*Egyptian J. Nutrition and Feeds (2006) 9 (2):299-314*

# USE OF FISH SILAGE FOR PARTIAL OR COMPLETE REPLACEMENT OF FISH MEAL IN DIETS OF NILE TILAPIA (*OREOCHROMIS NILOTICUS*) AND AFRICAN CATFISH (*CLARIAS GARIEPINUS*)

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**(Received 24/7/2006, accepted 6/9/2006)**

## SUMMARY

Fish silage was prepared by fermentation of fish by-products with *Lactobacillus plantarum*, molasses and rice bran. The ensilage process completed after 30 days and the fermented fish silage (FFS) was sun-dried for 3 days and incorporated into the experimental diets.

Two growth trials were conducted to investigate the effect of partial or complete replacement of fish meal (FM) by dried fermented fish silage (FFS) in diets of Nile tilapia, *Oreochromis niloticus* and African catfish, *Clarias gariepinus*. Five dry pelleted diets containing 0, 10, 20, 30 and 40% FFS to replace 0, 25, 50, 75 and 100% of FM (on protein content basis) were prepared to be isonitrogenous (30% CP) and isocaloric (2600 kcal ME/kg diet) and tested in 3 months feeding separate two trials. Nile tilapia fry (2.57- 2.71 g) and catfish (3.98 - 4.03 g) fed the tested diets twice daily for six days a week in triplicate (Nile tilapia) and duplicate (African catfish) groups experiments. Results indicated that, dried FFS can successfully replace up to 25 and 50% of FM in tilapia and catfish diets, respectively without any significant loss in growth performance and feed utilization. The higher levels of replacement of FM by FFS (50, 75 or 100% in tilapia diets and 75 or 100% in catfish diets) significantly reduced growth performance, feed utilization parameters as well as significant effect on fish body composition of tilapia and catfish. Apparently, FFS can be used efficiently as a protein source in Nile tilapia and catfish diets to reduce feed costs for the two fish species.

From economic view, it was observed that replacing 25% (tilapia) or 50% (catfish) of FM by FFS in diets did not significantly adversed growth or feed utilization parameters of Nile tilapia and catfish and this replacement reduced feed costs/kg diet and feed costs/kg weight gain by 7.35 and 11.30%, for tilapia and by 15.59 and 19.39% for catfish, respectively.

***Keywords***: *fermented fish silage, fish meal replacement, growth, feed utilization, tilapia, catfish .*

## INTRODUCTION

Aquaculture is a fast growing agribusiness in Egypt. Feed is the key input and fish meal is the main ingredient as a source of valuable animal protein in fish diets (Mukhopadhyay et al., 1991). Fish meal is quit expensive and is in short supply. Replacement of fish meal with alternative proteins or alternative processing methods is valid. The adverse effect has been related to deficiencies of certain essential amino acids, particularly methionine and lysine. For this reason, fish nutritionists have supplemented the diet with crystalline amino acids to improve fish growth. In contrast, animal proteins had an adequate concentration of these amino acids which are essential for normal growth. Animal protein also has the advantage of having low concentrations of anti-nutritional factors that might reduce the digestibility and assimilation of nutrients, as is the case when fish are fed plant proteins (Abdel-Fattah and El-Sayed, 1999).

Thus, studies on the use of other efficient and cheaper sources of protein as substitutes for FM are necessary for aquaculture development.

Alternative resources such as meat and bone meal, hydrolyzed feather meal, fleshings-meal and blood meal (Paul et al., 1997 and Millamena, 2002) dried fish and chicken viscera (Giri et al., 2000), poultry silage (Middleton et al., 2001), Cryfish meal (Agouz and Tonsy, 2003) and shrimp meal (Al-Azab, 2005) have been tried to replace fish meal either partially or fully but even these pooled meals of various animal sources are not sufficient to meet the growing demands of fish raising industry.

