USE OF SOME AGRO-INDUSTRIAL BY PRODUCTS IN NILE TILAPIA FISH DIETS

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Abstract

In the present study, utilization and nutrients digestibility of agro-industrial by-products such as apricot seed kernels (ASK) and mango seed kernels (MSK) by monosix Nile tilapia (*Oreochromis niloticus*) fingerlings, were investigated under laboratory conditions. The two ingredients were incorporated at separate levels of 0, 15, 25, 35 and 45% instead of yellow corn. The feeding period lasted for 140 days. In general, in the first experiment, the results showed that yellow corn can be partially replaced by ASK on the levels of 15, 25 and 35%. In the second experiment, the substitution of MSK for yellow corn at replacement levels of 15, 25 and 35% had no adverse effect on the performance of the fish. In addition the results showed that the preferable FCR was recorded by fish given treatment TA_5 (45% ASK). While, the lowest values were obtained by fish given the control diet TA_1. Fish fed the experimental diets in which yellow corn was replaced by ASK at all levels tested were superior significantly (P>0.05) in the FCR compared with the fish fed the control diet. In the second experiment, the best FCR was obtained by the control TM_1, when compared to the lowest FCR value which recorded by TM_5 (45%).Therefore, partially substitution of yellow corn with ASK or MSK can be used in feed Nile tilapia (*O. niloticus*) fingerlings.

Keywords: *Nile tilapia, agro-industrial by-products, apricot seed kernel, mango seed kernel, nutrients digestibility, growth performance.*

INTRODUCTION

The shortage and sharp rise in prices of the conventional feedstuff such as yellow corn along with the competition among human and animals have forced nutritionists to investigate alternative ones which are not consumed by humans. By-products from food and beverage processing such as bran, middling, tankage, oil meals, brewers and distillers grains represent one such class of alternatives. Some of these wastes have been used extensively as feeds and their use has resulted in more economical fish production, but many other potentially valuable feed sources have been underutilized. These by-products include food processing wastes, such as vegetable and fruit processing residues. (Fontenot *et al.,* 1983).

Apricot (*Prunus armeniaca*) is the most delicious fruit consume during the summer season in Egypt. The cultivated areas have been increased during the last few

years. It is using fresh or processed as apricot juice, jam and dried sheets (Abd El-Aal *et al.,* 1986). The large quantities of fruits are usually oriented to feed processing factories. This could be a hazard in vicinity of the feed processing plant as a waste by products (El-Adawy, 1992). Therefore, utilization of seeds in fish diets will help in eliminating or reducing of pollution either inside the factory or in surrounding area with a possibility of reducing the total production costs.

Mango (*Mangifera indica*) belongs to fruits of the family include mango, pistachio and cashew nuts. Large quantities of mango seeds are available after processing in large factories. The seeds are mostly wasted, however, the kernel can be obtained after removal of the hard seed coat and it can be processed to produce oil and residual kernel meal which is rich in carbohydrate (Salunke and Desai, 1984).

The present study aimed to determine the effects of partially replacing of the main energy source, which was the yellow corn, with apricot seed kernels (ASK) or mango seed kernels (MSK) as agro-industrial by-products on growth performance and body composition of Nile tilapia (*Oreochromis niloticus*) fingerlings.

MATERIALS AND METHODS

This study has been carried out at the fish laboratory of the Faculty of Agriculture, Poultry Production Department, Minufiya University, Shibin El-Koom, Minufiya, Egypt.

Feed ingredients and the tested materials

The main feed ingredients used in the present study were herring fish meal, soybean meal, yellow corn, corn oil, wheat brain and vitamins and minerals mixture. All of the feed ingredients were purchased from the local market. Apricot and mango seeds were collected from fruit processing unit in Vitrac Company. The obtained amounts of seeds were washed, sun-dried for two weeks, thereafter, the kernels were removed by manual dehiscing of the hard seeds coat. The chemical compositions of the used ingredients and the tested materials used in the experimental diets are presented in Table (1). To detoxification of the tested materials, crushed apricot seed kernels (ASK) were abounded to detoxification process according to method of Khairy *et al.,* (1975) to eliminate its content from tannins and amygdalin. While, crushed mango seed kernels (MSK) were subjected to method of Ravindran and Sivakanesan, (1996) to eliminate some of that harmful components like tannins, hydrocyanic and phytic acid exist in mango kernels.

