THE USE OF SMOKED FISH WASTE MEAL AS A FEED IN PRACTICAL DIET FOR ALL-MALE MONOSEX NILE TILAPIA (*OREOCHROMIS NILOTICUS*)

MOHAMMAD H. AHMAD[1] AND AHMED S. DIAB[2]

1. *Fish Nutrition Dept. and 2- Fish Disease Dept., Central Laboratory for Aquaculture Research, Abbassa, Abo-Hammad, Sharkia, Egypt.*

Corresponding author e-mail: md_ahmad55@yahoo.com

Abstract

A 15-week experiment was conducted to evaluate the use of smoked fish waste meal (SFWM) in practical diets for all-male monosex Nile tilapia, *Oreochromis Niloticus* (30.1±0.01 g). Five isonitrogenous diets (25% protein) were formulated in which SFWM replaced 0.0%, 25%, 50%, 75% or 100% of the protein supplied by herring fish meal (HFM). Fish were fed the tested diets at the rate of 3% of the fish body weight. Diets were fed to the fish 6 days a week 2 times a day at 9.00 and 14.00 h. Results demonstrated that SFWM has good potential as a complete substitute of the protein supplied by HFM for all male monosex Nile tilapia No significant (P > 0.05) changes were observed in growth performance,feed efficiency and protein utilization compared to fish fed the HFM–based diet (control diet). Survival rate of Nile tilapia fed all the experimental diets was high and its range was 98.90 - 100% without significantly difference among them (P > 0.05). At the end of the study, partial or complete replacement of SFWM-protein for HFM–protein in the diets did not affect fish composition dry mater, protein or fat levels compared to the control treatment. This study clearly indicates that SFWM can serve as a complete replacement for fish meal in fish diets.

Keywords: Smoked fish waste meal, all male monosex Nile tilapia, growth, feed utilization, and proximate chemical composition.

INTRODUCTION

Aquaculture sector is growing fast worldwide. This rapid development largely depends upon fish meal (FM), which is considered the most desirable animal protein ingredient in aquaculture feeds because of its high protein content, balanced amino acid profile, high digestibility and palatability, and as a source of essential n-3 polyenoic fatty acids (Hardy and Tacon, 2002). Global FM production is approximately 6-7 million tons per year. The continuous increasing demand for fish meal use in animal feed especially in aqua feed has resulted in fish meal becoming difficult to obtain and more expensive. Therefore, the search for alternatives to fish meal is an international research priority (Abdelghany, 2003; Abdelghany *et al.*, 2005; Ahmad, 2008). The increase cost of FM and concerns regarding its future availability have made it imperative for the aquaculture industry to reduce or eliminate FM from fish diets when possible. So, many studies tried to partially or totally substitute FM with less expensive animal and/or plant protein sources. Despite the fact that large amounts of fishery by–products and by-catch are produced annually in the world, little attention has been paid to the commercial use of these by-products for tilapia (El-Sayed, 2004).

The industry of smocked fish waste meal (SFWM) produced a huge waste rich in protein (39% on dry matter basis) and it may be used as a replacer of fish meal in fish diets. Therefore, this study was carried out to evaluate the use of SFWM as a herring fish meal (HFM) substitute in practical diets for all male mono-sex Nile tilapia and its relation to fish growth, feed utilization, and whole fish body composition.

MATERIALS AND METHODS

Water quality

Water samples were collected every 2 weeks from the entrance, the middle and the end of the cages location. Water temperature and dissolved oxygen were measured by oxygen-meter (YSI model 58, USA) and pH was measured by pH-meter (Fisher Scientific, USA) Water conductivity and salinity were measured by conductivity-meter (YSI model 33, USA). Water transparency was measured by Secchi disc. The values of these parameters are within the acceptable range of fish farming except dissolved oxygen (Boyd, 1990).

Table 1. Water quality parameters in the cages region during the experimental period as ranges.

Site	Temp. (°C)	D.O. (mg/l)	S.D. (cm)	pH	NH4 (mg/l)	TDS (g/l)	Salinity (g/l)
Water entrance to cages	22.5-29.5	2.2-4.2	67	8	1.1-2.2	2.232	1.1
Cage in middle	23.5-29.5	1.6-4.0	65	8	1.3-2.4	2.238	1.1
Cage in the end	23-30	1.2-3.3	64	8	1.4-2.4	2.241	1.1
Outlet of water	23.5-29.5	1.1-3.0	67	8	1.4-2.4	2.244	1.1

Diet preparation and feeding regime

Five diets have formulated to be isonitrogenous (25.2% crude protein) and isolipidic (6.92% crude fat). The composition of the diets is shown in Table (2). Diet 1 (control) contained HFM as a sole source of animal protein and diet 5 contained SFWM as a sole source of animal protein. Diets 2 to 4 contain mixtures of HFM and SFWM as sources of animal protein supplements with the proportions of each adjusted so that each of the two ingredients provide similar graded levels of animal protein in the diet. Graded levels of protein replacements were 0%, 25 %, 50 %, 75%, or 100%, respectively. All the diets contained a constant level of plant protein from soybean meal (SBM), corn meal, and wheat bran to complete Nile tilapia protein requirements.