Fish wastes can be advantageously upgraded into fish feed by fermentation with lactic acid bacteria. This procedure is safe, economically advantageous and environment friendly. The pH value of the fish pastes decreases below 4.5 during ensilage and this pH decrease in partly responsible for preservation (Maria et al., 2000). Fish silage (FS) is generally a product of high biological value presenting practically the same composition as the original raw material (Wassef, 1990, Fagbenro and Jauncey, 1994 and Vidotti and Carneiro, 2002). In developing countries such as Egypt, FS is cheaper to produce, involves simple artisanal technology and possess good storage properties. It represents an alternative to FM in utilizing waste/trash fish (accounted for about 5% of annual farm production) as protein feedstuff for tilapia (Wassef et al., 2003). Acid or fermented fish silage (AFS or FFS), from different raw materials could be stored at ambient temperature (30°C) for six months little or no nitrogen loss or major change in nutritional quality (Wassef, 1990 and Fagbenro and Jauncey, 1993). Some authors stated that FFS generally has a higher nutritional value compared to ASF (Kompiang, 1981 and Okerman and Hansen, 1994). Maria et al., (1998) reported that, ensiling by biological methods, seems promising and yielded both considerable reduction in protein solubilisation and in basic volatile nitrogen when compared with acid ensilage in addition, the oil from biological silages had lower peroxide values than the oil from acid silage. In Egypt, Wassef (1991 and 2002) indicated the successful of partially replacement of FM by AFS in the diets of gilthead bream (*Sparus aurata*) and Nile tilapia (*O. niloticus* × *O. aureus*), respectively. In another study, Wassef et al., (2003) found that dried FFS when used singly or mixed with soybean meal can replace half or three quarters of FM in 28% CP Nile tilapia diets without significant affect on growth performance, feed conversion, protein utilization or fish composition. Vidotti et al., (2003) prepared FFS from commercial marine fish waste, commercial freshwater fish waste or tilapia filleting residue and he concluded that FFS prepared from these wastes are appropriate for use in balanced fish diets.

The present study aimed to evaluate the nutritive value of FFS as protein source in the diets of Nile tilapia and African catfish.

## MATERIALS AND METHODS

The practical work of the present study was carried out at Fish Nutrition Laboratory, Fac. Agric. Moshtohor, Benha University.

### *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%) with rice bran (30%) as filler, dried molasses (5%) as a source of carbohydrate (energy) and 5% of *Lactobacillus plantarum* media as the inculum for lactic acid anaerobic fermentation process. 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 32.5% crude protein (CP).

### *Experimental diets:*

Five experimental diets were formulated (Table, 1) 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 (2600 kcal metabolizable energy (ME)/kg diet). 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.

### *Fish and Experimental system:*

Fingerlings of Nile tilapia and African catfish were obtained from World Fish Center located at Abbassa, Sharkia Governorate, Egypt. The experimental fish were transported in plastic bags filled with water and oxygen to the fish laboratory. Fish were adapted to laboratory conditions and distributed randomly into 4 fiberglass tanks. The fish were weighed and the initial weight for each aquarium (first experiment) and fiberglass tank (second experiment) was recorded.

For tilapia experiment fifteen rectangular aquaria 100 × 50 × 40 cm (200 liter for each) were used (3 replicates for each treatment) and each aquarium was stocked with 20 Nile tilapia fish. The average body weights (BW) were nearly similar and ranged between 2.57 and 2.71 g. For catfish experiment (the second experiment), ten circular fiberglass tanks (700 liter for each) were used (2 replicates for each treatment) and each tank was stocked with 50 catfish fingerlings averaged 3.98 and 4.03 g in weight. All experimental aquaria and fiberglass tanks were aerated by compressed air.

Fish in the two experiments were fed on the pelleted diets (2 mm in diameter) at a daily rate of 10% (during the 1$^{st}$ month), then gradually reduced to 7% (2nd month) and 4% (3rd month) of total biomass and fish were fed 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 and fiberglass tank 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) of both tested fish species.

Records of live BW (g) and BL (cm) of individual fish were measured at the start and the end of tilapia experiment while BW only measured at the start and the end of catfish experiment for each tank. Growth performance and feed utilization parameters were measured by using the following equations:

Specific growth rate (SGR) =

$$\frac{LnW2 - LnW1}{t} \times 100$$

Where:- Ln = the natural log, W1 = initial fish weight; W2 = the final fish weight in "grams" and t= period in days.

Weight gain (WG) = 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).

***Chemical analysis:***

At the end of each experiment, three fish were randomly sampled from each aquarium (tilapia) and five catfish were chosen from each tank and subjected to the chemical analysis of whole fish body according to the methods described in AOAC (1990). Moisture, dry matter (DM), ether extract (EE), crude protein (CP), crude fiber (CF) and ash content of FM, FFM, diets and fish were determined. Dry matter after drying in an oven at 105°C until constant weight; ash content by incineration in a muffle furnace at 600°C for 12 hrs; crude protein (N × 6.25) by the kjeldhal method after acid digestion; and ether extract by petroleum ether (60-80°C) extraction.