Diets formulation

The first experimental diets were formulated almost isonitrogenous (30% crude protein) and almost isoenergetic (4668 ± 183 Kcal GE /kg) with C/P ratio 155. The second experimental diets were formulated also iso-nitrogenous (30% CP) and iso-energetic (4528 ± 36 Kcal GE /kg) with C/P ratio 150. In both experiment, yellow

corn in the control diet was replaced by 0, 15, 25, 35 and 45% of the apricot seed kernels ASK (TA_1, TA_2, TA_3, TA_4 and TA_5, respectively) in the first experiment or mango seed kernels MSK (TM_1, TM_2, TM_3, TM_4 and TM_5%, respectively) in the second experiment. All the diets were floated for 8-9 seconds. This property allows the fish to consume all the offered meal. Formulation and chemical Composition of the experimental diets fed by Nile tilapia (*Oreochromis niloticus*) fingerlings are shown in Tables (2) and (3), respectively.

Fish laboratory facilities

The experimental system consisted of a series of 30 glass aquaria (80 L). The water exchange was done every 2 days with one third of the water aquarium to remove the feces from the bottom of the aquaria. The aquaria were completely drained and cleaned every week. They were provided with continuous aeration through air compressor free oil.

The experimental fish

Monosix Nile tilapia (*Oreochromis niloticus*) fingerlings were obtained from private fish farm and acclimated to the laboratory conditions for 2 weeks in fiber glass tank (1 m^3). During this period, the fish were fed a commercial feed. Before starting the experiments, about 50 fish were randomly selected and killed immediately. After body weigh were recorded, they were stored as zero group at -40°C for the proximate analysis at a later stage. Fish being used in the experiments were transferred to the aquaria. Four hundred and fifty fingerlings were randomly divided into ten different groups. Each experimental diet was fed to fish in three aquaria. Every aquarium contained 15 fingerlings with initial average weight of 7.29 ± 0.05 g for the first and the second experiments.

The fish were fed their respective experimental diets at a rate of 3% of their body weight per day increased after six weeks to 4% of fish body weight per day because increasing palatability of all consumed diets was observed. The daily amount of feed was subdivided into two equal feeding meals and offered to the fish at 08.30 and 15.30 hr. The fish were weighed once every 2 weeks and the amount of the diet fed was adjusted accordingly. The whole period of each feeding experiment was extended to 140 days.

Measurements of feeding experiments

Average weight gain (AWG), relative growth rate (RGR), feed conversion ratio (FCR), specific growth rate (SGR), protein efficiency ratio (PER), protein productive value (PPV), fat productive value (FPV) and energy utilization (EU) were calculated according to following equations:

1. AWG (g/fish) = [Average final weight (g) – Average initial weight (g)]
2. SGR (%/day) = [(Ln final weight (g) – Ln initial weight (g)) × 100]/experimental period (d).
3. FCR = Feed intake, dry weight (g) / live weight gain (g)

4. PER = Live weight gain (g) / protein intake (g)
5. PPV (%) = 100 × [Final fish body protein (g) – initial fish body protein (g)/ crude protein intake (g)].
6. FPV (%) = [Retained fat (g) **/** fat intake (g)] **×** 100
7. EU (%) = [Retained energy (kcal) **/** energy intake (kcal)] **×** 100

Water quality

Water samples were taken weekly for analysis of ammonia, nitrate and nitrite. Analytical methods were done according to American Public Health Association (APHA, 1992). The pH and water temperature values were determined by digital temperature and pH meter. Dissolved oxygen was monitored once per day using Oxymeter, Jan way model 9071.

