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EVALUATION OF SOME NON CONVENTIONAL DIETS FOR NILE TILAPIA FISH:
I- CONCERNING DIETARY COMPOSITION, WATER QUALITY, GROWTH PERFORMANCE, AND NUTRIENTS UTILIZATION OF THE FISH.

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ABSTRACT

The aim of this study was to evaluate some unconventional diets on water quality, diets composition, growth performance, feed utilization and whole fish and fish muscles composition of Nile tilapia fingerlings (7-8g). Glass aquaria were used in duplicate/treatment for 16 weeks. The basal diet contained 25% crude protein. The diets were offered daily at two meals at 3% of fish body weight. The experimental diets were nearly isocaloric and isonitrogenus. The 1st diet was a control, diets No. 2 – 5 are the control diet but their fishmeal was substituted by 25, 50, 75 and 100%, respectively with duckweed meal (DW), diets No. 6 – 9 included crayfish meal (C_rF_i) at the same previous replacement rates, and diets No. 10 – 13 included a mixture of DW + C_rF_i (1:1) as a substitute for fishmeal at the same rates. The obtained results revealed that DW contained higher crude protein and ether extract percentages as well as cadmium level than C_rF_i. The C_rF_i contained more nitrogen free extract, ash, lead and silica than DW. There were significant differences among the experimental diets in their dry matter, crude protein, ether extract, crude fiber and ash contents. Diet No. 13 included the highest crude protein percentage. The increased DW substitution rate up to 75% and C_rF_i up to 50% led to increase the dietary crude protein. The increased C_rF_i level from 25 to 100% gradually decreased the ether extract % in diets No. 6 – 9. The increased dietary inclusion of DW from 25 to 100% (diets No. 2 – 5) led to increase dietary crude fiber %. Diets No. 6 – 9 contained the highest ash %, with gradual increase proportional to the increase in C_rF_i substitution rate. Water quality parameters measured (temperature, pH and dissolved oxygen) did not differ among treatments. There were significant differences among dietary treatments in growth performance parameters including final body weight, body weight gain, and daily body weight gain. The highest values of these criteria were realized with diets No. 11 and 6, respectively. Specific growth rates did not differ significantly, but relative growth rates significantly differed among dietary treatment groups, being the highest with diets No. 11 and 6, respectively. The dietary treatments significantly affected feed intake, feed conversion, protein intake, protein productive value, protein efficiency ratio, and energy retention. The highest feed and protein intakes were found with diet No. 6, but the lowest were recorded for diet No. 12. The best feed conversion was calculated for diet No. 11 (the best treatment in fish bodyweight gain). The best protein utilization (protein productive value and protein efficiency ratio) was calculated for diet No. 13 although the superiority of diet No. 5 in energy retention. From the foregoing results, it would be clear that the 6th diet (25% freshwater crayfish meal as a partial replacer of dietary fish meal) was significantly the best concerning fish bodyweight gain, relative growth rate, and feed and protein intakes. This was followed by the 11th diet (50% substitution with mixture (1/1) of duckweed meal and freshwater crayfish meal), which was responsible for highest final body weight, bodyweight gain, daily body weight gain, and feed conversion, which may reflect the economical diet by decreasing feed costs to produce one Kg fish bodyweight gain. This leads to recommend the partial replacement of fish meal in Nile tilapia diets with 25% crayfish meal or 50% mixture of crayfish meal plus duckweed meal (1/1). These diets were responsible for better results than control and it is to expect that they will reduce the costs of fish feeding and production for the lower prices of either duckweed meal or freshwater crayfish meal comparing with the very expensive price of fish meal.

Keywords: Tilapia- Duckweed- Freshwater crayfish- Performance- Nutrients utilization.

INTRODUCTION

Tilapia are the third most important cultured fish group in the world, after carps and salmonids (FAO, 2002). Tilapia production has increased greatly in the past two decades and world production of farmed tilapia exceeded two million metric tons in 2004.Tilapia are currently raised in different types of production systems ranging from pond, tank, cage, flowing water and intensive water reuse culture systems (El Sayed *et al*., 2005). Commercial fish feeds utilized in aquaculture often contain fishmeal, which can comprise up to 65% of the diet. As long as protein component represents 55-75% of the total diet cost, protein alternatives have the first priority in formulating diet of tilapia as alternatives for the high cost of fish meal (Hanley, 2000). Little research was conducted on animal protein sources as alternatives for fish meal such as blood meal, earth worms, fish silage, silk worm pupae and processed meat soluble (Millamena *et al*., 2000). The utilization of the cheaper sources such as freshwater crayfish meal or aquatic plants meal is promising and need further investigations. Optimal feeding regimes may result in reduced feed costs by minimizing expenditure of metabolic rate of fish. Studies on feed stimulants can provide information on physiology of the animals concerned and may also detect additives, which can be incorporated into aquaculture feeds. Attractive feed may be looted and consumed quickly, thus reducing losses by leaching of essential water-soluble components. An addition of chemo-attractants to pelletized feeds may increase ingestion rates and improve growth, survival and food conversion (El Sayed *et al*., 2005). The objective of this study was to evaluate replacing dietary fish meal protein by plant and animal protein sources in tilapia fish diets and to investigate its effects on dietary composition, water quality, growth performance, and nutrients utilization of tilapia fingerlings.