In the present study, SFWM was a product brought from the Negma factors (Giza, Egypt), and it consists of some fish not good for smoking and some part of fish such as head, skin, bone and some meat. The diets were prepared palletized, stored, and previously described by Abdelghany (2003).

Fish and culture technique

Hormone treated all male monosex Nile tilapia was divided into 15 groups (in fifteen cages), each one was stocked by 10 fish (average weight 30.1 g each). Each subgroup of fish was transferred randomly into cage (1x1x1 m). The fish cages were inserted in Mazola lake at the Port-Said Government, Egypt. The feeding rate was 3% of fish body weight during the course of the experiment. Feed was offered to fish two times daily; 6 days a week for 15 weeks. Fish from each cage were collected every two weeks and collectively weighed and the feed ratio was adjusted each time accordingly.

Table 2. Ingredients and chemical composition of the experimental diets (on dry matter basis).

Ingredients	SFWM levels (%)				
	0.0	25	50	75	100
HFM	7.88	5.91	3.94	1.98	0.00
SFBM	0	3.55	7.08	10.60	14.16
Soybean meal	31.11	31.11	31.11	31.11	31.1
Corn meal	19.50	19.50	19.50	19.50	19.50
Wheat bran	27.68	27.68	27.68	27.68	27.68
Starch	4.00	3.03	1.69	0.13	0.00
Cod - liver oil	0.83	0.22	0.00	0.00	0.00
Corn oil	1.50	1.50	1.50	1.50	1.50
Vit [1]+Min. premix[2](1 :1)	2.00	2.00	2.00	2.00	2.00
Binding agent (starch)	2.00	2.00	2.00	2.00	2.00
Cellulose	3.50	3.50	3.50	3.50	2.05
Total	100	100	100	100	100
Chemical analyses (%)					
Moisture	8.53	8.58	9.01	8.78	8.62
Crude protein	25.10	25.34	25.22	25.42	25.01
Ether extract	6.88	6.71	6.91	6.78	6.99
Ash	6.10	6.34	6.55	6.61	7.31
Crude fiber	5.60	5.48	5.81	5.62	5.55
NFE[3]	56.31	56.13	55.51	55.57	55.14
GE (kcal/100g)[4]	437.71	436.71	435.38	435.53	433.44
P/E ratio	57.34	58.02	57.93	58.37	57.70

[1] Vitamin premix (per kg of premix): thiamine, 2.5 g; riboflavin, 2.5 g; pyridoxine, 2.0 g; inositol, 100.0 g; biotin, 0.3 g; pantothenic acid, 100.0 g; folic acid, 0.75 g; para-aminobenzoic acid, 2.5 g; choline, 200.0 g; nicotinic acid, 10.0 g; cyanocobalamine, 0.005 g; a-tocopherol acetate, 20.1 g; menadione, 2.0 g; retinol palmitate, 100,000 IU; cholecalciferol, 500,000 IU.

[2] Mineral premix (g/kg of premix): $CaHPO_4.2H_2O$, 727.2; $MgCO_4.7H_2O$, 127.5; KCl 50.0; NaCl, 60.0; $FeC_6H_5O_7.3H_2O$, 25.0; $ZnCO_3$, 5.5; $MnCl_2.4H_2O$, 2.5; $Cu(OAc)_2.H_2O$, 0.785; $CoCl_3..6H_2O$, 0.477; $CaIO_3.6H_2O$, 0.295; $CrCl_3.6H_2O$, 0.128; $AlCl_3.6H_2O$, 0.54; Na_2SeO_3, 0.03.

[3] Nitrogen-Free Extract (calculated by difference) = 100 – (protein + lipid + ash + fiber).

[4] Gross energy (GE) was calculated from (NRC, 1993) as 5.65, 9.45, and 4.1 kcal/g for protein, lipid, and carbohydrates, respectively.