2.8 Analytical methods

The chemical analysis of the feed ingredients, the tested materials, the experimental diets, fish carcass and fecal materials were done to estimate moisture, crude protein (CP%), ether extract (EE%), crude fiber (CF%) and ash contents according to the methods of A.O.A.C., (2000), while nitrogen free extract (NFE%) was calculated by difference. Gross energy (Kcal GE/Kg) contents of all the samples were calculated according to Jobling, (1983). Analysis of amino acids was done in the Central Lab for Feed and Feeding, Giza, Egypt by using Amino Acid Analyzer (LKB Alpha Plus high performance Amino Acid Analyzer LKB Biochrom LTD England). Amygdalin content was estimated as hydrocyanic acid which it was determined according to the method of A.O.A.C., (1980). The phytic acid content was estimated by the method described by Wheeler and Ferrel, (1971). Tannins content were determined by the method of A.O.A.C., (1980). Statistical analysis was conducted according to Duncan, (1955). The data were analyzed using the SAS program, (1999) for all the experiments. Differences were considered significant at ($P<0.05$).

RESULTS AND DISCUSSION

Effect of detoxification treatment on composition of tested materials

Chemical composition of apricot seed kernel after treatment showed decreasing in crude protein to 20.29%, apparent decrease in lipid as a result of its leaching out from the kernel during soaking and the value of carbohydrate content was increased to 13.89%. In mango seed kernel, decline in protein content was observed (4.96%), while the crude fat of detoxified MSK was higher (14.99%) than that of the raw MSK being 11.62% (Table 1).

The essential amino acids composition (% protein) of detoxified ASK and MSK are shown in Table (4). It could be noticed that detoxified apricot seed kernel was rich in lysine, methionine, phenyalanine, tyrosine and threonine when compared with detoxified MSK. On the other hand, detoxified MSK had higher content of isoleucine,

leucine and valine than that detoxified ASK. Generally, detoxified ASK had higher total essential amino acids (32.52%) than detoxified MSK (26.81%).

Some anti-nutritional factors presented in the apricot and mango seed kernels are detected. Raw mango seed kernel contained more concentration of HCN and amygdalin contents being 0.61 and 10.32%, respectively, while, detoxified MSK, HCN and amygdalin were decreased to 0.29 and 4.90%, respectively. However, the level of HCN and amygdalin in raw ASK were 0.16 and 2.71% and after treatment they decreased to 0.08 and 0.35%, respectively.

On the other hand, detoxified mango seed kernel had the highest value of HCN and amygdalin. Concerning to tannins and phytic acid contents of ASK and MSK, it could be noticed that the highest values of tannin and phytic acid contents were found in mango seed kernel comparable to apricot seed kernel. Dealing with effect of detoxification treatment on the ASK and MSK, it revealed a sharply decrease in tannin and phytic acid contents in ASK being 0.09 and 0.01%, respectively, while in MSK their levels were 2.91 and 0.09% respectively. Apparently, detoxified MSK had the highest values of tannin and phytic acid contents.

Water quality measurements

Water quality measurements expressed as mean values for the two experiments. They were monitored throughout the two experiments every week and remained stable for the following variables: dissolved oxygen was ranged from 5 to 6.2 mg/l, water temperature from 23.7 to 28.6 °C**,** pH from 7 to 7.9, ammonia from 0.05 to 0.1 mg/l, nitrite from 0.03 to 0.07 mg/l and nitrate from 3.5 to 5.0 mg/l. These records of water quality are in consistence with the means needed for the growth of tilapia fish used in the study.

Growth performance parameters

The average of initial and final body weight, average weight gain, relative growth rate (RGR) and specific growth rate (SGR) of Nile tilapia (*Oreochromis niloticus*) fingerlings fed the first and the second experimental diets are given in Tables (5,6), respectively.

Apparently, results of the first experiment in Table (5) illustrated that the differences between all treatments from TA_2 to TA_5 were not significantly ($P>0.05$) on final body weight, average weight gain, RGR, FI, SGR and PER. The values of all the mentioned parameters decreased gradually as the substitution level increased from 15% to 45% of ASK. While, there were significant differences ($P<0.05$) between the control diet (TA_1) and the other diets (TA_2 to TA_5), there are insignificant differences ($P>0.05$) between diets from TA_2 (15%) to TA_5 (45%). Fish group fed the control diet (TA_1) presented the best values of the growth parameters ($P<0.05$) comparable to those fish groups fed the others diets. It is noticed that feed intake was significantly declined with increasing the substitution levels of ASK from 15% (TA_2) to 45% (TA_5). This may be due to the antinational factors existed in ASK even after treatment.

