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REPLACEMENT OF FISH MEAL BY FERMENTED FISH BY-PRODUCTS SILAGE IN THE DIETS OF NILE TILAPIA, (*OREOCHROMIS NILOTICS)* FRY

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SUMMARY

The present study aimed to study the effect of incorporation of increasing levels of fermented silage made from fish by-products in diets of Nile tilapia (*Oreochromis niloticus*) fry. After 90 days from the experimental start, the highest average BW (27.38) was recorded for control group which fed on the basal diet and replacing of 25% or 50% of fish meal FM by fermented fish silage FFS in the diets FFS25 and FFS50 reduced the final body weight BW to 25.08 and 25.22 g but these weights did not significantly different from that fed the basal diet. The higher replacing levels of FM by FFS (75 or 100%) in the diets FFS75 and FFS100 significantly (P<0.001) decreased the BW 20.77 and 13.50 g, respectively. Similar results were also obtained for final body length (BL).

The highest weight gain WG (25.05 g) was recorded for fish fed the control diet (FFS0) followed by those fed the diet FFS50 (22.01 g), FFS25 (21.96 g), FFS75 (17.20 g) and FFS100 (17.16 g), respectively and the differences in weight gain among the different fry groups were significant (P<0.05) and the same trend was observed for specific growth rate SGR. The average feed intake and feed conversion ratio and protein efficiency ratio of Nile tilapia were significantly (P<0.05) affected by the incorporation of fermented fish meal as a substitute of fish meal.

Dry mater in whole fish body ranged between 25.99 and 22.18 with insignificant differences. Crude protein ranged between 60.63 and 50.74, ether extract ranged between 22.85 and 17.97, ash ranged between 17.25 and 16.20 with significant differences for ether extract and protein content of whole fish bodies.

In conclusion, replacing up to 50% of FM by FFS did not affected growth and feed utilization and reduced feeding costs by 15.59% for tilapia fry. The higher replacing levels (75 or 100%) significantly adversed growth and feed utilization parameters.

Keywords: Replacement, fish meal, fish by-products silage, Nile tilapia fry.

INTRODUCTION

During recent years there has been increased interest in the use of enzymatic stabilization techniques for the preservation and utilization of feed materials for animal feeding in particular, a great deal of attention has been concentrated on the utilization of fishery by-products, including low grade industrial fish species, filleting waste and by-catch. Although it has also been possible to treat plant protein and terrestrial animal by-products using ensiling techniques (Norman *et al.* 1979), the concentration of research effort on fishery by-products has arisen because of the high level of wastage within the industry due to its often seasonal nature and cost of storing (freezing) and transporting these materials over long distances to the nearest fish meal plant.

The two techniques which have deals ensiling through chemical acidification (acid preserved silage) or bacterial fermentation (fermented silage).
Acid preserved silages, various acids, (both organic and inorganic), have been used. In organic acids, typically sulphuric acid and hydrochloric acid, have the advantage of being strong acids, relatively cheap and widely available but they require the pH of the final silage to be 2 or below to prevent bacterial spoilage, in addition before such a silage is fed (by mixing with an appropriate dry binder premix).

In contrast, organic acids although more expensive have much better anti-bacterial properties (Woolford, 1975) .It is possible to use a mixture of inorganic and organic acids to obtain the strength and economy of the former with the preservative properties of the latter. Propionic acid is often used not only for its antibacterial properties but also because it prevents mould growth. Mould growth, in particular *Aspergihus flavus.* have been reported in formic acid silage stored in tropical conditions even at pH less than 4 (Kompiang *et al,* 1980 a). Rungruangsak and Utne (1981) fed fish silages prepared by using different acids to rainbow trout and examined changes in protease activity in the digestive tracts. They reported that, the acids tested (formic; hydrochloric and sulphuric) only hydrochloric acid had no effect on protease activity in any region of the intestine, while formic and sulphuric acids caused reduction in protease activity at high dietary silage levels.

Co-dried sulphuric/propionic fish silage has been used successfully as a replacement for fish meal in rainbow trout diets (Hardy *et al.,* 1984).

Fermented silages, silage production is also possible by lactic acid bacterial fermentation. To undergo proper fermentation the raw material must contain lactic acid bacteria, a suitable nutritional substrate for the bacteria and a temperature compatible with rapid growth. Although lactic acid bacteria are invariably present in the raw material and a starter culture is not required (Kompiang *et al.,* 1980b and 1980c) the inoculation of material with fermented starter culture is recommended.

To favor the growth of lactic acid bacteria as opposed to spoilage bacteria a specific fermentable substrate is mixed with the minced raw material to be ensiled. Molasses added at a ratio of at least 1:10 (w/w) molasses to fish are particularly effective (Kompiang *et al.*, 1980b and Raa and Gildberg, 1982). Under favourable conditions the lactic acid produced reduces the PH of the silage, preserving it form spoilage and encouraging autolysis by naturally occurring protease enzymes. Preliminary feeding trials with fish indicated that fermented silages are nutritionally equivalent to fish meal. In view of the enhanced storage properties of these acid preservation techniques animal/Carbohydrates silages hold particular promise for use within the subtropical/tropical regions where conventional freezing techniques are expensive or not available (Jackson, *et al.,* 1984). Soltan and Tharwat (2006) indicated that fermented fish silage can successfully replace up to 25 and 50% of fish meal in Nile tilapia, *O. niloticus* and African catfish, *Claris gariepinus* diets without adverse effect on growth performance or feed utilization of each of tilapia catfish.