MATERIALS AND METHODS

Experimental Fish:

A group of Nile tilapia (*O. niloticus)* with an average initial body weigh of 7 – 8 g were obtained from the stock of earthen ponds (from a private farm at AL Hamoul, Kafr El-Sheikh governorate) and transported to the aquaria located in the fish laboratory of Al Hamoul, Kafr El-Sheikh governorate. Fish were maintained in these aquaria for 2 weeks before the beginning of the experiment for acclimatization purpose. The fish were fed during the acclimatization period on the basal diet (25% crude protein) at a rate of 3% of the body weight daily, at 2 times daily. The experimental treatments were tested at two aquaria (replicates) for each. Fish were stocked at a density of 7 fish / aquarium.

Experimental Diet:

Partial or complete replacement of fishmeal (0, 25, 50, 75, and 100%) by whole crayfish meal and / or duck weeds meal in Nile tilapia fish diets was carried out to investigate its effect on water quality parameters, growth performance, and feed and nutrients utilization. All feedstuffs used in the experimental dies were purchased from Al-Iman Factory, Al-Hamoul, Kafr El-Sheikh governorate. Grayfish (*Procambarus clarkii*) was purchased from Imbaba market, Giza governorate, then sun-dried, ground and sieved (21 mash). Duckweed (*Lemna perpusilla*) was collected from Nabarow drainage, Dakaliah governorate, then sun-dried and ground. Diets were formulated by hand mixing the ground ingredients with little water through meat mincer to pellets (3 mm), then air dried. The basal diet No.1 was considered as a control. Composition of the basal and experimental diets are presented in Tables (1), (2) ,and (3). The composition of the vitamins and minerals mixture is Vitamins: A 5.714.286 IU, D_3 85.714 IU, E 7.143 mg, K_3 1.429 mg, B_1 571 mg, B_2 343 mg, B_6 571 mg, B_{12} 7.143 ug, C 857 ug, Biotin 2.857 mg, Folic acid 86 mg, Pantothenic acid 1.143 mg, Minerals: Phosphorus 28.571 mg, Manganese 68.571 mg, Zinc 51.429 mg, Iron 34.286 mg, Copper 5.714 mg, Cobalt 229 mg, Selenium 286 mg, Iodine 114 mg, Inert essential agent: Starch 57 g, Natural H. 29 g, and $CaCo_3$ up to 1000 g.

Experimental Procedure:

The experiment continued for 16 weeks. During the experimental period, the fish were fed the experimental diets at a rate of 3% of the live body weight daily. The diets were introduced twice daily, at 8 a.m. and 2 p.m. The amount of food was adjusted weekly based on the actual body weight changes. Light was controlled by a timer to provide a 14 hrs light: 10 hrs dark as a daily photoperiod. The experimental design was T1:Control (0% replacement) 100% fishmeal (FM), T2: 25% duckweeds (DW) 75% FM, T3: 5o% DW 50% FM, T4: 75% DW 25% FM, T5: 100% DW 0% FM, T6: 25% crayfish (Cr Fi) 75% FM, T7: 50% Cr Fi 50% FM, T8: 75% Cr Fi 25% FM, T9: 100% Cr Fi 0%FM, T10: 25% Mixed (DW+ Cr Fi) 75% FM, T11: 50% (DW+ Cr Fi) 50% FM, T12: 75% (DW+ Cr Fi) 25% FM, T13 100% (DW+ Cr Fi) o% FM, respectively.

Water Quality Analysis:

Samples of water from each aquarium were taken to determine daily the water temperature (using a thermometer) and pH value (using Jenway Ltd, model 350-pH meter) and weekly dissolved oxygen concentrations (using an oxygen meter model, d-5509) according to Abdelhamed (1996).

Chemical Analysis of the Experimental Ingredients and Diets:

Determination of DM, CP, EE, CF, ash and silica in the dietary ingredients, diets and in fish body at the start and at the end of the experiment for different groups were carried out according to the methods of A.OA.C. (1990). At the end of the experiment, three fish were derived from each group (aquarium) for drying at 60ºC for 48 hours and then milled through electrical mill and kept at 4ºC until analysis. Heavy metals determination was carried out at Botany Department lab of the National Research Center, Dokki using Atomic Absorption Spectrophotometry (Germany Company).

Growth Performance and Efficiency of Feed and Protein Utilization:

The growth performance and feed utilization parameters were calculated according to the following equations:

- Average weight gain (AWG, g/fish)= Average final weight (g)-Average initial weight (g).
- Average daily gain (ADG, g/fish)= Average final weight (g)-Average initial weight (g) / Time (days).
- Survival rate (SR %)= Total number of fish at the end of the experiment×100/total number of fish at the start of the experiment.
- Relative growth rate (RGR)= Average weight gain (g) / Average initial weight (g) x 100.
- Specific growth rate (SGR, % / day)= 100 [ln wt_1- ln wt_o/T]

  Where: ln: Natural log., Wt_o: Initial weight (g), Wt_1: Final weight (g), T: Time in days.
- Feed conversion ratio (FCR)= Total feed consumption (g) / Weight gain (g).
- Protein efficiency ratio (PER)= Body weight gain (g)/protein intake (g).
- Protein productive value (PPV %)= 100 [Retained protein (g)/protein intake (g)].
- Energy retention (ER %)= 100 [Retained energy (Kcal) / Energy intake (Kcal).