***Statistical analysis:***

The statistical analysis of data was carried out by applying the computer program, SAS (1996) by adopting the following model :-

$$Y_{ij} = \mu + \alpha_i + e_{ij}$$

Where, $Y_{ij}$ = the observation on the ij$^{th}$ fish eaten the i$^{th}$ diet; $\mu$ = overall mean, $\alpha_i$ = the effect of i$^{th}$ diet and $e_{ij}$ = random error.

**RESULTS AND DISCUSSION**

***a) Proximate analysis of FFS:***

Proximate analysis of FFS used in the present study is shown in Table (2). As shown in this table, FFS contained 96.37, 32.51, 6.64 and 9.21% DM, CP, EE and ash, respectively. Salah El-Din (1995) found that, dry FFS contained 50.07, 15.70 and 19.76% CP, EE and ash, respectively. The high protein content of FFS indicated that FFS considered to be an excellent protein source in tilapia and catfish diets. Vidotti et al., (2003) prepared FFS from three raw materials, commercial marine fish waste, commercial freshwater fish waste and tilapia filleting residue and he found that, protein contents of FFS were 77.67, 49.62 and 42.99 in FFS prepared from these wastes, respectively.

Results presented in Table (2) show that FM displayed better amino acid profile as it had higher levels of all indispensable amino acids except for histidine compared to those of FFS. Similar results were obtained by Wassef et al., (2003).

With regard to amino acid requirements of Nile tilapia, data of Table (2) indicated that, amino acids content of FFS covered requirements of leucine, valine and histidine and it is deficient in the other indispensable amino acids however amino acid content of FFS covered all indispensable amino acid requirements for catfish except for lysine, isoleucine and arginine. Wassef et al., (2003) showed that, amino acids content of FFS did not covered all indispensable amino acid requirements for *O. niloticus* except for leucine.

Although it was not determined in the present trials, a good apparent digestibilities for DM, CP and EE were reported during previous FFS feeding trials with Nile tilapia (Fagbenro and Jauncey, 1993 and 1994). They indicated that apparent protein digestibility decreased with the increase of FFS (from 85.5 to 80.6% for the 25 and 100% FM replacement levels, respectively). In another study, Fagbenro and Bello-Olusoii (1997) showed that, apparent digestibility coefficient of DM, CP and gross energy for fermented shrimp head silage was high (> 70%) for catfish fingerlings. In another study, Fagbenro and Jauncey (1998) mixed FFS (2:1, w/w) with poultry by-products meal, soybean-hydrolyzed feather meal or menhaden fish meal and each mixture pelleted by cold extrusion method. They found that, apparent digestibility coefficient (ADC) for dry matter, crude protein and gross energy of the pellets were high (>80%) and similar (P>0.05) among diets for *O. niloticus*.

***Growth trials:***

***a. Tilapia:***

***1. Growth performance:***

The effect of the experimental diets on fish growth and feed utilization after 3 months of experimental feeding are included in Table (3). The highest growth trend was obtained with FFS0 (control) followed in descending order by FFS25, FFS50, FFS75 and FFS100 diets. Lower response was registered with FFS100. Key variables such as final body weight (BW), final body length (BL), weight gain (WG) and specific growth rate (SGR) presented significantly higher values (P<0.05) for FFS0 and FFS25 diets. In general, the best response in growth obtained with FFS0 and FFS25 and the worst with the higher levels of FFS inclusion.

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 25% of fish meal protein without adverse effect on growth performance of Nile tilapia.

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% of FM protein was replaced by FFS protein it did not followed by significant effect on all growth parameters (BW, BL, WG and SGR) while the higher replacing levels significantly adversed these parameters. Table (2) show that FM 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, 3)

It is important to remark that the lower substitution level of FM by FFS (25%) supported better growth rates in tilapia in comparison with the higher levels (50, 75 and 100%). These results are relatively in accord with Espe et al., (1999) who re[ported a similar effect for low inclusion levels (15%) using fish silage in Atlantic salmon diets. Also, Jatomea et al., (2002) found that, replacing FM by shrimp head silage in Nile tilapia diets up to 15% showed the best response in growth performance while the higher replacing levels (20, 25 or 30%) resulted in the worst growth response. Berge and Storebakken (1996) reported that small amounts of silage improved the growth efficiency of Atlantic salmon fry.