The aim of the study was aimed to investigate the effect of replace fish meal by fermented silage at different rates 0, 25, 50, 75 and 100% in Nile tilapia fry diets.

MATERIALS AND METHODS

The present study was carried out at the Laboratory of Fish Nutrition Faculty of Agriculture at Moshtohor, Benha University. The practical work of the present experiment was started on the 1 June 2006 and lasted until the 30 August of the same year (90 days). Fifteen rectangular aquaria 100×40×50cm (200 liter for each) were filled by 180 liter freshwater (3 replicates for each treatment) and each aquarium was stocked with 20 fish with an initial weight ranged from 1.71 to 1.72 g,

The experimental fish were obtained from Abbassa hatchery, Abu-Hammad. After acclimatization fish were randomly distributed into the experimental aquaria representing the five treatments At stocking body weight (BW) and body length (BL) for each aquarium were recorded. The aquaria were cleaned and water was replaced every four days, dissolved oxygen was maintained at 3.5 – 7.0 mg/l by continuous aeration and water temperature at 25 to 28°C.

Preparation of fermented fish silage (FFS):

Fish by-products (non edible parts) were obtained from El-Obour market and minced. FFS was prepared by mixing the minced fish by-products (60%) rice bran (30%) as filler, dried molasses (5%) as a source of carbohydrate (energy) and 5% yogurt (as a source of *Lactobacillus spp* for lactic acid anaerobic fermentation process). Potassium sorbate solution (1%) as antimicrobial agent was sprayed and the mixture was packed in black polyethylene bags. All bags were incubated in tightly hard plastic container and stored at ambient temperature that ranged from 30 to 38°C. The ensilage process completed after 30 days and at the end, a liquid FFS of pH 4.5 was obtained and sun-dried for 3 days. The resultant dried FFS had brownish color and strong fish odor and contained 38.12% crude protein (CP).

Diet preparation

Five diets were prepared by thoroughly mixing the ingredients which composed of fish meal, soybean meal, fermented fish silage, yellow corn, vegetable oil and wheat bran with different percentage (Table 1). In preparing the diets, dry ingredients were first ground to a small particle size. Ingredients were mixed and then water was added to obtain a 30% moisture level. Diets were passed through a mincer machine with diameter of 2 mm and were sun dried for 3 days. The experimental diets were formulated to replace 0, 25, 50, 75 or 100% of FM by FFS based on protein content. All diets were formulated to be isonitrogenous (30% protein) and isocaloric (2700 kcal ME/kg diet).

Table 1: Composition and chemical analysis of the experimental diets.

	Experimental diets				
Feed ingredients	Diet1	Diet2	Diet3	Diet4	Diet5
Fish meal (65%)	20	15	10	5	0
Fermented fish silage (FFS)	0	10	20	30	40
Soybean meal	47	47	47	48	48
Yellow corn	18	18	16	10	5
Wheat bran	9	4	1	1	1
Vegetable oil	3	3	3	3	3
Vit. & Min. mixture[1]	3	3	3	3	3
Sum	100	100	100	100	100
Chemical analysis *(determined on dry matter basis)*					
Dry matter (DM)	94.52	95.11	94.78	95.05	93.98
Crude protein (CP)	33.33	33.18	32.92	32.80	32.49
Ether extract (EE)	6.15	6.16	7.54	6.97	6.46
Crude fiber (CF)	8.56	9.25	8.67	9.88	10.36
Ash	7.55	8.45	9.36	7.66	8.16
NFE[2]	44.41	42.96	41.51	42.69	42.53
ME (Kcal/kg diet)[3]	2520	2513	2532	2500	2457
P/E ratio[4]	132.25	132.03	130.00	131.00	132.23

[1] Vitamin & mineral mixture/kg premix : Vitamin D_3, 0.8 million IU; A, 4.8 million IU; E, 4 g; K, 0.8 g; B1, 0.4 g; Riboflavin, 1.6 g; B6, 0.6 g, B12, 4 mg; Pantothenic acid, 4 g; Nicotinic acid, 8 g; Folic acid, 0.4 g Biotin,20 mg , Mn, 22 g; Zn, 22 g; Fe, 12 g; Cu, 4 g; I, 0.4 g, Selenium, 0.4 g and Co, 4.8 mg.

[2] Nitrogen free extract (NFE) =100-(CP+EE+CF+Ash)

[3] Metabolizable energy was calculated from ingredients based on NRC (1993) values for tilapia.

[4] Protein to energy ratio in mg protein/Kcal ME.

Tilapia fry fed the pelleted diets (2 mm in diameter) at a daily rate of 10% (during the 1st month), then gradually decreased to 7% (2nd month) and 4% (3rd month) of total biomass 6 day/week (twice daily at 9.00 am and 3.00 pm) and the amount of feed was bi-weekly adjusted according to the changes in body weight throughout the experimental period (90 days). About 25% of water volume in each aquarium was daily replaced by aerated fresh water after cleaning and removing the accumulated excreta. Water temperature, pH and dissolved oxygen were measured daily at 2.00 pm while total ammonia was weekly measured. Water quality parameters measured were found to be within acceptable limits for fish growth and health (Boyd, 1979).