Statistical Analysis:

The data were statistically analyzed by using general linear models procedure adapted by SAS (1996) for users guide. Means were separated using Duncan's multiple range test (Duncan, 1955).

Table (1): Composition (%) of the experimental diets.

Ingredients	Diet No. 1 Control	Diet No.2 Duckweeds (25%)	Diet No. 3 Duckweeds (50%)	Diet No.4 Duckweeds (75%)	Diet No.5 Duckweeds (100%)
Fish meal	6	4.50	3	1.50	-
Duckweeds	0	1.50	3	4.50	6
Soybean meal	41	42.50	44.10	45.65	46.50
Yellow corn	30	30	30	30	30
Wheat bran	8	8	8	8	8
Rice bran	10	8.5	6.90	5.35	4.50
Sunflower oil	3	3	3	3	3
Vitamins & minerals	2	2	2	2	2
Gross energy (GE)* (kcal/100 g DM)	426.44	423.77	422.07	418.87	418.41
Protein/energy (P/E) ratio (mg CP/kcal GE)	63.76	62.03	62.40	66.75	62.90
Metabolizable energy (ME)** (kcal/100g)	377.28	375.47	373.64	373.12	370.29

***GE (kcal/100 g DM) = CP x 5.64 + EE x 9.44 + NFE x 4.11 calculated according to (Macdonald *et al*., 1973)**

****ME (kcal/100g DM) = Metabolizable energy was calculated by using factors 3.49, 8.1 and 4.5 kcal/g for carbohydrates, fat and protein, respectively according to Pantha (1982).**

Table (2): Composition (%)of the experimental diets.

Ingredients	***Diet No. 1***	***Diet No. 6***	***Diet No. 7***	***Diet No. 8***	***Diet No. 9***
	Control (0 %)	**Crayfish meal (25%)**	**Crayfish meal (50%)**	**Crayfish meal (75%)**	**Crayfish meal (100%)**
Fish meal	6	4.50	3	1.50	-
Crayfish meal	0	1.50	3	4.50	6
Soybean meal	41	42.50	44	٤٥,٦٥	47
Yellow corn	30	30	30	30	30
Wheat bran	8	8	8	8	8
Rice bran	10	8. 50	7	5.35	4
Sunflower oil	3	3	3	3	3
Vitamins & minerals	2	2	2	2	2
Gross energy (GE)* (kcal/100 g DM)	426.44	422.24	421.79	417.69	416.39
Protein/energy (P/E) ratio (mg CP/kcal GE)	63.76	64.51	64.70	63.10	63.30
Metabolizable energy (ME)** (kcal/100g)	377.28	373.05	372.63	369.74	368.80

***GE (kcal/100 g DM) = CP x 5.64 + EE x 9.44 + NFE x 4.11calculated according to (Macdonald *et al*., 1973)**

****ME (kcal/100g DM) = Metabolizable energy was calculated by using factors 3.49, 8.1 and 4.5 kcal/g for carbohydrates, fat and protein, respectively according to Pantha (1982).**

Table (3): Composition (%)of the experimental diets.

Ingredients	***Diet No.1***	***Diet No. 10***	***Diet No. 11***	***Diet No. 12***	***Diet No. 13***
	Control	**Duckweeds: Crayfish (1: 1) (25%)**	**Duckweeds: Crayfish (1: 1) (50%)**	**Duckweeds: Crayfish (1: 1) (75%)**	**Duckweeds: Crayfish (1: 1) (100%)**
Fish meal	6	4.50	3	1.50	-
Duckweeds: Crayfish (1: 1)	0	1.50	3	4.50	6
Soybean meal	41	42.38	43.75	45.12	46.50
Yellow corn	30	30	30	30	30
Wheat bran	8	8	8	8	8
Rice bran	10	8.62	7.25	5.88	4.50
Sunflower oil	3	3	3	3	3
Vitamins & minerals	2	2	2	2	2
Gross energy (GE)* (kcal/100 g DM)	426.44	423.82	421.48	420.39	420.68
Protein/energy (P/E) ratio (mg CP/kcal GE)	63.76	62.14	64.58	62.77	64.63
Metabolizable energy (ME)** (kcal/100g)	377.28	375.81	372.55	372	371.37

***GE (kcal/100 g DM) = CP x 5.64 + EE x 9.44 + NFE x 4.11 calculated according to (Macdonald *et al*., 1973).**

****ME (kcal/100g DM) = Metabolizable energy was calculated by using factors 3.49, 8.1 and 4.5 kcal/g for carbohydrates, fat and protein, respectively according to Pantha (1982).**

RESULTS AND DISCUSSION

Chemical Composition of the Experimental Diets:

The chemical analysis of both tested substitute unconventional materials crayfish (C_rF_i) and duckweed (DW) is illustrated in Table (4), from which it is obvious that DW contained more crude protein (CP), crude fiber (CF), ether extract (EE) and cadmium (Cd) contents, but lower nitrogen free extract (NFE), ash, lead and silica contents than C_rF_i, on dry matter (DM) basis. In this respect, Hassan and Edwards (1992) reported that DW (*Lemna perpusilla*) contained 25.3% CP, 4.5% crude fat, .6% CF and 17.6% ash on dry matter basis. Therefore, DW is used as a protein feedstuff in fish diets (BMO, 2009). Also, Tharwat (2000) analyzed the entire body of C_rF_i (*Procambarus clarkii*) and found that it contained 62.2% CP, 6.1% EE and 27.0 ash which is more proteinious than shrimp meal and local fish meal. Moreover, Abd El-Aty (2006) reported the chemical composition of the freshwater crayfish meal on DM basis as 32.1% CP, 1.9% EE and 33.9 ash. So, C_rF_i was evaluated as a protein source in fish diets (Abd El-Rahman and Badrawy, 2007). Habib (2004) cited that crayfish contain lead and cadmium as 1.82 – 2.41 and 0.06 – 0.70 μg/g dry weight of the external skeleton but 0.28 – 0.49 and 0.02 – 0.03 μg/g dry weight of the muscles when their rearing water contains 0.08 – 0.10 ppm Pb and 0.01 = 0.40 ppm Cd.

Table (4): Chemical analysis of crayfish (Cr Fi) and Duckweeds (DW), %dray matter basis.

Item	Crayfish	Duckweeds
DM	18.50	8.70
CP	34.13	43.13
CF	----	8.56
EE	2.79	5.28
NFE	30.79	27.05
Ash	32.29	15.98
Lead, mg/kg	45.5	42
Cadmium, mg/kg	178.5	229.5
Silica, mg/kg	227.75	202.30

Table (5) presents data of chemical analysis of the tested diets. Their analysis of variance reflects significant differences among the experimental diets concerning DM, CP, EE, CF and ash contents. Diet No. 13 (100% replacement of fishmeal with DW + C_rF_i, 1:1) contained the highest CP%. Increasing DW replacement level up to 75% or C_rF_i up to 50% led to significantly higher CP content than the other replacement level (except diet No. 13) and the control (diet No. 1). Increasing C_rF_i replacement level from 25 to 100% gradually decreased EE% of the diets No. 6 – 9. Increasing DW from 25 to 100% replacement in diets No. 2 – 5 increased their CF%. Diets No. 6 – 9 had the highest ash % in gradual increase in proportion to the C_rF_i inclusion level. These variations are mainly due to the variations between C_rF_i and DW analyses (Table 4).

Table (5): Means*(± SE) of diets chemical composition of the experimental diets.

Treatments	DM %	Proximate analysis , %DM basis			
		CP	EE	CF	Ash
Control	90.06±0.01e	27.19±0.02b	4.92±0.02de	4.10±0.02e	8.64±0.00h
Duckweeds (25%)	89.29±0.05g	26.29±0.01c	5.10±0.00abcde	4.12±0.02e	9.17 ±0.00gf
Duckweeds (50%)	90.51±0.1d	26.34±0.01c	5.12±0.01abcd	4.21±0.01ed	9.55±0.04cd
Duckweeds (75%)	90.49±0.05d	27.27±0.02ab	4.99±0.01bcde	4.78±0.01b	9.23±0.07efg
Duckweeds (100%)	90.82±0.02bc	26.32±0.00c	5.05±0.02abcde	5.12±0.02a	9.43±0.02efd
Cray fish (25%)	89.85±0.02ef	27.25±0.01b	5.16±0.02abc	4.12±0.05e	9.97±0.01b
Cray fish (50%)	90.61±0.02cd	27.29±0.00ab	5.10±0.04abcde	4.16±0.01ed	9.97±0.01b
Cray fish (75%)	90.77±0.03bc	26.32±0.00c	4.90±0.02e	4.04±0.12e	10.48±0.02a
Cray fish (100%)	89.72±0.03f	26.36±0.01c	4.95±0.01cde	4.17±0.01ed	10.66±0.00a
Mixed (DW+CrFi) 25%	91.89±0.01a	26.27±0.00c	5.22±0.00a	4.32±0.08d	8.99±0.02g
Mixed (DW+CrFi) 50%	90.46±0.02d	27.22±0.01b	4.92±0.08de	4.51±0.05c	9.45±0.05ecd
Mixed (DW+CrFi) 75%	90.96±0.02b	26.39±0.02c	5.17±0.01ab	4.61±0.02bc	9.63±0.04cd
Mixed (DW+CrFi) 100%	89.32±0.02g	27.46±0.01a	5.00±0.02bcde	4.55±0.02c	9.72±0.003bc

***Means (in the same column) superscripted with different letters significantly (P≤0.05) differ.**

Physico – Chemical Parameters of Water Quality:

Fish rearing water was analyzed periodically for some water quality criteria (Table 6) including temperature, pH and dissolved oxygen (DO). However, there was no effect on these parameters of different experimental diets, whether of substitute commodities or their replacement levels. However, the ranges of these criteria (25.5 – 26.3ºC, 7.12 – 7.70 pH value, and 5.90 – 6.10 mg/l DO) are suitable for rearing Nile tilapia fish (Abdelhamid, 1996 and 2009).