Results of Table (3) concerning growth performance of Nile tilapia 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, 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) significantly ($P<0.05$) decreased the final BW of Nile tilapia fed 28% CP experimental diets while WG and SGR did not significantly affected by the partial or the complete contained comparatively higher total replacement of FFS alone or when mixed with soybean meal.

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*.

### *2. Feed utilization:*

As shown in Table (3), feed intake (FI) was significantly ($P<0.01$) decreased with each increase in FFS content of tilapia diets as a replacement of FM. FCR increased when the substitution of FM by FFS increased. FCR for the diets FFS0 and FFS25 was significantly lower than the other diets tested. Also, PER was significantly higher for these treatments (Table, 3). 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 and PER.

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 diet

FFS25. FFS included in diets fed to tilapia had positive feed utilization and digestibility (Fagbenro and Bello-Olusoii, 1997 and Fagbenro, 1994). Jatomea et al., (2002) found that the higher FI and the best FCR and PER 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, FCR and PER were obtained for 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 FI, FCR and PER.

***3- Proximate analysis:***

Averages of whole body chemical composition of Nile tilapia including DM, CP, EE and ash are presented in Table (3). As shown in this table, increasing replacing levels of FM by FFS decreased DM content in the whole body and the differences among fish groups were not significant. 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. Wassef et al., (2003) found that, replacing of FM by FFS up to 75% did not significantly affected protein content of tilapia bodies.

Partial or total replacement of FFS by FM did not significantly affected EE content of tilapia fish. As compared to control group (FFS0), all replacing levels of FM by FFS significantly ($P<0.01$) increased ash content of whole fish bodies and these results may be due to the high ash content of fish by-products used in preparation of FFS and these results were relatively similar to those obtained by Wassef et al., (2003).

**2. Catfish:**

***1. Growth performance:***

Mean BW, WG and SGR of catfish are presented in Table (4). As described in this table, the initial BW of fish groups were relatively the same and ranged between 3.98 and 4.03 g. At the experimental termination (90 days) there were gradually decreased ($P<0.001$) in final BW as the replacing levels of FM by FFS increased. Results of Table (4) show that, increasing replacing levels of FM by FFS up to 50% in catfish diets did not significantly affected the final BW of catfish while the higher replacing levels (75 or 100%) significantly ($P<0.001$) decreased the final BW of catfish and the same trend was also observed for WG and SGR. Guzmān and Viana (1998) demonstrated that, ablone viscera silage can be used to replace FM in diets for ablone without significant differences in growth. Fagbenro and Bello-Olusoii (1997) concluded that dried FFS is suitable and has a potential as a protein feedstuff in catfish, *Clarias gariepinus* diets.

Results of growth performance (Table 4) revealed the possibility of replacing 50% of FM by FFS in catfish diets without negative effects on BW, WG and SGR and these results may be attributed to the IAA content of FFS which covered the requirements of IAA for catfish except for lysine, isoleucine and arginine (Table, 2). Another reason for the good response of fish fed the FFS diets might be the presence of pre-hydrolyzed proteins, which facilitate digestion and therefore assimilation. In this hence Fagbenro (1994) reported similar behaviour for fish fed dried fermented fish silage. It is known that fish can assimilate protein as amino acids and short peptides, so the protein breakdown during the treatment could have a positive effect on the digestibility and assimilation of this nutrient.

Results of growth performance of Nile tilapia and African catfish (Tables 3 and 4) revealed the possibility of replacing 25% of FM protein by FFS protein in tilapia diets and 50% in catfish diets without significant effect on growth performance and these results may be due to the higher requirements of IAA for Nile tilapia compared to African catfish (Table 2).

### *2. Feed utilization:*

Results of Table (4) outlined FI, FCR and PER for catfish groups fed the diets contained the graded levels of FFS as replacement of FM. As described in this table FI (g/fish) significantly ($P<0.05$) decreased as FFS increased in the diets and FI values lie in three groups, the first group is FF0 (control); the second group included fish fed the diets FFS25 and FFS50 and the third one contained fish groups fed the diets FFS75 and FFS100. The differences in FI between the first and the third groups were significant ($P<0.05$) while the differences between the second group and each of the first or the third groups were not significant. Considering the acceptability of the FFS diets, the use of FFS in diets might act as a natural feed stimulant.