Growth performance and feed utilization parameters were measured as follows:

Condition factor (K) = $(W/L^3) \times 100$ Where:- W = weight of fish in "grams", L = total length of fish in "cm"

Specific growth rate (SGR) = $\frac{LnW2 - LnW1}{t} x\, 100$ Where Ln = the natural log, W_1 = first fish weight, W_2 = the following fish weight in "grams" and t = period in days.

Weight gain = final weight (g) – initial weight (g)

Feed conversion ratio (FCR) = Feed ingested (g)/Weight gain (g)

Protein efficiency ratio (PER) = Weight gain (g)/Protein ingested (g)

At the end of each experiment, three fish were randomly sampled from each aquarium and subjected to the chemical analysis of whole fish body. Moisture, dry matter (DM), ether extract (EE), crude protein (CP), crude fiber (CF) and ash content of diets and fish were determined according to the methods described in AOAC (1990).

Statistical analysis of the obtained data for the experiment were analyzed according to SAS (1996). Differences between means were tested for significance according to Duncan's multiple rang test as described by Duncan (1955). The following model was used to analyze the obtained data:

$$Y_{ij} = \mu + \alpha i + e_{ij}$$

Where: Y_{ij} = the observation on the ij^{th} fish eaten the i^{th} diet; μ = overall mean, α_i= the effect of i^{th} diet E_{ij} = random error assumed to be independently and randomly distributed $(0, \delta^2 e)$.

RESULTS AND DISCUSSION

Body weight(BW) and body length (BL):

As described in Table (2), the highest average BW (27.38) was recorded for control group which fed the basal diet (control). Replacing of 25% or 50% of fish meal (FM) by fermented fish silage (FFS) in the diets FFS25 and FFS50 reduced the final BW to 25.08 and 25.22 g but these values did not significantly different (P<0.05) from that fed the basal diet (Table 2).

Compared to fish fed the basal diet, the higher replacing levels of FM by FFS (75 or 100%) in the diets FFS75 and FFS100 significantly (P<0.001) decreased the BW of Nile tilapia fry to 20.77 and 13.50 g, respectively indicating the possibility of replacing 50% of FM in the basal diets of Nile tilapia fry by FFS without adverse effect on the final BW.

At experiment termination the highest average BL (11.57cm) was recorded for fish group 3 which fed the diet FFS50 (50% of FM replaced by FFS) followed in a descending order by those fed the control diet, FFS0 (11.01 cm), FFS25 (10.43), FFS75 (10.38), and FFS100 (8.95), respectively and the differences between fish groups were significant.

The highest average condition factor (2.08) was recorded for fish group fed the diet FFS100 (complete replacement of FM by FFS) followed in descending order by those fed the diet FFS75 (2.5), FFS50 (2.04), FFS0 (1.02), and FFS25 (1.96).

Results of Table (2) are in accordance with the results of Nwanna and Daramola (2001) who found that, replacing FM by shrimp head waste meal at 0, 15, 30, 45 and 60% in 30% protein diets decreased final BW and the decrease was more pronounced at the higher replacing levels. In another study, Wassef *et al.,* (2003) found that replacement of 25, 50, 75 or 100% of FF by FFS alone or mixed with soybean meal (1:1) significantly (P<0.05) decreased the final BW of Nile tilapia fed 28% CP experimental diets.

Soltan and Tharwat (2006) incorporated fermented fish by-products silage in iso-nitrogenous (30% CP) and isocaloric (2600 Kcal ME) diets for Nile tilapia, *Oreochromis niloticus* and African catfish, *Clarias garipinus* to replace 25, 50, 75 or 100% of FM and they found that, dried FFS can successfully replace up to 25 and 50% of FM in tilapia and catfish diets, respectively without any significant loss in final BW while the higher replacing levels (50, 75 or 100% for tilapia and 75 or 100% for catfish) significantly reduced the final BW for the two fish species. In another study, Soltan and El-Laithy (2008) evaluated the silage made from fish by-products and tomato and potato by-products in isonitrogenous (30%) and isocaloric (2700 Kcal ME) diets fed to Nile tilapia fry and they found that replacement of 30% of the dietary protein by silage did not significantly affected the final BW of Nile tilapia while the higher replacing levels (40 or 50%) significantly reduced BW of Nile tilapia.

Table 2: Least square means and standard error for the effect of replacing levels of fish meal by fermented fish silage in the diets on body weight (BW), body length (BL) and condition factor (K) of Nile tilapia fry.