The results in Table (5) showed that the preferable (FCR) being 2.42, was recorded by fish group fed the control diet (TA_1), while the worst value was obtained by fish group given diet (TA_5) being 3.20. In addition, there were no significant differences among all levels of substitution (TA_2 to TA_5), regarding to (PER) values.
Concerning to (PPV), it could be observed that there were no significant differences between the control diet (TA_1) and those fish groups fed TA_2, TA_3 and TA_4. Conversely, there were significant differences among TA_3, TA_5 and therein TA_3 had the highest value of PPV (20.71%), inversely TA_5 had the lowest value of PPV being (17.37%). The highest value of fat productive value (FPV) was obtained in fish group fed the control diet TA_1 (19.92%) followed in significant difference ($P<0.05$) by those fed TA_3 being, (15.32%).
With respect to energy utilization (EU), fish fed diet TA_3 had the highest value (11.26%). However, fish fed diets containing 45% ASK presented the lowest values (8.90%) of EU. These results confirmed the findings obtained before that yellow corn can be partially replaced by ASK on the levels of 15, 25 and 35%. Meanwhile, PPV and FPV were improved ($P>0.05$) at 25% level of ASK substitution instead of yellow corn. Moreover, EU improved ($P<0.05$) when the yellow corn were replaced with 25% of ASK.

In the second experiment (Table 6), the results demonstrated that the control diet (TM_1) was superior in all growth parameters. Understandably, the treatment values were decrease from TM_2 to TM_5 with the increasing of MSK proportion in the diets. Results obtained by El-Alaily *et al.,* (1976) were agreed with the present study. It is worth to notice that the feed intake was decreased ($P>0.05$) gradually when the level of substitution was increased until the level of 25% (TM_3) and there were significant differences when the substitution levels were increased to 35% or 45%. These may be due to the fact of MSK was unpalatable, thereby depressing feed intake. These results are matched with the previous study by (Patil *et al.,* 1982) who observed that feed intake was not significantly affected by MSK except at the highest inclusion level (7.4 g/ chick/ d). Also the same results were obtained by El-Alaily *et al.,* (1976), who found that feed intake per chick was decreased with the increasing of MSK substitution levels compared to the control diet.

There were no significant differences obtained in all levels of substitution in all parameters in the second experiment expect in FCR and PPV in fish group fed TM_4. These results were in agreement with that indicated by Omoregie, (2001). The results of FCR illustrated that the best value was obtained by fish group fed the control diet TM_1 (2.68), compared to the worst value recorded by TM_5 (3.69). Also, there were no significant differences ($P>0.05$) between TM_2, TM_3 and TM_4.

Values of EU of the second experiment demonstrated that fish group fed diet TM_1 showed the best figure (9.29%) followed with not significantly differences TM_2, TM_3 and TM_4, respectively. However, the lowest EU was observed ($P<0.05$) in fish fed TM_5 (45% MSK).

The results concluded that the substitution of MSK for yellow at replacement levels of 15, 25 and 35% in Nile tilapia (*O. niloticus*) diets contained 30% crude protein and 4528 Kcal GE, had no adverse effect on the performance of the fish expressed as the growth performance and PER. On the other hand, the mentioned substitution levels of MSK for yellow corn neither affected the fat productive values (FPV) nor energy utilization (EU) compared with the control diet TM_1.

Chemical composition of the experimental fish

Concerning to chemical composition and energy content (on DM basis) of Nile tilapia (*O. niloticus*) fingerlings recorded at the start and the end of the first and the second feeding experiments are presented in Tables (7, 8), respectively.

In the first experiment (Table 7), the results demonstrated that CP content of Nile tilapia carcass at the end of the experiment were increased significantly ($P<0.05$) in all experiment treatments compared to the control diet TA_1. These increasing CP contents were commenced with the increasing in substitution of ASK instead of yellow corn.