As shown in Table (4), increasing the replacing levels of FM by FFS up to 50% did not significantly affected FCR and PER while the higher replacing levels (75 or 100%) significantly adversed FCR and PER of catfish. Many reasons may explain the good feed and protein utilization of the experimental diets: a) feed were nutritionally adequate, particularly the essential amino acid content, b) there were minimal losses of nutrients because the diets were water stable and rapidly consumed and c) the presence of rapidly assimilated pre-digested proteins. Similarly, Lapie and Bigueras-Benitez (1992) found that the inclusion of pre-digested protein from dried acid-preserved offals of *Sardinella* spp. was beneficial to tilapia and provided 50% of the total dietary protein without affecting growth, feed intake, feed conversion or protein utilization.

### *3- Proximate analysis:*

Proximate analysis of catfish (Table, 4) indicated that, DM of whole fish bodies did not significantly affected by all replacing levels of FM by FFS and the same trend was also observed for ash content of whole fish bodies. Compared to control fish group, all replacing levels of FM by FFS significantly ($P<0.001$) decreased protein content and the opposite trend was observed for EE whereas fish group fed the control diet (FFS0) gained the highest protein and the lowest EE contents. Fish group fed the diet FFS25 showed the lowest ($P<0.001$) ash content of whole fish bodies but the differences among the other groups (FFS0, FFS50, FFS75 and FFS100) were not significant.

### *Economical evaluation:*

Results of economic evaluation including feed costs, costs of one kg gain in weight and its ratio to that of control group fed the diet FFS0 are presented in Table (5). As presented in this table, costs of one ton of the diets FFS0, FFS25, FFS50, FFS75 and FFS100 were 2735.5, 2518.5, 2309.0, 2103.0 and 1891.25 L.E., respectively.

These results indicated that incorporation of FFS in tilapia and catfish diets as a substitute of FM decreased feed costs by 7.93, 15.59, 23.12 and 30.86% for the diets FFS25, FFS50, FFS75 and FFS100 compared to the control diet (FFS0). Costs of one kg gain in weight were 5.22, 4.63, 4.99, 4.61 and 4.56 L.E for Nile tilapia and 4.90, 4.43, 3.95, 4.56 and 4.41 L.E for catfish fed the diets FFS0, FFS25, FFS50, FFS75 and FFS100, respectively.

Results of the present study indicated that, replacement of 25% of FM protein by FFS protein in tilapia diets did not significantly adversed all growth and feed utilization parameters and reduced feed costs/kg diet and feed costs/kg weight gain by 7.93 and 11.30%, respectively. Also, replacement of 50% of FM by FFS in catfish diets did not significantly affected all growth and feed utilization parameters and reduced feed costs/kg diet and feed costs/kg weight gain by 15.59 and 19.39%, respectively. The higher replacing levels of FM by FFS (50, 75 or 100% (in tilapia diets) and 75 or 100% (in catfish diets) significantly reduced all growth and feed utilization parameters and also reduced feed costs/kg diet and feed costs/kg weight gain.

## CONCLUSION

From results obtained in the present study it could be concluded the possibility of replacing 25% (tilapia) and 50% (catfish) of FM by FFS in the diets, without adverse effect on growth or feed utilization parameters of Nile tilapia and catfish, and this replacement reduced feed costs/kg diet and feed costs/kg weight gain by 7.93 and 11.30%, for tilapia and reduced feed costs/kg diet and feed costs/kg weight gain by 15.59 and 19.39% for catfish, respectively.

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**Table (1): Composition and proximate analysis of the experimental diets.**

| Ingredients | Diets | | | | |
|---|---|---|---|---|---|
| | FFS0 | FFS25 | FFS50 | FFS75 | FFS100 |
| Fish meal (65%) | 20 | 15 | 10 | 5 | 0 |
| Yellow corn | 30 | 26 | 21 | 17 | 14.5 |
| Soybean meal (44%) | 30 | 31 | 33 | 35 | 36 |
| Fermented fish silage | 0 | 10 | 20 | 30 | 40 |
| Wheat bran | 14.5 | 11.5 | 8.5 | 4.5 | 0 |
| Vegetable oil | 2 | 3 | 4 | 5 | 6 |
| Vit. & Min. Mixture[1] | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 |
| Sum | 100 | 100 | 100 | 100 | 100 |
| ***Proximate analysis*** | *(determined on dry matter basis)* | | | | |
| Dry matter (DM) | 93.71 | 94.10 | 93.82 | 95.92 | 94.07 |
| Crude protein (CP) | 30.45 | 30.27 | 30.43 | 30.60 | 30.44 |
| Ether extract (EE) | 6.22 | 5.98 | 5.65 | 6.01 | 5.99 |
| Crude fiber (CF) | 9.87 | 9.56 | 8.74 | 7.61 | 7.22 |
| Ash | 7.94 | 8.11 | 8.24 | 8.55 | 8.97 |
| NFE[2] | 45.52 | 46.08 | 46.94 | 47.23 | 47.38 |
| ME[3] (Kcal/kg diet) | 2644 | 2631 | 2606 | 2600 | 2623 |
| P/E ratio[4] | 115.17 | 115.05 | 116.77 | 117.69 | 116.05 |