Table (6): Ranges of some important measured physico-chemical parameters of water quality.

Parameters	Treatments												
	Control	Duckweeds (DW)				Cray fish (CrFi)				Mixed (DW+ CrFi)			
	0%	25%	50%	75%	100%	25%	50%	75%	100%	25%	50%	75%	100%
Temperature ºC	26.1-26.2	26.1-26.2	26.1-26.2	26.2-26.3	25.5-26.2	25.6-25.7	25.6-25.6	25.6-25.6	25.6-25.7	25.6-25.7	25.6-25.7	25.8-26.1	26.1-26.1
PH value	7.53-7.75	7.42-7.75	7.45-7.46	7.46-7.53	7.38-7.40	7.46-7.55	7.38-7.39	7.10-7.27	7.20-7.74	7.12-7.21	7.14-7.36	7.02-7.53	7.7-7.9
DO, mg/l	6.05-6.05	6.05-6.05	5.95-5.95	5.90-5.90	5.90-5.90	6.05-6.05	6.05-6.05	6.05-6.05	6.05-6.05	6.05-6.10	6.05-6.05	6.10-6.10	6.10-6.10

Fish Growth Performance:

Although there were no significant differences for initial bodyweight (IW) among the experimental fish groups (Table 7); yet, the other growth performance parameters including final bodyweight (FW), average weight gain (AWG) and average daily gain (ADW) showed significant variations due to the dietary treatments. Since the heaviest FW, AWG and ADG were realized by diet No. 11 (50% replacement by 1:1 DW + C_rF_i) followed by diet No. 6 (25% C_rF_i). This may be due to the chemical composition of both commodities used herein as novel protein sources to replace fish meal in the control diet No. 1, i.e. high CF, EE, and Cd levels in DW as well as high inclusion levels of ash, lead (Pb) and silica of C_rF_i. These may affect feed intake (Table 9) as well as nutrients digestibility which reflected also on nutrients utilization in form of protein efficiency ratio (PER, Table 9). Specific growth rates (SGR) and survival rates (SR) did not differ significantly by the dietary treatments; yet, relative growth rate (RGR) differed significantly among fish groups (Table 8) being the highest for diets No. 11 and 6, respectively.

Table (7): Effect of dietary treatments on growth performance parameters of Nile tilapia.

Treatments	I W, g / fish	F W, g / fish	AWG, g / fish	ADG, g / fish
Control	7.14±0.00a	21.92±0.05b	14.78±0.04ab	0.13±0.00ab
Duckweeds (25%)	7.07±0.04a	18.16±0.11d	9.91±0.17ef	0.08±0.00ef
Duckweeds (50%)	7.28±0.00a	18.37±0.16d	9.62±0.86f	0.08±0.00f
Duckweeds (75%)	7.14±0.09a	20.44±0.11c	11.90±0.77cde	0.10±0.00de
Duckweeds (100%)	7.21±0.04a	18.28±0.00d	11.07±0.04def	0.09±0.00ef
Cray fish (25%)	7.07±0.04a	23.63±0.15a	15.11±0.92ab	0.13±0.00ab
Cray fish (50%)	7.21±0.04a	21.42±0.00b	14.21±0.04ab	0.12±0.00bc
Cray fish (75%)	7.07±0.04a	20.14±0.09c	13.07±0.04bcd	0.11±0.00cd
Cray fish (100%)	7.14±0.09a	20.14±0.00c	12.99±0.10bcd	0.11±0.00cd
Mixed (DW+CrFi) 25%	7.21±0.04a	20.66±0.06c	13.35±0.04bc	0.11±0.00cd
Mixed (DW+CrFi) 50%	7.28±0.00a	23.64±0.04a	16.35±0.04a	0.14±0.00a
Mixed (DW+CrFi) 75%	7.07±0.04a	18.57±0.30d	10.07±0.75ef	0.08±0.00ef
Mixed (DW+CrFi) 100%	7.14±0.00a	21.71±0.00b	14.66±0.09ab	0.13±0.00ab

***Means (in the same column) superscripted with different letters significantly (P≤0.05) differ.**

Table (8): Effect of dietary treatments on growth rates and survival rate by Nile tilapia.