Concerning, carcass EE content at the end of the experiment of Nile tilapia fed the first experimental diets indicated that significantly differences in EE content in all levels of substitution. It is worthy noting that, the lowest treatment of EE content was that fish fed 15% ASK (TA_2), while the highest treatment of EE content was TA_4 (35% ASK) followed by the EE content of fish groups fed TA_3.

Focusing on energy content, clarified significant decrease ($P<0.05$) in energy content except TA_4 (35% ASK) compared with those at the control diet. In addition, TA_4 (35%) was the highest content of energy. Meanwhile, the lowest content of energy was that fish fed the control diet.

Results concluded that, the treatment TA_3 and TA_5 had no significant differences on CP, EE, ash and energy, except the moisture content.

The chemical composition and energy content of Nile tilapia carcass as affected by the second experimental diets (Table 8) are illustrated that the CP content was higher in fish group fed diet TM_2 (15%) compared with those fed the other diets. It is worthy noting that, the treatment TM5 was the lowest content of CP in comparison with the treatment TM2 (15%), which was superior in CP content.

Regarding to EE content TM_2 and TM_5 had significant differences among them. Also, there were not significantly ($P>0.05$) among the control TM_1 and TM_3 (25%) on

EE content. Furthermore, treatment TM_5 was the highest value in EE content, meanwhile, TM_3 was the lowest value. The results of Omregie, (2001) were not agreed with the present study.

Regard to carcass energy content, results showed that the treatment TM_5 (45%) was the lowest value of energy content, on the contrary, EE content of TM_5 showed the highest values at the end of the experiment.

Economical evaluation

Cost of one ton of feed and the feed cost to produce one Kg of fish gain produced from each diet obtained from the first and the second experiment are presented in Tables (9, 10), respectively.

In the first experiment (Table 9), the results showed that the cost of one ton of feed mixture reduced in all levels of yellow corn substitutions by apricot seed kernels (ASK). The control diet (TA_1) showed the lowest feed cost needed for producing one Kg fish gain (6.12 L.E) followed by the diet TA_4 (35%).

The highest feed cost (7.36 L.E) to obtain one Kg fish gain was obtained when the yellow corn was partially replaced by (15% ASK), followed by TA_3 (25%) and TA_5 (45%) being 7.15 and 7.07 L.E.

It is remarkable that the costs gain of all levels of yellow corn substitution in both feeding experiments were increased comparing to the control diets. It could be recommended to replace up to 35% of yellow corn by treated apricot seed kernels or treated mango seed kernels in case of sever unavailability of yellow corn or its high price and to decrease the competition among human and animals on limited corn yield.

CONCLUSION

The results concluded that the substitution levels of apricot seed kernels for yellow corn up to 25% and up to 35% of mango seed kernels in Nile tilapia (*O. niloticus*) diets containing 30% CP had no adverse effects on the performance of the fish.

On the economical point of view, in case of sever unavailability of yellow corn or its high price and to decrease the competition among human and animals on limited corn yield, treated apricot seed kernels or treated mango seed kernels could be recommended to replace up to 35% of the yellow corn which presented 45% on the basal diet.

Table 1. The chemical composition (%) of the ingredients and the tested materials (on DM basis) used in formulating the experimental diets.

Ingredients	Moist.	CP	EE	CF	Ash	NFE*	GE**
	%						Kcal/kg
Yellow corn	11.00	8.50	3.80	2.60	1.30	83.80	4183
ASK	5.15	25.40	47.18	16.09	2.69	8.64	6216
MSK	8.70	5.60	11.62	2.36	1.96	78.37	4544
Fish meal	9.00	72.00	8.40	00.70	10.50	8.40	5133
Soybean meal	11.97	44.80	1.20	7.30	5.40	41.30	4256
Wheat bran	11.00	15.20	3.90	12.00	6.20	62.70	4790
Corn oil	-	-	100	-	-	-	9450

* Calculated by difference.

** Jobling (1983).

Table 2. Formulation and chemical composition (% DM) of the first experimental diets.