[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 (mg protein/kcal ME).

**Table (2): Proximate analysis of FFS compared to FM and the indispensable amino acid requirements of Nile tilapia and catfish.**

| | Proximate analysis (%), on dry matter basis | | | |
|---|---|---|---|---|
| | DM | CP | EE | Ash |
| FFS | 96.37 | 32.51 | 6.64 | 9.21 |

| Amino acids profile (g/100 g protein) | | | | |
|---|---|---|---|---|
| Amino acid | Requirements of Nile tilapia* | Requirements of catfish** | Fish male (FM) | Fermented fish silage (FFS) |
| Lysine | 5.12 | 5.10 | 5.80 | 4.43 |
| Leucine | 3.39 | 3.50 | 7.30 | 3.83 |
| Isoleucine | 3.11 | 2.60 | 4.30 | 2.00 |
| Cystine Methionine | 3.21 | 2.30 | 3.30 | 2.68 |
| Phenylalanine Tyrosine | 5.54 | 5.00 | 7.20 | 5.48 |
| Threonine | 3.75 | 2.00 | 3.60 | 2.12 |
| Valine | 2.80 | 3.00 | 5.40 | 3.09 |
| Tryptophane | 1.00 | 0.50 | 1.10 | 0.57 |
| Histidine | 1.72 | 1.50 | 2.50 | 5.85 |
| Arginine | 4.20 | 4.30 | 5.00 | 3.32 |
| Total (%) | | | 45.50 | 33.37 |

* Data resulting from growth experiments **(Santiago and Lovell, (1988)**

** **NRC (1993)**

**Table (3): Growth performance, feed utilization and proximate analysis of Nile tilapia as affected by replacing FM by FFS.**

| Item | No. | Diets | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | FFS0 | FFS25 | FFS50 | FFS75 | FFS100 | ±SE | *Prob.* |
| ***Growth performance*** | | | | | | | | |
| Body weight (g) | | | | | | | | |
| Initial | 60 | 2.66 | 2.60 | 2.71 | 2.57 | 2.62 | 0.09 | 0.8473 |
| Final | 60 | 41.96 a | 39.59 a | 34.13 b | 30.59 c | 26.55 d | 1.01 | 0.0001 |
| Body length (cm) | | | | | | | | |
| Initial | 60 | 5.45 | 5.43 | 5.56 | 5.41 | 5.34 | 0.08 | 0.3317 |
| Final | 60 | 13.21 a | 13.07 a | 12.57 b | 12.10 c | 11.48 d | 0.15 | 0.0006 |
| Weight gain (g/fish) | 3+ | 39.30 a | 36.99 a | 31.42 b | 28.02 b | 23.93 c | 0.05 | 0.0011 |
| Specific growth rate | 3+ | 3.06 a | 3.03 a | 2.81 b | 2.75 b | 2.57 c | 0.01 | 0.0001 |
| ***Feed utilization*** | | | | | | | | |
| FI (g/fish) | 3+ | 74.99 a | 68.11 b | 67.81 b | 61.25 c | 57.54 d | 0.83 | 0.0060 |
| FCR | 3+ | 1.91 c | 1.84 c | 2.16 b | 2.19 b | 2.40 a | 0.03 | 0.0010 |
| PER | 3+ | 1.72 a | 1.79 a | 1.52 b | 1.50 b | 1.37 c | 0.02 | 0.0007 |
| *Proximate analysis* | | | | | | | | |
| Dry matter (DM) | 9 | 76.66 | 76.03 | 75.68 | 75.26 | 75.25 | 0.31 | 0.0882 |
| Crude protein (CP) | 9 | 67.26 b | 67.32 b | 67.36 b | 68.84 a | 68.98 a | 0.19 | 0.0010 |
| Eteher Extract (EE) | 9 | 15.75 | 15.47 | 15.12 | 14.96 | 14.97 | 0.17 | 0.0860 |
| Ash | 9 | 14.15 b | 15.02 a | 15.52 a | 15.55 a | 15.44 a | 0.39 | 0.0064 |

Means with the different letters in each row for each trait are significantly different (P<0.05).