Diets	No.	Body weight/g		Body length/cm		Condition factor	
		Initial	Final	Initial	Final	Initial	Final
FFS0 (control)	60		27.38 a	4.71	11.01a	1.77	1.02
FFS25	60	1.71	25.08ab	4.50	10.43a	1.70	1.96
FFS50	60	1.72	25.22ab	4.53	11.57a	1.87	2.04
FFS75	60	1.72	20.77 b	4.51	10.38a	1.99	2.05
FFS100	60	1.72	13.50 c	4.38	8.95 b	1.98	2.08
Standard error		±0.10	±1.78	±0.11	±0.28	±0.06	±0.08

Averages within each column followed by different letters are significantly different ($P<0.05$)

Weight gain (WG) and specific growth rate (SGR):

Results of Table (3) indicated that, increasing level of substituting levels of FM by FFS up to 50% did not significantly affected WG of Nile tilapia fry while the highest substituting levels (75 or 100%) significantly decreased WG and the same trend was also observed for specific growth rate (SGR). Nwanna and Daramola (2001) found that, replacing FM by shrimp head waste meal at 0, 15, 30, 45 and 60% in 30% protein diets decreased final WG and SGR and the decrease was more pronounced at the higher replacement levels. In another study, Wassef *et al.,* (2003) found that replacement of 25, 50, 75 or 100% of FF by FFS alone or mixed with soybean meal (1:1) did not significantly affected WG and SGR of Nile tilapia by the partial or the complete replacement of FFS alone or when mixed with soybean meal.

Similar results were obtained by Soltan and Tharwat (2006) who indicated that dried FFS can successfully replace up to 25 and 50% of FM in tilapia and catfish diets, respectively without any negative significant effect in WG or SGR while the highest replacing levels (50, 75 or 100% for tilapia and 75 or 100% for catfish) significantly reduced the WG and for the two fish species. In another study, Soltan and El-Laithy (2008) evaluated the silage made from fish by-products and tomato and potato by-products in isonitrogenous (30%) and isocaloric (2700 Kcal ME) diets fed to Nile tilapia fry and he found that replacement of 30% of the dietary protein by silage did not significantly affected the WG or SGR of Nile tilapia fry while the higher replacing levels (40 or 50%) significantly reduced WG of Nile tilapia.

The present study showed that FFS possessed adequate nutritional value for Nile tilapia fry at low inclusion levels, making possible substitution level of up to 50% of fish meal protein without adverse effect on growth performance of Nile tilapia fry.

The superior performance of control fish group fed the diet FFS0 was referred to the fact that the nutritional value of FM-protein approximating almost exactly to the nutritional requirements of cultured finfish species (Tacon, 1993). When 25% or 50% of FM protein was replaced by FFS protein did not followed by significant effect on all growth parameters (BW, BL, WG and SGR) while the higher replacing levels (75 or 100%) significantly adversed these parameters. Soltan and Tharwat (2006) showed that FM contained comparatively higher total indispensable amino acid (IAA) content (45.50%) than FFS (33.37%) and the IAA of FFS did not cover the requirements of Nile tilapia from these amino acids. Therefore, the higher replacing levels of FM by FFS (50, 75 or 100%) significantly reduced all growth performance parameters of Nile tilapia (Table 2).

Table 3: Least square means and standard error for the effect of replacing levels of fish meal (FM) by fermented fish silage (FFS) in the diets on weight gain (WG) and specific growth rate (SGR) of Nile tilapia fry.

Diets	**No.+**	**WG (g/fish)**	**SGR (%)**
FFS0 (control)	3	25.05±1.97 a	3.06± 0.13 a
FFS25	3	21.96±1.97 a	2.90± 0.13 a
FFS50	3	22.01±1.97 a	2.92± 0.13 a
FFS75	3	17.20±1.97 b	2.62± 0.13 b
FFS100	3	17.16±1.97 b	2.62± 0.13 b

Averages within each column having different letters are significantly different (P<0.05).

+ Average of three replicates (aquaria)

The higher levels (50% FM replacement by FFS) were reported in earlier reports of Lapie and Bigueras-Benitez (1992) who found no differences in growth performance of Nile tilapia fed a formic acid preserved fish silage blended with FM (1:1), and growth performance was significantly reduced when the replacing levels increased up to 75%. Also, Fagbenro (1994) and Fagbenro *et al.,* (1994) stated that, up to 75% of FM protein could be successfully replaced with tilapia silage and soybean meal (1:1) in 30% CP diets for all male *O. niloticus.*

Feed intake (FI):

Table (4) show that, the highest average feed intake (72.65 g) was recorded for fish fed control diet and the lowest one was recorded for fish fed the diet FFS100 where the FM was completely replaced by FFS and the differences between fish groups were significant (P<0.05).

Results of Soltan and Tharwat (2006) indicated that feed intake was significantly (P<0.01) decreased with each increase in FFS content of tilapia diets as a replacement of FM. On the other hand Wassef *et al.,* (2003) found that, partial or total replacement of FM by FFS alone or mixed with soybean meal did not significantly affected feed intake.

One of the most common difficulties observed when using alternative sources of animal proteins is the acceptance of the feed, evidently related to its palatability. In this experiment the acceptance of the diets was very good, especially the basal diet FFS0. FFS included in diets fed to tilapia had positive feed utilization and digestibility (Fagbenro and Bello-Olusoji, 1997 and Fagbenro, 1994). Jatomea *et al.,* (2002) found that the higher FI were recorded for Nile tilapia fry fed diets contained 0, 10 and 15% shrimp head silage as a replacement to fish meal and the worst FI was obtained the higher replacing levels (20, 25 and 30%).