	Diets				
	Control (0%)	(15%)	(25%)	(35%)	(45%)
Ingredients	TA_1	TA_2	TA_3	TA_4	TA_5
Yellow corn	45.00	38.25	33.75	29.25	24.75
Fish meal (72%)	22.00	21.50	19.50	19.50	19.00
Soybean meal (44%)	21.50	21.50	22.00	21.00	21.50
Wheat bran	8.00	8.50	10.00	11.00	11.00
Apricot seed kernels(ASK)	-	6.75	11.25	15.75	20.25
Corn oil	2.00	2.00	2.00	2.00	2.00
Vit. & Min. mix*	1.50	1.50	1.50	1.50	1.50
Total	100	100	100	100	100
Chemical composition (%)					
DM	10.76	9.18	12.82	13.23	12.57
CP	31.00	29.97	29.97	30.00	30.00
EE	7.68	7.68	10.94	13.10	15.14
CF	1.76	3.28	3.75	2.82	3.19
Ash	7.79	7.21	7.67	7.72	8.03
NFE**	51.77	51.86	47.67	46.36	43.64
Gross energy (Kcal/Kg)	4543.82	4505.21	4633.54	4787.35	4871.33

*****Each 1 kg contains: Vitamin A, 4.8 m.i.u, Vitamin D_3, 0.8 m.i.u, Vitamin E, 4.0g, Vitamin K, 0.8g, Vitamin B_1, 0.4g, Vitamin B_2, 1.6g, Vitamin B_6, 0.6g, Vitamin B_{12}, 4.0g, Pantothenic acid, 4.0g, Nicotinic acid, 8.0g, Folic acid, 400.0mg, Biotine, 20.0g, Chlorine chloride, 200.0g, Copper, 4.0g, Iodine, 4.0g, Iron, 12.0g, Zink, 22.0g and Selenium, 0.04g.

** Calculated by difference.

Table 3. Formulation and chemical composition (% DM) of the second experimental diets.

	Diets				
	Control (0%)	(15%)	(25%)	(35%)	(45%)
Ingredients	TM_1	TM_2	TM_3	TM_4	TM_5
Yellow corn	45.00	38.25	33.75	29.25	24.75
Fish meal (72%)	22.00	22.50	21.50	22.50	22.50
Soybean meal (44%)	21.50	20.00	22.00	21.00	21.50
Wheat bran	8.00	9.00	8.00	8.00	7.50
Mango seed kernels(MSK)	-	6.75	11.25	15.75	20.25
Corn oil	2.00	2.00	2.00	2.00	2.00
Vit. & Min. mix*	1.50	1.50	1.50	1.50	1.50
Total	100	100	100	100	100
Chemical composition (%)					
DM	10.76	9.18	12.82	13.23	12.57
CP	31.00	29.96	30.00	30.01	30.02
EE	7.68	7.72	7.53	7.93	8.78
CF	1.76	2.12	1.28	3.18	3.07
Ash	7.79	6.97	7.79	8.01	7.94
NFE**	51.77	53.23	53.40	50.87	51.19
Gross energy (Kcal/Kg)	4543	4551.48	4542.59	4479.75	4525.59

*Each 1 kg contains: Vitamin A, 4.8 m.i.u, Vitamin D_3, 0.8 m.i.u, Vitamin E, 4.0g, Vitamin K, 0.8g, Vitamin B_1, 0.4g, Vitamin B_2, 1.6g, Vitamin B_6, 0.6g, Vitamin B_{12}, 4.0g, Pantothenic acid, 4.0g, Nicotinic acid, 8.0g, Folic acid, 400.0mg, Biotine, 20.0g, Chlorine chloride, 200.0g, Copper, 4.0g, Iodine, 4.0g, Iron, 12.0g, Zink, 22.0g and Selenium, 0.04g.

** Calculated by difference.

Table 4. Essential amino acids, EAA, composition (% of protein) of the treated apricot and mango seed kernels.

Amino acids	Apricot	Mango
Iso leucine	0.99	4.01
Leucine	1.66	7.30
Lysine	6.72	1.52
Methionine	1.10	0.20
Phenylalanine	9.01	5.88
Tyrosine	3.98	3.93
Threonine	7.02	2.89
Valine	1.19	4.68
Cystine*	0.85	N.D
Tryptophan*	N.D	N.D
T.E.A.A	32.52	26.81

*Not detected.