+ average of 3 aquaria (replicates)

**Table (4): Growth performance, feed utilization and proximate analysis of African catfish as affected by replacing FM by FFS.**

| Item | No. | Diets FFS0 | FFS25 | FFS50 | FFS75 | FFS100 | ±SE | *Prob.* |
|---|---|---|---|---|---|---|---|---|
| *Growth performance* | | | | | | | | |
| Body weight (g) | | | | | | | | |
| Initial | 100 | 4.03 | 4.00 | 3.98 | 3.99 | 4.03 | 0.17 | 0.9541 |
| Final | 100 | 60.48 a | 57.89 a | 56.00 a | 43.50 b | 39.34 b | 1.20 | 0.0001 |
| Weight gain (g/fish) | 2+ | 56.45 a | 53.89 a | 52.02 a | 39.51 b | 35.31 c | 0.17 | 0.0001 |
| Specific growth rate | 2+ | 3.01 a | 2.97 a | 2.94 a | 2.65 b | 2.53 c | 0.01 | 0.0001 |
| ***Feed utilization*** | | | | | | | | |
| FI (g/fish) | 2+ | 100.9 a | 94.90 ab | 88.80 ab | 85.60 b | 82.40 b | 2.31 | 0.0452 |
| FCR | 2+ | 1.79 b | 1.76 b | 1.71 b | 2.17 a | 2.33 a | 0.07 | 0.0010 |
| PER | 2+ | 1.84 a | 1.88 a | 1.93 a | 1.51 b | 1.41 b | 0.07 | 0.0029 |
| *Proximate analysis* | | | | | | | | |
| Dry matter (DM) | 10 | 28.95 | 29.58 | 28.63 | 29.51 | 29.13 | 0.30 | 0.6301 |
| Crude protein (CP) | 10 | 66.62 a | 62.29 c | 64.32 b | 65.22 b | 61.98 c | 1.56 | 0.0007 |
| Ether extract (EE) | 10 | 18.67 d | 24.48 a | 23.63 a | 20.41 c | 23.64 b | 0.14 | 0.0005 |
| Ash | 10 | 12.13 | 11.59 | 11.41 | 12.41 | 12.37 | 0.59 | 0.0037 |

Means with the different letters in each row for each trait are significantly different ($P<0.05$).
+ average of 2 Tanks (replicates)

**Table (5): Feed costs (L.E) for producing one kg weight gain by fish fed the experimental diets.**

| 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 |
|---|---|---|---|---|---|---|---|
| **Nile tilapia** | | | | | | | |
| FFS0 | 2735.5 | 100 | 0.00 | 1.91 | 5.22 | 100 | 0.00 |
| FFS25 | 2518.5 | 92.07 | 7.93 | 1.84 | 4.63 | 88.70 | 11.30 |
| FFS50 | 2309.0 | 84.41 | 15.59 | 2.16 | 4.99 | 95.59 | 4.41 |
| FFS75 | 2103.0 | 76.88 | 23.12 | 2.19 | 4.61 | 88.31 | 11.69 |
| FFS100 | 1891.25 | 69.14 | 30.86 | 2.40 | 4.54 | 96.97 | 13.03 |
| **African catfish** | | | | | | | |
| Diets | Costs (L.E)/ ton | Relative to control % | Decrease in feed costs (%) | FCR | Feed costs* (L.E.)/kg weight gain | Relative to control % | Decrease in Feed costs * (L.E)/kg Weight gain |
| FFS0 | 2735.5 | 100 | 0.00 | 1.79 | 4.90 | 100 | 0.00 |
| FFS25 | 2518.5 | 92.07 | 7.93 | 1.76 | 4.43 | 90.41 | 9.59 |
| FFS50 | 2309.0 | 84.41 | 15.59 | 1.71 | 3.95 | 80.61 | 19.39 |
| FFS75 | 2103.0 | 76.88 | 23.12 | 2.17 | 4.56 | 93.06 | 6.94 |
| FFS100 | 1891.25 | 69.14 | 30.86 | 2.33 | 4.41 | 90.00 | 10.00 |

* Feed costs/kg weight gain = FCR × costs of kg feed.
Local market price (L.E./ton) for feed ingredients used for formulating the experimental diets when the experiment was started; fish meal 6000 LE/ton, yellow corn 1250, soybean meal 2000, FFS 1000, wheat bran 900, corn oil 4000 and vit.& Min. Mixture 10000 LE/ton.