Feed conversion ratio:

Table (4) showed that FCR values were found to be 2.90, 3.00, 2.77, 3.45 and 2.99 for fish groups fed the different experimental diets (FFS0, FFS25, FFS50, FFS75 and FFS100, respectively) and the differences were significant (P<0.05).

The best FCR was recorded for fish fed the diet FFS50 where 50% of FM protein was replaced by FFS protein and did not significantly different from those obtained for fish group fed the control diet (FFS0). The highest replacing levels of FM by FFS (75 or 100%) significantly (P<0.001) adversed FCR. Similar results were also obtained by Soltan and Tharwat (2006) who found that the best FCR and PER were recorded for fish fed the diet FFS25 where 25% of FM protein was replaced by FFS protein and did not significantly different from those obtained for fish group fed the control diet (FFS0). The higher replacing levels of FM by FFS (50, 75 or 100%) significantly (P<0.001) adversed FCR for Nile tilapia. Fagbenro and Bello-Olusoji (1997), Fagbenro (1994) and Jatomea *et al.,* (2002) found that, the best FCR was recorded for Nile tilapia fry fed diets contained 0, 10 and 15% shrimp head silage as a replacement to fish meal and the worst FCR was obtained by the higher replacing levels (20, 25 and 30%). On the other hand, Lapie and Bigueras-Benitez (1992) found no difference in feed efficiency between *O. niloticus* fed a formic acid preserved fish silage blended with FM (1:1) or a FM-based diet. In another study Wassef *et al.,* (2003) found that, partial or total replacement of FM by FFS alone or mixed with soybean meal did not significantly affected FCR. Stone *et al.*, (1989) studied the apparent digestibility and utilization of fish protein subjected to the ensilaging process, comparing with fish meal in dry diets fed to rainbow trout (*Salmo gairdneri*).

They reported that digestibility values were higher for the fish silage than for fish meal, the fish silages were not efficiently utilized for growth. Whole fish and fish processing wastes were found to be equivalent sources of nitrogen provided the degree of autolysis was the same and the diets were other wise nutritionally balanced.

Protein efficiency ratio (PER):

Results of PER of tilapia fry fed the different experimental diets are summarized in Table (4). As described in this table, the average PER for fish groups fed the experimental diets ranged between 0.95 and 1.13 and the highest value was observed for fish group fed the diet FFS50 where 50% of FM was replaced by FFS while the worst one was recorded for fish fed the diet FFS75. **Hardy *et al.,* (1984)** reported that PER of rainbow trout fed fish silage at levels of 12.5, 25 and 50% were 1.69, 1.61 and 1.66, respectively.

Table 4: Least square means and standard error for the effect of replacing levels of fish meal (FM) by fermented fish silage (FFS) in the diets on Feed intake (gm/fish), Feed conversion ratio (FCR) and Protein efficiency ratio (PER) of Nile tilapia fry.

Diets	No.+	Feed intake (gm/fish	Feed conversion ratio	Protein efficiency ratio
FFS0 (control)	3	72.65±3.08 a	2.90±0.36 b	1.04±0.11
FFS25	3	64.61±3.08 ab	3.00±0.36 ab	1.02±0.11
FFS50	3	59.74±3.08 b	2.77±0.36 b	1.13±0.11
FFS75	3	54.65±3.08 bc	3.45±0.36 a	0.95±0.11
FFS100	3	46.88±3.08 c	2.99±0.36 ab	1.11±0.11

Averages within each column having different letters are significantly different ($P<0.05$),

+ Average of three replicates (aquaria)

Fagbenro and Bello-Olusoji (1997), Fagbenro (1994) and Jatomea *et al.,* (2002) found that the higher PPR was recorded for Nile tilapia fry fed diets contained 0, 10 and 15% shrimp head silage as a replacement to fish meal and the worst PER was obtained the higher replacing levels (20, 25 and 30%). In another study Soltan and Tharwat (2006) stated that the best PER were recorded for fish fed the diet FFS25 where 25% of FM protein was replaced by FFS protein and did not significantly different from those obtained for fish group fed the control diet (FFS0) and The higher replacing levels of FM by FFS (50, 75 or 100%) significantly ($P<0.001$) adversed PER. On the other hand, Wassef *et al.,* (2003) found that, partial or total replacement of FM by FFS alone or mixed with soybean meal did not significantly affected PER.

Proximate analysis of whole fish:

The average proximate analysis of tilapia as affected by replacing levels of FM by FFS in the diets outlined in table (5). As described in this table, dry mater ranged between 22.18 and 25.99%; crude protein 50.74 to 60.63%; ether extract ranged between 17.97 to 22.85 and ash from 16.20 to 17.25% and the differences among the different experimental fish groups were significant for ether extract ($P<0.05$) and crude protein ($P<0.01$) only.