Table 5. Growth performance and nutrients utilization of Nile tilapia (*Oreochromis niloticus*) fingerlings fed the first experimental diets.

Productive index	Experimental Diets				
	Control (0%)	(15%)	(25%)	(35%)	(45%)
	TA_1	TA_2	TA_3	TA_4	TA_5
IBW (g)	7.29 ±0.04 a	7.35 ±0.02 b	7.33 ±0.00 b	7.34 ±0.03 b	7.30 ±0.06 b
FBW (g)	26.07 ±0.39 a	20.94 ±1.31 b	20.60 ±0.52 b	19.82 ±0.29 b	19.18 ±0.05 b
AWG (g)	18.78 ±0.35 a	13.59 ±1.31 b	13.27 ±0.52 b	12.47 ±0.31 b	11.88 ±0.01 b
RGR (%)	258 ±3.37 a	185 ±18.11 b	181 ±7.05 b	170 ±4.81 b	163 ±1.41 b
FI (g)	45.48 ±0.37 a	40.06 ±0.73 b	40.87 ±1.03 b	38.24 ±1.07 b	38.06 ±0.77 b
FCR	2.42 ±0.05 a	2.99 ±0.24 b	3.08 ±0.06 b	3.07 ±0.60 b	3.20 ±0.06 b
SGR (%/day)	0.91 ±0.01 a	0.75 ±0.04 b	0.74 ±0.02 b	0.71 ±0.02 b	0.69 ±0.01 b
PER	1.33 ±0.01 ab	1.13 ±0.09 ab	1.08 ±0.04 a	1.09 ±0.02 ab	1.04 ±0.02 b
PPV (%)	19.15 ±0.67 a	18.75 ±1.28 bc	20.71 ±0.67 b	18.08 ±0.57 bc	17.37 ±0.86 c
FPV (%)	19.92 ±2.15 ab	13.24 ±1.51 ab	15.32 ±1.01 a	12.54 ±0.48 ab	8.92 ±0.68 b
EU (%)	10.81 ±0.76	9.57 ±0.62	11.26 ±0.44	9.97 ±0.14	8.90 ±0.54

a, b, c…etc: Means in the same raw with different superscripts are significantly different ($P<0.05$).

Table 6. Growth performance and nutrients utilization of Nile tilapia (*Oreochromis niloticus*) fingerlings fed the second experimental diets.

Productive index	Experimental Diets				
	Control (0%)	(15%)	(25%)	(35%)	(45%)
	TM_1	TM_2	TM_3	TM_4	TM_5
IBW (g)	7.33 ±0.00 a	7.28 ±0.04 ab	7.28 ±0.04 ab	7.24 ±0.00 b	7.24 ±0.04 b
FBW (g)	23.01 ±1.92 a	19.90 ±1.25 ab	19.93 ±1.15 ab	18.82 ±0.36 b	17.10 ±0.62 b
AWG (g)	15.68 ±1.92 a	12.62 ±1.22 ab	12.65 ±1.12 ab	11.58 ±0.33 b	9.85 ±0.58 b
RGR(%)	214 ±26.24 a	173 ±16.06 ab	174 ±14.74 ab	160 ±4.15 b	136 ±7.12 b
FI (g)	44.14 ±2.80 a	41.98 ±3.05 bc	39.66 ±2.37 ab	36.07 ±0.20 ab	36.27 ±1.02 c
FCR	2.68 ±0.18 a	3.35 ±0.21 ab	3.15 ±0.10 ab	3.12 ±0.08 ab	3.69 ±0.12 b
SGR (%/day)	0.82 ±0.06 a	0.72 ±0.04 ab	0.72 ±0.05 ab	0.68 ±0.01 ab	0.61 ±0.02 b
PER	1.14 ±0.08 a	1.00 ±0.06 a	1.06 ±0.04 a	1.07 ±0.03 a	0.91 ±0.03 b
PPV (%)	16.35 ±0.48 a	16.25 ±1.42 ab	15.36 ±0.68 ab	15.40 ±0.45 ab	11.21 ±0.74 b
FPV (%)	16.34 ±0.81 a	15.09 ±1.31 ab	14.51 ±1.25 ab	14.91 ±0.75 ab	11.80 ±0.65 b
EU (%)	9.29 ±0.25	8.76 ±0.86	8.35 ±0.35	8.68 ±0.27	6.74 ±0.39

a, b, c…etc: Means in the same raw with different superscripts are significantly different ($P<0.05$).