*Egyptian J. Nutrition and Feeds (2006) 9 (2):299-314*

**إستخدام سيلاج الأسماك كبديل جزئى أو كلى لمسحوق السمك فى علائق أسماك البلطى النيلى والقرموط الأفريقى**

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فى هذه الدراسة تم إعداد سيلاج الأسماك بإستخدام مخلفات الأسماك (الأجزاء الغير مأكولة) والتى تم فرمها وخلطها بنسبة ٦٠% مع ٥% بيئة بكتريا اللاكتوبسلس ، ٥% مولاس كمصدر للطاقة ، ٣٠% رجيع أرز وقد استغرقت عملية التخمر ٣٠ يوم حيث تم تجفيف السيلاج فى الشمس وتم إدخاله فى العلائق التجريبيه ثم أجريت تجربتان لدراسة تأثير الإحلال الجزئى والكلى لمسحوق السمك بسيلاج الأسماك المخمر فى علائق أسماك البلطى النيلى والقرموط الأفريقى ولذلك تم تكوين خمس علائق تجريبية تم فيها إحلال بروتين مسحوق السمك ببروتين السيلاج بنسبة صفر ، ٢٥ ، ٥٠ ، ٧٥ ، ١٠٠% بحيث كانت جميع العلائق متماثلة فى محتواها من البروتين الخام (٣٠%) والطاقة الممثلة (٢٦٠٠ كيلو كالورى طاقة ممثلة/كجم عليقة) ثم أختبرت هذه العلائق فى تجربتين منفصلتين وكانت مدة كل تجربة ثلاثة اشهر. وتم تغذية أسماك البلطى النيلى ( ٢٫٥٧- ٢٫٧١ جم وزن إبتدائى) كما غذيت أسماك القرموط ( ٣٫٩٨- ٤٫٠٣ جم وزن إبتدائى) مرتين يومياً (ستة أيام فى الأسبوع) وأختبرت كل عليقة فى ثلاث أحواض (مكررات) بالنسبة لأسماك البلطى وحوضين (مكررين) لأسماك القرموط.

هذا وقد أظهرت النتائج أن سيلاج الأسماك المعد بطريقة التخمر قد حل محل مسحوق السمك بنسبة وصلت إلى ٢٥% فى علائق أسماك البلطى ، ٥٠% فى علائق أسماك القرموط دون أن تؤثر عملية الإحلال هذه معنوياً على صفات النمو والكفاءة الغذائية لكلاً من أسماك البلطى والقرموط. أما نسب الإحلال الأعلى (٥٠ ، ٧٥ أو ١٠٠ بالنسبة للبلطى) أو (٧٥ ، ١٠٠ بالنسبة للقرموط) فقد أدت هذه النسب إلى تناقص معدلات النمو والكفاءة الغذائية لكلاً من أسماك البلطى والقرموط. وبالتالى يمكن القول بأن سيلاج الأسماك يمكن إستخدامة فى تكوين علائق أسماك البلطى والقرموط لتقليل تكاليف التغذية.

من الناحية الإقتصادية فقد وجد أن إحلال ٢٥ % من بروتين مسحوق السمك ببروتين سيلاج الأسماك فى علائق أسماك البلطى لم يؤثر معنوياً على صفات النمو والكفاءة الغذائية مع تقليل تكاليف الغذاء وتكاليف التغذية اللآزمة لإنتاج كجم زيادة فى وزن الجسم بقدار ٧٫٣٥ ، ١١٫٣٠% على التوالى. أما بالنسبة لأسماك القرموط فقد وجد أن عملية الإحلال حتى ٥٠ % من بروتين مسحوق السمك ببروتين سيلاج الأسماك لم تؤثر معنوياً على صفات النمو والكفاءة الغذائية مع تقليل تكاليف الغذاء وتكاليف التغذية اللآزمه لإنتاج كجم زيادة فى وزن الجسم بمقدار ١٥٫٥٩ ، ١٩٫٣٩% على التوالى.