As compared to control group (FFS0), all replacing levels of FM by FFS significantly ($P<0.01$) increased ash content of whole fish bodies compared to control group and these results may be due to the high ash content of fish wastes used in preparation of FFS and these results were relatively similar to those obtained by Wassef *et al.,* (2003) who found that, replacing of FM by FFS up to 75% did not significantly affected protein content of tilapia bodies. In recent study, Cavalheiro *et al.,* (2007) substituted fish meal by fermented shrimp industry wastes at a substituting levels of 0, 33.3, 66.6 and 100% in the diets of Nile tilapia, *O. niloticus* and they found that, the partial or complete replacement of FM by fermented shrimp industry wastes did not show any appreciable variation for the dry matter and protein content of fish. Soltan and Tharwat (2006) found that increasing replacing levels of FM by FFS in Nile tilapia diets decreased DM content in the whole body and the differences between fish groups were not significant and increasing FFS levels in tilapia diets up to 50% as a substitute of FM did not significantly affected protein content in whole body while the higher replacing levels (75 or 100%) significantly increased protein content of whole body. They also added that partial or total replacement of FFS by FM did not significantly affected EE content of tilapia fish.

Soltan *et al.,* (2008) found that DM of catfish did not significantly affected by all replacing levels of FM by FFS (25, 50, 74 and 100%) and the same trend was also observed for ash content of whole fish bodies and they added that compared to control fish group, all replacing levels of FM by FFS significantly ($P<0.001$) decreased protein and EE content whereas fish group fed the control diet (FFS0) gained the highest protein and EE contents.

Table 5: Least square means and standard error for the effect of replacing levels of fish meal (FM) by fermented fish silage (FFS) in the diets on proximate analysis of Nile tilapia fry.

Diets	No.+	Dry matter	Crude protein	Ether extract	Ash
FFS0 (control)	9	25.99±0.67	60.63±1.48 a	17.97±0.79 b	16.67±0.74
FFS25	9	24.75±0.67	51.74±1.48 b	19.14±0.79 b	16.55±0.74
FFS50	9	22.18±0.67	50.74±1.48 b	22.85±0.79 a	16.63±0.74
FFS75	9	24.76±0.67	51.38±1.48 b	19.53±0.79 b	16.20±0.74
FFS100	9	24.80±0.67	57.62±1.48 a	18.81±0.79 b	17.25±0.74

Averages within each column having different letters are significantly different ($P<0.05$),

Economical Efficiency:

The current investigation highlights the potential of using fermented fish silage as a replacement for fish meal in the diets of Nile tilapia fry. Generally, results of the present study showed the possibility of replacing of FM by FFS up to 50% in tilapia fry diets without adverse effect on growth performance and feed utilization.

Feed cost is considered to be the highest recurrent cost in aquaculture, often ranging from 30 to 60%, depending on the intensity of the operation. Any reduction in feed costs either through diet development, improved husbandry or other direct or indirect means is therefore decreased the total production investment and increased the net return (Collins and Delmendo, 1979; Green; 1992 and De Silva and Anderson, 1995).

All other costs are almost constant, therefore, the feeding costs required to produce one kg gain in weight could be used to compare the economical efficiency of different experimental treatments.

As shown in Tables (6 and 7), feed costs (LE/ton) decreased gradually with increasing substitution level of FM by FFS. Data presented in the same tables showed that, increasing substitution level of FM by FFS at 25, 50, 75 and 100% decreased feed costs by 7.93, 15.59, 23.12 and 30.86%, respectively.

Compared to the control diet, feed costs (LE/kg WG) decreased for all substitution levels of FM by FFS in the diets. In conclusion, replacing 50% of fish meal by fermented fish silage reduced feeding costs by 15.59% for tilapia fry.

Table 6: Feed costs (L.E) for producing one kg weight gain by fish fed the experimental diets.

Nile tilapia fry							
Diets	Costs (L.E)/ton	Relative to control %	Decrease in feed cost (%)	FCR	Feed costs * (L.E)/kg Weight gain	Relative to control %	Decrease in Feed costs (L.E)/kg Weight gain
FFS0	2735.50	100	0.00	2.90	7.93	100	0
FFS25	2518.50	92.07	7.93	3.00	7.56	95.33	4.67
FFS50	2309.00	84.41	15.59	2.77	6.40	80.71	19.29
FFS75	2103.00	76.88	23.12	3.45	7.25	91.42	8.58
FFS100	1891.25	69.14	30.86	2.99	5.65	71.25	28.75

* Feed costs/kg weight gain = FCR × costs of kg feed.

Table 7: Local market price (L.E./ton) for feed ingredients used for formulating the experimental diets when the experiment was started.

Ingredients	Price (L.E.) / ton
Fish meal	6000
Yellow corn	1250
Soybean meal	2000
Fermented fish silage (FFS)	1000
Wheat bran	900
Vegetable oil	4000
Vit. & Min. Mixture	10000

REFERENCES

Association of Official Analytical Chemists, AOAC (1990): Official Methods of Analysis. Washington, D. C.

Boyd, D. (1979): Water Quality in Warm water Fish Ponds. Auburn University Agricultural Experiment Station, Auburn, AL.

Cavalheiro, J. M. O., Oliveira de Souza, E. and Bora, P. S. (2007): Utilization of shrimp industry waste in the formulation of tilapia (*Oreochromis niloticus* Linnaeus) feed. Bioresource Technology, 98:602-606.

Collins, R. A. and Delmendo, M. N. (1979): Comparative economics of aquaculture in cages, raceways and enclosures. In: Advance in aquaculture, England, Fishing News Books.