Treatments	RGR	SGR,%/d	SR%
Control	2.06±0.00abc	0.54±0.00a	100.00±0.00a
Duckweeds (25%)	1.40±0.03g	0.63±0.00a	85.71±0.00a
Duckweeds (50%)	1.32±0.12g	0.65±0.07a	85.71±10.10a
Duckweeds (75%)	1.66±0.08def	0.64±0.07a	85.71±10.10a
Duckweeds (100%)	1.53±0.01efg	0.54±0.00a	100.00±0.00a
Cray fish (25%)	2.13±0.14ab	0.65±0.07a	85.71±10.10a
Cray fish (50%)	1.97±0.02abcd	0.54±0.00a	100.00±0.00a
Cray fish (75%)	1.84±0.00bcde	0.54±0.00a	100.00±0.00a
Cray fish (100%)	1.80±0.02cde	0.54±0.00a	100.00±0.00a
Mixed (DW+CrFi) 25%	1.84±0.01bcde	0.54±0.00a	100.00±0.00a
Mixed (DW+CrFi) 50%	2.24±0.00a	0.54±0.00a	100.00±0.00a
Mixed (DW+CrFi) 75%	1.42±0.11fg	0.65±0.07a	85.71±10.10a
Mixed (DW+CrFi) 100%	2.04±0.00abc	0.54±0.00a	100.00±0.00a

***Means (in the same column) superscripted with different letters significantly (P≤0.05) differ.**

However, Hassan and Edwards (1992) working on Nile tilapia found that the optimal daily feeding rates of *Lemna* were 5, 4 and 3% of the total fish body weight on a duckweed dry weight basis for fish of 25 – 44 g, 45 – 74 g and 75 – 105 g in weight, respectively. Since DW has potential as fish food in the development of low-cost aquaculture systems in the tropics; yet, it must be fed not more than 4% of the fish body weight daily to avoid its negative effects on the fish weight gain and survival. Moreover, Eid *et al*. (1995) reported that 2.5% inclusion level of DW of the Nile tilapia fish diet showed the highest body weight gain, absolute growth rate, and SGR. Additionally, Fasakin *et al*. (1999) did not find differences ($P \geq 0.05$) in growth performance of Nile tilapia fish fed on diets containing up to 20% duckweed inclusion and the control.

It was noticed that 30% fermented *Lemna* leaf meal incorporated in the diet resulted in the best growth performance of the fish superior to those fed diets containing raw leaf meal (Bairagi *et al*., 2002). However, El-Shafai *et al*. (2004b) found that more than 20% DW in the diet resulted in lower growth, although tilapia fish have the potency to digest and metabolize green food (Bakeer, 2006), but it may be due to its inclusion of high levels of trace metals, since such aquatic plants are able to significantly reduce the pollution load of the aquaculture wastewater by accumulating it in their tissues (Snow and Ghaly, 2008).

Generally, developing alternate protein sources for fish feeds which support rapid fish growth but do not increase pollution from aquaculture will require the combined efforts of all of the major scientific disciplines that collectively constitute aquaculture (Hardy, 1999). Feeding tilapia fish on diets supplemented with chitin and chitosan depresses tilapia growth regardless of the supplementation level (Shiau and Yu, 1999). This may interpretate the C_rF_i effect on fish performance recorded herein. Recently, Abd El-Aty (2006) reported that including crayfish meal in the diet decreased growth parameters but crayfish silage at a level of 33% did not decrease AWG, ADG or SGR.

Feed and Nutrients Utilization:

Table (9) presents data of feed intake (FI), feed conversion ratio (FCR), dietary protein intake (PI), protein productive value (PPV), protein efficiency ratio (PER), and energy retention (ER). The ANOVA of these data presented significant effects of the dietary treatments on FI, FCR, PI, PPV, PER and ER. The diet No. 6 (25% C_rF_i replacement) was significantly responsible for the highest FI and PI, while the worst was the diet No. 12 (75% replacement 1:1 DW + C_rF_i). The best feed conversion was obtained with mixed DW + C_rF_i at 50% replacement level (diet No. 11, which led to the best AWG and ADG (Table 7)), while the worst was the diet No. 3 (50% DW replacement, led to the lowest AWG and ADG as shown from Table 7). The best protein utilization expressed as PPV and PER was realized with the diet No. 13 (100% replacement by mixed DW + C_rF_i, 1:1, due to its highest CP content, Table 5); yet, diet No. 5 (100% DW replacement) was the best in ER. This may be due to the high energy content or the low ash of DW (Tables 1 and 5).

In these concerns, Hassan and Edwards (1992) recorded lower feed conversion by increasing DW level in Nile tilapia diets. However, Eid *et al*. (1995) reported a best digestion by fish fed on 2.5% DW level. Also, Fasakin *et al*. (1999) did not find significant differences in nutrient utilization of fish fed on diets containing up to 20% DW inclusion and the control. Yet, Bairagi *et al*. (2002) reported that feed utilization efficiencies of fish fed fermented leaf meal containing diets were superior than those fed diets containing raw leaf meal. It is worth mentioned that unionized ammonia nitrogen (UIAN) concentration must be maintained below 0.1 mg/l to avoid chronic ammonia toxicity to duckweed-fed tilapia, which increased FCR and reduced PER. Since DW grown on domestic sewage increases water UIAN (El-Shafai *et al*., 2004a). Moreover, ammonia excretion rate increases with a decline in protein quality (Eid and Matty, 1989). Yet, Ruenglertpanyakul *et al*. (2004) mentioned that DW could efficiently remove nutrients in the effluent, especially ammonia, which seemed to be the preferred nitrogen source of the plant. However, Abdel-Aziz and El-Shafai (2004) concluded that DW could be used in intensive tilapia culture either as partial substitute of fishmeal or complete substitute of some plant ingredients. They added that DW provided good values for FCR (0.98 – 1.1), PER (2.49 – 2.78), CP digestibility (78 – 92%) and energy digestibility (78.1 – 90.7%).