Table 7. Carcass composition (on DM basis) of Nile tilapia (*Oreochromis niloticus*) fed the first experimental diets.

Treatments	Moisture	CP	EE	Ash	GE Kcal/kg
	%				
At the start	76.50 ±0.70	53.37 ±0.27	22.48 ±0.26	24.15 ±0.29	5478.45 ±40.02
At the end TA_1 (0%)	a 75.76 ±0.89	c 58.82 ±0.43	c 16.95 ±0.06	b 24.23 ±0.27	c 4924.92 ±26.32
TA_2 (15%)	ab 74.41 ±0.52	b 61.28 ±0.14	d 14.83 ±0.10	a 23.89 ±0.08	d 4863.76 ±14.50
TA_3 (25%)	b 72.82 ±0.54	a 63.52 ±0.06	b 19.06 ±0.11	c 17.42 ±0.14	b 5392.89 ±10.85
TA_4 (35%)	a 75.29 ±0.55	a 63.30 ±0.18	a 20.73 ±0.07	d 15.97 ±0.14	a 5535.56 ±6.28
TA_5 (45%)	a 75.38 ±0.46	a 63.49 ±0.15	b 18.99 ±0.17	c 17.52 ±0.16	b 5382.06 ±11.68

a, b, c…etc: Means in the same column with different superscripts are significantly different (P<0.05).

Table 8. Carcass composition (on DM basis) of Nile tilapia (*Oreochromis niloticus*) fed the second experimental diets.

Treatments	Moisture	CP	EE	Ash	GE* Kcal/kg
	%				
At the start Zero group	76.50 ±0.70	59.37 ±0.27	22.48 ±0.26	18.15 ±0.29	5478.77 ±40.02
At the end TM_1 (0%)	75.76 ±0.89	b 58.82 ±0.43	c 16.95 ±0.06	c 24.23 ±0.27	bc 4925.11 ±26.32
TM_2 (15%)	75.16 ±0.53	a 61.79 ±0.27	b 17.69 ±0.11	d 20.52 ±0.14	a 5161.15 ±19.07
TM_3 (25%)	75.47 ±0.36	b 58.31 ±0.14	c 16.73 ±0.04	a 24.96 ±0.12	c 4875.50 ±4.58
TM_4 (35%)	75.66 ±0.33	b 58.45 ±0.13	b 17.64 ±0.14	b 23.91 ±0.27	b 4969.41 ±8.86
TM_5 (45%)	75.59 ±1.00	c 53.53 ±0.27	a 18.20 ±0.11	a 28.27 ±0.17	d 4744.35 ±23.73

a, b, c…etc: Means in the same column with different superscripts are significantly different (P<0.05).

Table 9. Feed cost (L.E) of the first experimental diets (ASK).

Treatments	Diet cost (L.E) of one ton	Diet cost (L.E) of one kilo	Relative diet cost %	Cost gain (LE/Kg gain)	Relative cost of gain
TA_1 (0%)	2543.50	2.54	100	6.15	1.0
TA2 (15%)	2465.26	2.47	97	7.36	1.20
TA_3 (25%)	2314.76	2.32	91	7.15	1.17
TA_4 (35%)	2273.26	2.27	89	6.97	1.14
TA_5 (45%)	2215.76	2.22	87	7.07	1.16

Table 10. Feed cost (L.E) of the second experimental diets (MSK).

Treatments	Diet cost (L.E) of one ton	Diet cost (L.E) of one kilo	Relative diet cost %	Cost gain (LE/Kg gain)	Relative cost of gain
TM_1 (0%)	2543.50	2.54	100	6.81	1.0
TM_2 (15%)	2518.88	2.52	99	8.41	1.24
TM_3 (25%)	2433.13	2.43	96	7.66	1.12
TM_4 (35%)	2451.38	2.45	96	7.64	1.12
TM_5 (45%)	2413.63	2.41	95	8.89	1.31

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