De-Silva, S. S. and Anderson, T. A. (1995): Fish nutrition in aquaculture. CHAPMAN edaw& HALL, London.

Duncan, D. B. (1955): Multiple range and Multiple test. Biometerics, 11: 1-42.

Fagbenro, O. A. (1994): Dried fermented fish silage in diets for *Oreochromis niloticus*. Israeli J. Aquacult., Bamidgeh, 46(3):140-147.

Fagbenro, O. A. and Jauncey, K. (1994): Chemical and nutritional quality of dried fermented fish silage and their nutritive value for tilapia (*Oreochromis niloticus*). Animal Feed Sci., Technol., 45:167-176.

Fagbenro, O. A. and Bello-Olusoii, O. A. (1997): Preparation, nutrient composition and digestibility of fermented shrimp head silage. Food

Chemistry, 60:489-493.

Fagbenro, O. A., Jauncey, K. and Haylor, G. (1994): Nutritive value of diets containing dried lactic acid fermented fish silage and soybean meal for juvenile *Oreochromis niloticus* and *Clarias gariepinus*. Aquat. Liv. Resour., 7:79-85.

Green, B. W. (1992): Substitution of organic manure for pelleted feed in tilapia production. Aquaculture, 101:213-222.

Hardy, R.W.; Shearer, K.D. and Spinelli, J. (1984): The Nutritional properties of Co- dries fish silage in rainbow trout (*Salmo gairdneri*) dry diets. Aquaculture 38, 35- 44.

Jackson, A.J.; Kerr, A.K. and Bullock, A.M. (1984): Fish silage as a dietary ingredient for salmon. II. Preliminary growth findings and nutritional pathology. Aquaculture 40, 283-291.

Jatomes, M. P., Novoa, M. A. O., Figueroa, J. L. A., Hall, G. M. and Shirai, K. (2002): Feasibility of fishmeal replacement by shrimp head silage protein hydrolysate in Nile tilapia (Oreochromis niloticus L) diets. J. Sci. Food Agric., 82:753-759.

Kompiang, I.P.; Arifudin, R. and Raa, J. (1980 a): In "Advances in fish science and technology" (J.J. Connell. ed.), pp. 349-352. Fishing News Book. Ltd- London.

Kompiang, I.P.; Darwanto, A. and Arifuddin, R. (1980 b): Nutritional value of fish silage. In: J.G. Disney and D. James (editors), fish silage production and its use. F.A.O Fish. Rep. No. 230- pp. 44-47.

Kompiang, I.P.; Yashadi T. and Cresswell, D.C. (1980 c): In" Fish silage production and its use" (J.C. Disney and D. James, eds.) pp 38-43. FAO fish Repy No. 230.

Lapie, L. P. and Bigueras-Benitez, C. M. (1992): Feeding studies on tilapia (*Oreochromis niloticus*) using fish silage. pp. 165-177 In: D. James (ed.) FAO Fish Rep., No. 470, FAO, Rome.

Norman, C.A.; Silverside, D.; Hector, D.A. and Francis, S. (1979): Fish silage, Trop. Sci. 21, 221-230.

NRC (1993): Nutrient requirement of fish. National Academy Press, Washington D.C.

Nwanna, L. C. and Daramola, J. A. (2001): Harnessing of shrimp head waste in Nigeria for low cost production of tilapia. Pakistan, J. of Nutrition 2 (6):339-345.

Raa, J. and Gildberg. A. (1982): Fish silage: A review. CRC (Critical Reviews in Food Science and Nutrition 1982), 383-419.

Rungruangsak, K. and Utne, F. (1981): Effect of different acidified wet feed on protease activities in the digestive tract and on growth rate of rainbow trout (*Salmo gairdneri richordson*) Aquaculture 22: 67- 79.

SAS (1996): SAS Procedure Guide "version 6.12 Ed". SAS Institute Inc., Cary, NC, USA.

Soltan, M. A. and El-Laithy, S. M. M. (2008): Evaluation of fermented silage made from fish, tomato and potato by-products as a feed ingredient for Nile tilapia, *Oreochromis niloticus. Egypt. J. Aquat. Biol. & Fish.,* 12(1):25-41.

Soltan, M. A. and Tharwat, A. A. (2006): Use of fish silage for partial or complete replacement of fish meal in diets of Nile tilapia, *Oreochromis niloticus* and African catfish, *Claris gariepinus.* Egyptian J. Nutrition and Feeds, 9(2):299-314.

Soltan, M. A., Hanafy, M. A. and Wafa, M. I. A. (2008): An Evaluation of Fermented Silage Made from Fish By-Products As A Feed Ingredient for African Catfish (*Clarias gariepinus).* Global Veterinaria, 2(2):80-86.

Stone, F. E.; Hardy, R.W.; Shearer, K.D. and Scott, T. M. (1989): Utilization of fish silage by rainbow trout (*Salmo Gairdneri*). Aquaculture, 76, 109-118.

Tacon, A. G. J. (1993): Feed ingredients for warm-water fish: fish meal and other processed feedstuffs. FAO Fisheries Circular No. 856. FAO, Rome.

