
Ether extract balance						
1	1537.4±32^{ax}	152.8±21.5^{ax}	-690.2±-32^{ax}	2358.9±12^{ay}	143.7±16.8^{ax}	-1502±-11^{ax}
2	1267.9±12^{ax}	93.7±4.9^{bcx}	-361.7±-11^{acx}	1133.2±19^{bx}	69.6±10.4^{bx}	-202±-17^{bx}
3	1129.9±70^{ax}	123.3±27^{acx}	-229±-74^{acx}	1388.3±12^{bx}	70.8±9.4^{by}	-460±-12^{bx}
4	837.8±19^{ax}	123.1±13^{acx}	39.1±19.3^{bcx}	1346±20^{by}	79.1±13.2^{bx}	-425±-21^{bx}
5	1190.3±82^{ax}	126.2±32.6^{acx}	-316.5±-74^{ax}	942.7±40^{by}	81.6±14.3^{bx}	-478±-11^{bx}

Values are means±standard error. Means value with different letters at the same column (a-d letters) or row (x-y letters) and period differ significantly at ($p \leq 0.05$). C = Protein*1.18*0.46 + Fat*1*0.76 + Carbohydrates*1.11*0.4, whereby 1.18, 1, 1.11 are the hydration factors of protein, fat and carbohydrates and 0.46, 0.76, 0.4 is the carbon content in the hydrolyzed molecule (Machiels and Henken, 1986) commercial diet, also Aiura and Carvalho (2006) stated that weight gain FCR and PER were not influenced in Nile tilapia fed on rations prepared by using corn and sorghum varieties.

Fish performance improvement when fed on the basal diet No. 1 (FM containing diet) with multi-enzyme supplementation was lower when compared with the fish performance fed on the basal diets containing PBM substituted FM with multi-enzyme supplementation and that difference may have been due to the interaction between the enzyme and higher oil content of the basal diet No. 1 which probably inhibited the enzyme from functioning effectively. The small amount of the enzyme may have been bounded with oil, which had probably limited or restrained the enzyme action in diet 1.

Regarding Apparent Digestibility Coefficients (ADC) of different nutrient (Table 4). The present study represents one of the few studies of digestibility data for PBM with different grain sources in Nile tilapia. Our results found much higher ADCs for PBM. Jobling (1994) stated that nutrient digestibility is affected by fish size. Hence, differences between the present study and that of Bras (2002) may be because of the fact that small Nile tilapia (0.35 g) was fed in the previous study, whereas 80 g size fish were fed in the present study. Moreover, the differences may be the species differences as most of the previous studies using fish other than Nile tilapia (Rawles *et al*., 2006; Yang *et al*., 2006). A more probable explanation to the differences in ADC values from the present study and other previous studies may be because of different sources of PBM used. By-product meals can differ greatly among sources based upon the percentage and composition of the materials used to make the meal.

The differences noted in the digestibility of nutrients in PBM among different Omnivorous fish could explain the variation in performance reported among pervious FM replacement studies and underscore the value of determining nutrient 7vailabilities and formulation diets on an available, rather than gross, nutrient basis.

Using of corn, wheat or sorghum grain as carbohydrate source in Nile tilapia diet had no significant effect on ADC of different nutrients, while exogenous multi-enzyme supplementation significantly improved ADCs when FM protein replaced by PBM with different sources of grains when compared with fish groups fed on the same diet without enzyme, but enzyme supplementation had no significant effect on ADCs with FM diet containing high vegetable oil addition. These finding are in agreement with the data obtained by Lin *et al*. (2007).

In regards to body composition and carcass traits of Nile tilapia fish fed diets containing PBM as a replacement of FM protein with different grain sources not significantly differed in the present study. These findings are in agreement with the values reported by Emre *et al*. (2003). The final body dry matter, crude protein and ether extract contents are higher (Flowler, 1991; Gouveia, 1992; Hasan *et al*., 1993) and ash content is lower (Hasan and Amin 1997; Neugas *et al*., 1999) than initial levels.

Diets containing sorghum instead of wheat, corn or 50% of both had no significant effect on DM or crude protein of fish body when compared with the fish body composition fed on PBM without sorghum, moreover sorghum non significantly increased body fat and non significantly reduced body ash content. These results are in agreement with the data obtained by Aiura and Carvalho (2006). Enzyme supplementation in fish diet had no significant effect on Nile tilapia body composition and agreed with the finding by Lin *et al*. (2007) they reported that exogenous enzyme supplementation in tilapia diets had no significant effect on whole body moisture, protein, lipid and ash contents.