Proximate analysis of diet and fish

At the start of the experiment, 50 fish were taken and kept frozen for chemical analysis. At the end, the basal diet and fish samples from each treatment were chemically analyzed according to the standard methods of AOAC (1990) for determination of moisture, crude protein, total lipids, and ash. Moisture content was estimated by heating samples in an oven at 85°C until constant weight and calculating the weight loss. Nitrogen content was measured using a microkjeldahl apparatus and crude protein was estimated by multiplying nitrogen content by 6.25. Lipid content was determined by ether extraction for 16 hours and ash was determined by combusting samples in a muffle furnace at 550°C for 6 hours. Crude fiber was estimated according to Goering and Van Soest (1970).

Growth Parameters

Growth performance was determined and feed utilization was calculated as follows:

Weight gain = $W_2 - W_1$;

Specific growth rate (SGR) = 100 ($\ln W_2 - \ln W_1$) / T

Where: W_1 and W_2 are the initial and final weight, respectively, and T is the number of days in the experimental period;

Feed conversion ratio (FCR) = feed intake / weight gain;

Feed efficiency ratio (FER) = weight gain / feed intake

Protein efficiency ratio (PER) = weight gain / protein intake;

Statistical analysis

The obtained data of fish growth, feed utilization and survival rate, proximate and chemical composition were subjected to one-way ANOVA. Differences between means were tested at the 5% probability level using Duncan test. All the statistical analyses were done using SPSS program version 10 (SPSS, Richmond, VI, USA) as described by Dytham (1999).

Economical evaluation

The cost of feed to raise unit biomass of fish was estimated by a simple economic analysis. The estimation was based on local retail sale market price of all the dietary ingredients at the time of the study. These prices (in LE/kg) were as follows: herring fish meal, 12.0; SFWM, 1.75; soybean meal, 2.0; corn meal, 1.40; wheat bran, 1.40; starch, 2.0; fish oil, 7.0; corn oil, 5.0; vitamin premix, 7.0; mineral mixture, 3.0; and cellulose, 3.0. An additional 150.0 LE/ton was added as manufacturing cost.

RESULTS

Initial body weigh at all experimental treatments did not differ significantly (Table 3). At the end of the study, the growth performance (final body weight, weight gain, weight gain %, and specific growth rate) and diet utilization (feed intake, FCR, FER and PER) were not significantly (P > 0.05) affected by SFWM inclusion levels.

Table 3. Growth performance and feed utilization of Nile tilapia fed diets containing different levels of SFWM Means in the same row having the same letter is not significantly different at P < 0.05.

	SFWM levels (%)				
	0.0	25	50	75	100
Initial weight (g)	30.07±0.08	30.10±0.05	30.03±0.03	29.93±0.05	30.00±0.05
Final weight (g)	96.33±1.13	96.83±0.7	97.87±1.27	98.73±0.47	97.67+0.58
Weight gain (g)	66.26±1.17	66.73±0.68	67.84±1.29	68.87±0.57	67.67±0.64
SGR (%g/d)	1.11±0.01	1.11±0.05	1.13±0.02	1.14± 0.01	1.12±0.01
Weight gain%	220.35±4.21	221.69+1.92	225.91±4.56	230.10±2.72	225.57±2.56
FI (g feed/fish)	134.76±1.85	134.95±1.38	137.54±1.15	139.78±0.21	136.41±0.45
FCR	2.03±0.01	2.02+0.01	2.03+0.05	2.03+0.01	2.02+0.01
FER	49.17±0.22	49.45±0.23	49.32±0.14	49.27±0.36	49.61±0.29
PER	2.15±0.03	2.15±0.03	2.12±0.03	2.14±0.01	2.17±0.02
Survival rate (%)	100±0.0 [ab]	98.9±1.1 [ab]	100±0.0 [a]	98.9±1.1 [ab]	100+0.0 [a]

Survival rate of Nile tilapia fed all the treatments was high and ranged from 98.1 to 100 % without significant difference among them (P > 0.05; Table 3). Moreover, the contents of dry matter, crude protein, fat, and ash in whole-fish body are shown in Table (4). Partial or complete replacement of SFWM for HFM–protein in the diets did not affect fish composition of dry matter, protein, or fat contents compared to the control treatment. Ash content was irregularly fluctuated in fish bodies among treatments.

Table 4. Proximate chemical analyses (%; on dry matter basis) of Nile tilapia fed diets containing different levels of SFWM. Means in the same row having the same letter is not significantly different at $P < 0.05$.