Table (9): Means ± standard errors of feed intake, feed conversion ratio, protein intake, protein productive value (PPV), protein efficiency ratio (PER) and energy retention (ER) of the tested Nile tilapia fingerlings as affected by dietary treatments.

Treatments	Feed Intake g/fish	FCR	Protein Intake g/fish	PPV%	PER	E R%
Control	44.13 ±0.24abc	2.98 ±0.00cd	11.99 ±0.06ab	17.26 ±0.03e	1.23 ±0.00ab	12.13 ±0.08ed
Duckweeds (25%)	37.22 ±0.24ef	3.75 ±0.04ab	9.78 ±0.06de	18.66 ±0.06cde	1.01 ±0.01cd	12.86 ±0.02cde
Duckweeds (50%)	38.78 ±0.27e	4.09 ±0.33a	10.21 ±0.07d	17.83 ±0.32de	0.94 ±0.07d	13.42 ±0.25bcd
Duckweeds (75%)	42.12 ±0.22cd	3.56 ±0.21abc	11.47 ±0.06bc	19.87 ±0.28bc	1.03 ±0.06bcd	15.71 ±0.24ab
Duckweeds (100%)	36.91 ±1.03ef	3.33 ±0.07bcd	9.71 ±0.27de	21.08 ±0.55ab	1.14 ±0.02abcd	15.95 ±0.41a
Cray fish (25%)	45.81 ±0.12a	3.05 ±0.16bcd	12.48 ±0.04a	19.22 ±0.18cd	1.21 ±0.06abc	12.95 ±0.10cde
Cray fish (50%)	44.95 ±0.26ab	3.16 ±0.00bcd	12.26 ±0.07a	17.33 ±0.07e	1.16 ±0.00abc	11.97 ±0.03de
Cray fish (75%)	42.57 ±1.57bcd	3.25 ±0.10bcd	11.20 ±0.41c	18.66 ±0.59cde	1.17 ±0.03abc	12.82 ±0.42cde
Cray fish (100%)	41.22 ±0.03d	3.17 ±0.02bcd	10.85 ±0.00c	15.29 ±0.07f	1.20 ±0.01abc	10.56 ±0.07ef
Mixed (DW+CrFi) 25%	41.77 ±0.28cd	3.12 ±0.01bcd	11.00 ±0.07c	13.22 ±0.12g	1.21 ±0.00abc	8.71 ±0.07f
Mixed (DW+CrFi) 50%	45.29 ±0.11a	2.76 ±0.01d	12.32 ±0.03a	19.14 ±0.10cd	1.32 ±0.00a	13.52 ±07bcd
Mixed (DW+CrFi) 75%	35.61 ±0.13f	3.57 ±0.25abc	9.39 ±0.04e	18.98 ±0.70cd	1.07 ±0.07bcd	15.23 ±1.65abc
Mixed (DW+CrFi) 100%	41.33 ±0.10d	2.81 ±0.00d	11.24 ±0.04c	21.63 ±0.31a	1.30 ±0.00a	12.84 ±0.03cde

***Means (in the same column) superscripted with different letters significantly (P≤0.05) differ.**

Anyhow, Nile tilapia fish reflect digestibility of energy and protein in duckweed as 7.81 – 10.7% and 88.4 – 93.% (El-Shafai *et al*., 2004b) and an crayfish meal being 88.8 and 68.4% (Boscolo *et al*., 2004), respectively. DW reflected a high N-retention (Schneider *et al*., 2004). Tilapia are capable to digest and metabolize algae (Bakeer, 2006). Abd El-Aty (2006) reported that C_rF_i can be successfully used up to 33% replacement of fishmeal of the Nile tilapia diets to reduce the feeding cost without a significant decrease in growth performance. Also, 50% crayfish meal diet reflected comparable FCR (Abd El-Rahman and Badrawy, 2007). However, Snow and Ghaly (2008) found that aquatic plants did not contain sufficient amounts of protein and fat to meet the dietary requirements of fish. They also contain high minerals concentrate, which can reduce feed intake, weight gain and growth rate in fish.

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تقييم بعض العلائق غير التقليدية لأسماك البلطى النيلى:
١- من حيث التأثير على تركيب العلائق، جودة الماء، أداء النمو، والاستفادة من المغذيات فى ألسمك