Dietary treatment had no significant ($p>0.05$) effect on Nile tilapia dressing percentage. These results are in agreement with Emre *et al*. (2003) they indicated that FM replacement by PBM at different levels in Mirror carp fingerling diets didn't exhibit any significant variation of dressing out percentage and the whole body composition. The non significant lower visceral fat percentage and HSI with inclusion of sorghum grain in the diets may be attributed to the tannin content of sorghum grains and due to low amount of digestible energy of the diet. These results are in agreement with those obtained by Pinto *et al*. (2001) observed decrease in the amount of visceral fat and fat deposition in liver with increase of the condensed tannin level in the "Piaucu" diets and Aiura and Carvalho (2006) who concluded that Nile tilapia feeding on diets containing sorghum provided lower levels of visceral fats and fat levels in the liver.

Feces recovery was significantly affected by diets (Table 7). The observed recovery rates are considered with the lower side compared to rates of 12-99% found elsewhere (Choubert *et al*., 1982; El-Shafai, 2004). Although, the variation among the treatments was statistically significant, a number of observations has been made for instance, PBM addition to the diets resulted in a higher recovery percent. The amount of non recovered fecal matter reflects differences in dry matter digestibility and followed by other PBM included diets (groups 3-5), while FM replacement by PBM (group, 2) resulted in the least amount. These findings are supported by other studies (Han *et al*., 1996a,b; Dias *et al*., 1998).

The non fecal loss for C is higher (465-578 g/Kg C) for all diets containing PBM compared to FM (365 g/Kg C) and C retention is low for PBM with different grain sources groups (No. 2-5) and the retention ranged from 255-357 g/Kg C) when compared with control (365 g/Kg C). This illustrates that fish has less C expenditure to grow on a fish meal containing diet than on the other diets. This supports the paradigm that a protein sources with a similar composition as the fish carcass composition are retained better than a protein sources with a different amino acid profile (Tacon, 1990; Allan *et al*., 2000; Storebakken *et al*., 2000; Schneider *et al*., 2004).

This effect returns in the N balances, where FM diet (No.1) has one of the lowest non-fecal losses (250 g/Kg N). The N balances show in general higher non-fecal losses for PBM with different grain sources (290-519 g/Kg N). N retention is highest for FM diet and PBM diet containing sorghum instead for whole wheat quantity (No. 3). The protein contained in FM is taken up and retained better in the fish body due to its composition (Tacon, 1990; Allan *et al*., 2000; Storebakken *et al*., 2000).

P retention is rather high with 654-982g/KgP (for FM and PBM with corn and sorghum) compared to values found in literature of 150-380 gP/KgP (Kim *et al*., 1998; Lupatsch and Kissil, 1998; Van Weerd *et al*., 1999), for different fish species grown from 20-400 g. The highest P retention recorded when PBM substitute FM without sorghum grain (group2) followed by FM containing diet (No. 1). The low non-fecal P loss is related to describe phenomenon of high relative retention (Bureau and Cho, 1999; Coloso *et al*., 2003). On the other hand replacement of FM by PBM non significantly reduced ether extract retention values and that may be attributed to the higher N and C retention. Higher EE retention and negative non fecal loss may be related to the conversion of the extra nutrient into body fat.

On the other hand, replacement of wheat grain or corn grain by sorghum grain in Nile tilapia diet increased N, C, P and EE non-fecal losses and reduced nutrient retention. Moreover, enzyme supplementation improved nutrient retention and reduced fecal and non fecal losses when compared with the fish group fed on the same diet without enzyme. It has indicated that enzyme supplementation

Conclusion: PBM as FM alternatives has a high potential as feed ingredients replacing FM. Nutrients balances and fecal recovery data showed that PBM with corn + wheat or corn + sorghum results in good fish performance for a similar replacement of FM on protein percent basis, because of their nutrients content and digestibility. However, they result as well in slightly higher waste loads, in particular of N and C to the system. Sorghum grain as alternative to corn (weight/weight) results in lower fish production and higher nutrient fecal and non fecal losses and prefer to rejected because it has a negative impact on the system. Moreover, enzyme supplementation highly improved the fish performance, nutrient digestibility, carcass traits and fecal recovery and reduces the excessive losses of the nutrient to the environment. The choice for FM replacement should depend, therefore on not only fish performance, but also N, C and P waste production and feces stability, if environmental sustainable feeds are developed.

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