Wassef, E. A., Sweilam, M. A. and Attalah, R. F. (2003): The use of fermented fish silage as a replacement for fish meal in Nile tilapia (*Oreochromis niloticus*) diets. Egypt. J. Nut. Feed, 6 (Special

Issue):357-370.

Woolford, M. (1975): Microbiological screening of the straight chain fatty acids. (C_{11}, C_{12}) as potential silage additives. Journal of the Science of Food and Agriculture. 26: 219- 228.

REPLACEMENT OF FISH MEAL BY FERMENTED FISH BY-PRODUCTS SILAGE IN THE DIETS OF NILE TILAPIA, (*OREOCHROMIS NILOTICS)* FRY

إحلال مسحوق السمك بالسيلاج الناتج من تخمر مخلفات الأسماك فى علائق زريعة أسماك البلطى النيلى

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الملخص العربي

تم إجراء هذة التجربة بمعمل تغذية الأسماك كلية الزراعة بمشتهر جامعة بنها، وفى هذه التجربة تم دراسة تأثير إدخال مستويات مختلفة من السيلاج المصنع من مخلفات الأسماك فى علائق زريعة أسماك البلطي النيلي. وكان من أهم النتائج المتحصل عليها مايلى:

- اعطت الأسماك التي غذيت على العليقة الاساسية أعلى متوسط لوزن الجسم، وعند إستبدال ٢٥ او ٥٠% من مسحوق لم يؤثر هذا الإحلال معنوياً على وزن جسم الأسماك ومع زيادة نسبة الإحلال لمسحوق السمك بالسيلاج (٧٥% ، ١٠٠%) فى العلائق إنخفض وزن الجسم إنخفاضاً معنوياً مقارنة بمجموعة الكنترول (المقارنة).
- سجلت المجموعة رقم ٣ والتي غذيت على العليقه التى تم فيها إحلال ٥٠% من مسحوق السمك بسيلاج مخلفات الأسماك سجلت أكبر قياس لمتوسط طول الجسم (٥٧, ١١ سم) بينمسا سجلت أسماك المجموعة الخامسة والتى تم فيها إحلال مسحوق السمك إحلالاً تاما بسيلاج مخلفات الأسماك أقل قياس لطول الجسم (٨,٩٥ سم) وكانت الاختلافات فى طول الجسم عند نهاية التجربة بين المعاملات المختلفة معنوية.
- تراوحت متوسطات معامل الحالة في بداية التجربة لزريعة الأسماك عند إحلال مستويات مختلفة من مسحوق السمك بالسيلاج في العلائق بين ١,٩٩ ، ٧٠, ١ وفي نهاية التجربة تراوحت هذه القيم بين ١,٩٦ ، ٢,٠٨ ولم تكن هناك فروقاً معنوية بين هذه المتوسطات فى بداية أو نهاية التجربة.
- سجلت مجموعة الكنترول أعلى زيادة في الوزن (٢٥,٠٥ جم) وأعلى معدل للنمو النسبى (٣ر٠٦) فى حين أعطت المجموعة الخامسة أقل زيادة فى وزن الجسم (١٧,١٦ جم) وأقل معدل للنمو النسبى (٢,٦٢) وكانت الاختلافات للزيادة في وزن الجسم ومعدل للنمو النسبى معنوية وقد أعطت نتائج الغذاء المأكول نتائج مشابهة حيث أستهلكت أسماك مجموعة الكنترول أعلى كمية من الغذاء (٧٢,٦٥ جرام/سمكة) فى حين أستهلكت أسماك المجموعة الخامسة أقل كمية غذاء (٤٦,٨٨ جم) وقد جد ان هناك تأثير معنوي نتج عن استخدام السيلاج كبديل لمسحوق السمك فى كمية الغذاء المستهلك.

- كانت قيم معامل تحويل الغذاء كانــت (٢,٩٠) ، (٣,٠٠) ، (٢,٧٧) (٣,٤٥) ، (٢,٩٩) للمعــاملات الغذائية المختلفة على التوالى وكانت الفروق بين هذه القيم فروقاً معنوية كما تراوحــت قــيم الكفــاءة النسبية للبروتين ما بين ٠,٩٥ ، ١,١٣ وكانت أفضل القيم تلك المتحصل عليها مــن الأســماك التــي تغذت على العليقة التى تم فيها إحلال ٥٠% من مسحوق السمك بالسيلاج.
- أظهرت نتائج التحليل الكيماوي للأسماك ان متوسطات نسب المادة الجافة قد تراوحــت مــابين ٢٢,١٨ ، ٢٥,٩٩% والبروتين الخام ٥٠,٧٤ ، ٦٠,٦٣% كما تراوحت قيم الدهن الخام مــابين ١٧,٩٧ ، ٢٢,٨٥% والرماد ١٦,٢٠ ، ١٧,٢٥% وكانت الفروق بين متوسطات قيم البــروتين والدهن والرماد فروقاً معنوية.

من نتائج هذه التجربة وجد أنه عند استبدال ٥٠% من مسحوق السمك بسيلاج مخلفات الأسماك أدى ذلك إلى تقليل تكاليف تكوين العلف بنسبة ١٥,٥٩%.