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أجريت هذه التجربة عام ٢٠٠٨م بمعمل رطب لدراسة تقييم بعض العلائق غير التقليدية على خواص جودة المياه ، تركيب العلائق، أداء نمو، والاستفادة الغذائية فى اصباعيات أسماك البلطى النيلى (٧-٨ جم). استعمل فى هذه التجربة (١٦ أسبوعا) أحوض زجاجية (٦٠ × ٣٥ × ٤٠ سم ارتفاع × عرض × طول)، العليقة الأساسية احتوت على ٢٥% بروتين خام، قدمت العلائق على وجبتين يومياً بمعدل ٣% من وزن السمك يومياً، كل معاملة كررت فى حوضين، معدل تخزين السمك ٧ سمكات لكل حوض، العلائق التجريبية كانت متساوية البروتين والطاقة تقريباً، العلائق رقم ١ مقارنة، وأرقام ٢ – ٥ استبدل فيها مسحوق سمك المقارنة بمعدل ٢٥، ٥٠، ٧٥، ١٠٠% بواسطة مسحوق نبات عدس الماء، والعلائق أرقام ٦ – ٩ استبدل فيها مسحوق سمك المقارنة بواسطة مسحوق استاكوزا المياه العذبة بنفس المعدلات السابقة، والعلائق أرقام ١٠ – ١٣ استبدل فيها مسحوق سمك المقارنة بنفس المعدلات السابقة لكن بمسحوق مخلوط عدس الماء + استاكوزا المياه العذبة (١/١). ولقد كانت أهم النتائج أن عدس الماء كان أغنى بالبروتين والدهن والكادميوم عن استاكوزا المياه العذبة. ارتفع محتوى استاكوزا المياه العذبة عن عدس الماء فى كل من المستخلص خالى الآزوت والرماد والرصاص والسليكا. كان هناك اختلافات معنوية بين العلائق فى كل من المادة الجافة، البروتين الخام، الدهن، الألياف، الرماد. كانت العليقة رقم ١٣ الأعلى فى محتوى البروتين. زيادة نسب إحلال عدس الماء إلى ٧٥% واستاكوزا المياه العذبة إلى ٥٠% من مسحوق السمك فى العليقة أدى إلى رفع بروتين العلائق عما سواها من نسب الإحلال (فيما عدا العليقة رقم ١٣ وعليقة المقارنة). زيادة نسب إحلال الاستاكوزا من ٢٥ إلى ١٠٠% خفضت تدريجيا من محتوى دهن العلائق أرقام ٦ – ٩ . زيادة نسب إحلال عدس الماء من ٢٥ – ١٠٠% من مسحوق السمك (فى العلائق أرقام ٢ – ٥) أدى إلى زيادة الألياف فى العلائق. العلائق أرقام ٦ – ٩ أظهرت أعلى نسبة رماد، بزيادة تدريجية تتفق مع زيادة نسبة إحلال

الاستاكوزا. لم تختلف خواص جودة المياه المقاسة (درجة الحرارة، الأس السالب لتركيز أيون الهيدروجين، الأكسجين الذائب) بين المعاملات المختلفة. تباينت معنوياً قياسات أداء النمو (وزن الجسم النهائى، الزيادة فى وزن الجسم، والزيادة اليومية فى وزن الجسم) بين المعاملات الغذائية. كانت أعلى هذه القياسات مع العليقة رقم ١١ يليها العليقة رقم ٦. رغم عدم اختلاف معدل النمو النوعى معنوياً، فإن معدل النمو النسبى قد تباين بين المعاملات الغذائية معنوياً محققاً أعلى معدل مع العليقتين ١١، ٦ على الترتيب. أثرت المعاملات الغذائية معنوياً على كل من استهلاك العلف، معدل تحويل الغذاء، استهلاك بروتين العلف، القيمة الإنتاجية للبروتين، معدل كفاءة البروتين، واختزان الطاقة. حققت العليقة رقم ٦ أعلى استهلاك علف وبروتين علف، بينما أقل هذه القيم كانت مع العليقة رقم ١٢. أفضل تحويل غذائى تحقق مع العليقة رقم ١١ (الأفضل فى الزيادة فى وزن جسم الأسماك). أفضل استفادة من البروتين (قيمة إنتاجية للبروتين ومعدل كفاءة البروتين) تحققت مع العليقة رقم ١٣، رغم أفضلية العليقة رقم ٥ فى اختزان الطاقة.

مما سبق عرضه من نتائج يتضح أن العليقة السادسة (٢٥% مسحوق استاكوزا مياه عذبة حلت محل مسحوق السمك فى عليقة المقارنة) هى الأفضل معنوياً من حيث زيادة وزن جسم السمك، معدل النمو النسبى، استهلاك العلف وبروتين العلف، يليها العليقة الحادية عشر (٥٠% إحلال مخلوط (١/١) مسحوق عدس الماء مع مسحوق استاكوزا المياه العذبة محل مسحوق السمك) والتى حققت ليس فقط أقصى وزن نهائى وزيادة فى الوزن وزيادة يومية فى وزن السمك، بل أيضاً حققت أفضل تحويل غذائى، بما ينعكس اقتصادياً بانخفاض تكاليف تغذية إنتاج كيلو زيادة فى وزن الأسماك، مما يدعو للتوصية باستبدال ٢٥% من مسحوق سمك العلائق بواسطة مسحوق استاكوزا المياه العذبة أو ٥٠% إحلال بواسطة مخلوط (١/١) مسحوق عدس ماء مع مسحوق استاكوزا مياه عذبة، إذ تفوقت نتائج هاتين العليقتين على نتائج المقارنة، علاوة على ما يتوقع من خفضهما لتكاليف التغذية وإنتاج أسماك البلطى النيلى لرخص سعر مسحوقى كل من عدس الماء واستاكوزا المياه العذبة جداً عن سعر مسحوق السمك.

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