Whole-body	SFWM levels (%)				
Composition (%)	0.0	25	50	75	100
Dry matter	24.08±0.44	25.23±0.23	25.39±0.71	25.21±0.41	25.76±0.61
Crude protein	61.46±0.28	61.88±0.39	62.12±0.53	62.68±0.37	62.86±0.15
Total lipid	16.29±0.21	16.34±0.19	16.54±0.56	16.87±0.28	16.90±0.26
Ash	21.66a±0.58	21.89±0.4	21.58±0.29	20.35±0.17	20.90±0.24

The economical evaluation of the experimental diets contained different SFWM levels to replace 25%, 50%, 75%, and 100% of HFM are shown in Table (5). The cost to produce one kg of the experimental diet compared with the cost of control diet showed that the lowest cost was obtained when the diet contained 100% SFWM. The reduction in feed cost to produce one kg fish gain using the diet containing 100% SFWM compared with the control diet was 31.37%.

Table 5. Economic efficiency for production of one Kg gain of Nile tilapia fed different treatments.

Items	SFWM levels (%)				
	0.0	25	50	75	100
Price/ kg feed P.T	2.84	2.60	2.28	2.18	1.96
Reduction in feed cost	100	8.45	19.72	23.24	30.99
FCR (kg feed/kg gain)	2.03	2.02	2.03	2.03	2.02
Feed cost / kg gain P.T	5.77	5.25	4.63	4.43	3.96
Reduction cost in kg gain	100	9.01	19.76	23.22	31.37

DISCUSSION

In the present study, fish became accustomed to the experimental diets and were observed to feed actively throughout the duration of this study without external sign of nutritional deficiency. This finding suggests that SFWM is good alternative protein source and may replace HFM protein in fish diets. Growth performance (final body weight, weight gain, specific growth rate and relative growth rate) of Nile tilapia fed diets containing various levels of SFWM were similar to those of fish fed a control diet in this study. These results coincide with the findings of Mansour (1998) and El-Sayed (1998) who reported that shrimp meal can replace FM in red tilapia (O. *niloticus* x *O. hornorum*), and Nile tilapia diets, at 50% and 100%, respectively, without significant retardation in weight gain. Also, Abdelghany *et al.* (2005) reported that fish fed diets, in which poultry by-product meal (PBM) replaced up to 100% of the protein supplied by HFM had similar growth performance. These observations suggested that the SFWM diets contained all the necessary growth factors required by Nile tilapia, the isoniterogenous, isolipidic, and isocaloric nature of the experimental diets, explained why there was no disparity in growth response of fish and efficiency of feed utilization.

The high improvement of the production cost by replacing the HFM by SFWM products in the present study did not coincide with the results obtained by previous studies for red tilapia (Abdelghany, 2003), sunshin bass, *Morone chrysops* x *Morone saxatilis* (Muzinic *et al.*, 2006), gibel carp, *Carassius auratus gibelio* (Yang *et al.* 2006), Black Sea turbot, *Psetta maeotica* (Yigit *et al.*, 2006), and Nile tilapia, *O. niloticus* (Ahmad, 2008). On the other hand, the high improvement of the production cost by replacing the HFM by SFWM products in the present study coincide with the results obtained by previous studies for, Nile tilapia *Oreochromis niloticus* (Abdelghany *et al.*, 2005).

In the present study, practical fish diets in which SFWM replaced up to 100% of the protein supplied by HFM had similar feed utilization efficiency (FI, FCR, FER, and PER) compared to the fish fed the HFM-based diet (Table 3). Partial and totally replacement of SFWM protein in the diets for Nile tilapia did not affect their FER and PER when compared with the fish fed HFM .These results coincide with the results of El-Sayed (1998) who reported that shrimp meal can replace FM in Nile tilapia diets at 100% without significant retardation in feed efficiency. Also, these results agreed with the results of Abdelghany *et al.* (2005). They reported that fish fed diets in which PBM replaced up to 100% of the protein supplied by HFM had similar FCR, FER, PER and APU to fish fed the HFM–based diet. Also, Yang *et al.*, (2006) found that feed utilization estimated for gible carp diet containing different PBM levels were higher than those in fish fed the control diet. On the other hand, Abdelghany (2003) found that the highest growth of red tilapia, *O. niloticus* x *O. mossambicus* was obtained when gambusia fish meal (GFM) replaced 50% of HFM. Also, Ahmad (2008) found that the highest growth and protein utilization for Nile tilapia was obtained at 75% GFM to replace HFM. In general, partial or complete replacement of SFWM for HFM protein in the experimental diets for Nile tilapia herein may have amino acid profiles that meet the requirements of this species. These results demonstrated that the amino acid profile of SFBM is as good as HFM and the quality of protein in terms of the quantitative essential amino acids of both ingredients are similar.

Dry matter contents of whole-fish body received SFWM diets were higher than that of the fish fed the control diet. These results indicated that partial or complete replacement of SFWM for HFM–protein did not alter the nutritional value of the fish produced. These results also suggested that all-male mono-sex Nile tilapia efficiently ingested, digested, assimilated and utilized protein from SFWM similar to HFM. These results agree with the results of Abdelghany (2003) who reported that partial or complete replacement of HFM with GFM did not affected whole-body composition (protein, fat, and dry mater) of red tilapia. Also, Yang *et al.* (2006) found no significant changes was observed in whole–body moisture and fat content resulted from the different replacement of fish meal with poultry by-product meal.

CONCLUSION

As a conclusion of this study, it is suggested that without amino acid supplementation, SFWM safely replace up to 100% of HFM in practical diets for all-male mono-sex Nile tilapia when cultured in cages. These results may allow for formulation of less expensive diet for Nile tilapia and may reduce the diet costs for producers.

Acknowledgment

This study is a part of the integrated coastal management zone project at Port Said supported by the European Commission.

REFERENCES

1. Abdelghany, A. E. 2003. Partial and complete replacement of fish meal with gambusia meal in diets for red tilapia, *Oreochromis niloticus* x *O. mossambicus.* Aquaculture Nutrition, 3: 1 – 10.
2. Abdelghany, A. E., M. H. Ahmad, S. H. Sayed, H. I. Ibrahim and M. E. Abdel-Fatah. 2005. Replacement of fish meal with poultry by- product meal in diets for mono- sex Nile tilapia, Oreochromis niloticus. Egyptian Journal of Nutrition and Feeds, 8 (1) special Issue: 1049 – 1063.
3. Ahmad, M. H. 2008. Evaluation of Gambusia, *Gambusia affinis,* fish meal in practical diets for fry Nile tilapia, *Oreochromis niloticus.* J. World Aqua. Soc., 39 (2) 243 – 250.
4. AOAC 1990. Association of Official Analytical Chemists. The Official Methods of Analyses Association of Official Analytical Chemists International.5*th* edition, Arlington, VA, USA.
5. Boyd, C. E. 1990. Water Quality in Ponds for Aquaculture. Birmingham Publishing Co., Birmingham, Alabama, USA.
6. Dytham, C. 1999. Choosing and Using Statistics: A Biologist's Guide. Blackwell Science Ltd., London, UK. pp 147.

7. El-Sayed, A.-F. M. 1998. Total replacement of fish meal with animal protein source in Nile tilapia *O. niloticus* (L.) feeds. Aquaculture Research, 29 (4): 275–280

8. El-Sayed, A.-F. M. 2004. Protein nutrition of farmed tilapia: searching for unconventional sources. Proceeding of the 6th International Symposium on Tilapia Aquaculture, 14-16 Sept. 2004, Manila, Philippines, volume 1, pp 364-378.

9. Goering, H. K. and P. G. Van Soest. 1970. Forage fiber analysis. Apparatus, 1368-1375.

10. Hardy, R. W. and A. G. J. Tacon. 2002. Fish meal historical uses, and production trends. In: Responsible Marine Aquaculture, CABI Publishing, New York., USA.

11. Mansour, C. R. 1998. Nutrition requirement of red tilapia fingerlings. M. Sc. These, Fac. Sci., Univ. Alex. Egypt, pp 121.

12. Muzinic, L. A., K. R. Thompson, L. S. Metts, S. Dasgupta and C. D. Webster. 2006. Use of turkey meal as partial and total replacement of fish meal in practical diets for Sunshine bass (*Morone chrysops* x *Morone Saxatils*) grown in tanks. Aquaculture Nutrition, 12: 71 –81.

13. NRC (National Research Council) 1993. Nutrient requirements of fish. Committee on Animal Nutrition. Board on Agriculture. National Research Council. National Academy Press. Washington DC, USA.

14. Yang, Y., S., S. Xie, Y. Cui, X. Zhu, W. Lei and Yang. 2006. Partial and total replacement of fish meal with poultry by- product meal in diets for gibel carp, *Carassius auratus gibelio* Bloch. Aquaculture Research, 37: 40 – 48.

15. Yigit, M., M. Erdem, Skoshio, S. Ergiin, A. Tiirker and B. Karaal. 2006. Substituting fish meal with poultry by-product meal in diets for black sea turbot *Psetta maeotica.* Aquaculture Nutrition, 12: 340 – 347.