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EFFECT OF PARTIAL AND TOTAL REPLACEMENT OF DIETARY FISHMEAL WITH FERMENTED FISH SILAGE ON GROWTH, PRODUCTION AND DIGESTIBILITY IN SOME FRESHWATER FISHES

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SUMMARY

The effects of partial and total replacement of dietary commercial fish meal (CFM) with fermented fish silage (FFS) on growth performance, digestibility coefficient and proximate composition were examined in three freshwater fishes namely, tilapia (*Sarotherodon galilaeus*), common carp (*Cyprinus carpio*) and African catfish (*Clarias gariepinus*). The fish had a starting weights of 50, 55 and 57g respectively and reared in concrete ponds (20 m2) at a rate of 6 fish/m2 (1:1:1) for 180 days. The diet containing 60 % CFM and 40 % FFS was suitable to tilapia species, where the highest total weight gain (168.5g) and optimum feed conversion ratio (2.92) were obtained. Nutrients digestibility had also their best percentages (78 % for proteins, 76 % for fats and 57.5 % for carbohydrates) at the same diet. Consequently the production and profitability reached their maximum values (1835.4 kg/feddan and 0.94 %) and the proximate composition of fish was improved. Common carp preferred diet containing 80 % CFM and 20 % FFS at which the total weight gain (TWG), specific growth rate (SGR) and normalized biomass index (NBI) had their highest values (196.5 g, 0.57 and 1.97). Feeding on the same diet showed maximum digestibility for proteins, fats and carbohydrates (81.5%, 71.0% and 61.5%) in fish body. The total production and profitability were also increased to 2112.6 kg/ feddan and 0.50 at 20 % FFS level in diet. The proximate composition (wet weight basis) and energy content of *C.carpio* were also improved where the protein, ash, gross energy and protein / energy ratio values reached to 23.0%, 3.3%, 8.01 kj/g and 120.17% respectively, while fat content decreased to 6.5%. In catfish, the growth performance had its highest val-

ues with diet containing 20 % CFM and 80 % FFS, where total weight gain specific growth rate and normalized biomass index were 238.5g, 0.92 and 2.39%. Also, feed conversion ratio (FCR), protein efficiency ratio (PER) and protein productive value (PPV) had its best values (2.77, 1.20 and 2.39). With the same diet the digestibility of proteins, fats, carbohydrates and energy showed its highest values (87.5%, 84.0%, 66.5% and 80.5%), consequently the production and profitability of fish recorded its maximum values (2482.2 kg/feddan and 0.76%). The proximate composition of soft tissue (wet weight basis) in catfish was significantly influenced by fermented fish silage levels in diets where the protein, ash and energy contents were increased, while fat decreased in fish bodies.

Key words: Growth, fermented fish silage, production, digestibility, feed utilization, proximate composition.

INTRODUCTION

The aquaculture is one of best ways for exploitation of the existing water bodies and constructed ponds (Hepher & Pruginin 1981). The potential of local fish farming in freshwater ponds is so great due to the suitable climate and fertility of the soils (Hassanen, 1986). Effects of different feed ingredients on growth and production of freshwater fish was studied by Degani et al. (1989). Fish meal constitutes the most feed ingredients for protein in fish feeds (Kanshik 1989). The cost of fish meal is continuously increasing, affecting directly on feed costs leading to an increase in total fish farm costs with consequent decrease in its profitability. For this reason, considerable research efforts have been directed towards the use of other ingredients as potential fish meal substitutes in fish diets. Fishery by-catch, undersize fish farm harvest and fish processing wastes, these materials can be easily used to produce fish silage (Wassef, 1990). Similarly Lo et al. (1993) mentioned that fish silage could be prepared from small fish, fishery wastes / by-products or fish farm mortalities. In addition, fish silage is prepared either by minerals organic acid preservation (acid silage) or by anaerobic microbial fermentation (fermented silage). The later is preferred in developing countries including Egypt because it is less expensive alternative protein feedstuffs and leads to a decrease in fish farm costs (Fagbenro et al., 1994). Fagbenro & Jauncey (1995) reported that fermented fish silage could be stored at 30°C for six months with little or no nitrogen loss and change in its nutritional quality. Wassef et al. (2001) mentioned that fermented fish silage is a promising feed ingredients for substituting fish meal at 25-50 % replacing level in diets of freshwater fish. This work was conducted to show effects of replacing dietary fish meal (most expensive ingredient) with fermented fish silage (cheaper alternative feedstuffs) to increase fish farms profitability and its easily digestible in fish body. Also, to determine the optimum fermented fish silage level for achieving best growth, production, digestibility and proximate composition of freshwater fish (tilapia, carp and catfish).

MATERIALS AND METHODS

This study was conducted at the Barrage Fish Farm (Inland Water and Fish Culture Branch), National Institute of Oceanography and Fisheries (30 Km North of Cairo, Egypt), with a 180 days rearing period.

Fish used and ponds

The fish species used in this study were *Sarotherodon galilaeus* (*S. galilaeus*), *Cyprinus carpio* (*C. carpio*) and *Clarias gariepinus* (*C. gariepinus*) with initial weights of 50, 55 and 57 g/fish respectively. The fish were stocked into a concrete ponds (outdoors) with a surface area of 20 m^2 (5 x 4m with 1.2 m depth/pond), at a rate of 6 fish /m^2.

Preparation of silage and diets

Fermented fish silage (FFS) was prepared from minced small size fish (<40g) mixed with 5% sugar beat molasses and 2% *Lactobacillus plantarum* as a culture media. This mixture was incubated at 30°C for 30 days (Fagbenro et al., 1994). The test feed ingredients were mixed mechanically using a horizontal mixer, then pelleted in a California Pellet Meal (CPM) machine (Otawa, Canada). The experimental diets formulated to six fermented fish silage levels (0, 20, 60, 80 and 100%) as fish meal replacement and containing about 30 % crude protein. The feed formulation and chemical composition of diets are summarized in table (1). The fish were hand-fed at 3% of their weight, once daily at 09.00 and 16.00 hours for 6 days/ week.

Water quality

Water temperature, pH and dissolved oxygen were measured daily (at 9.00 and 16.00 hours) using a mercury thermometer, Orion digital pH meter (model 201, Leshbona, Portugal) and oxygen meter (Cole Parmer Model 5946, Berlin, Germany) respectively. Total alkalinity ($CaCO_3$) nitrate (NO_3-N), nitrite (NO_2-N), ammonia (NH_3-N) and phosphorus (PO4-P) were determined biweekly according to AOAC (1995) methods.

Growth and feed utilization

Over the rearing period (180 days), a random sample of fish (15 fish for each species) from different ponds was taken biweekly by a small net to measure the total length (cm) and body weight (g) from each treatment, food intake and mortality for rearing fish were recorded daily. Specific growth rate (SGR), normalized biomass index (NBI), feed conversion ratio (FCR), protein efficiency ratio (PER) and protein productive value (PPV) were calculated using the following equations;

SGR = (Ln final weight - Ln initial weight) x 100 / Rearing period (days)

NBI = (Final body weight - Initial body weight)/

100

FCR = Dry feed consumed / Weight gain

PER = Weight gain / Protein consumed

PPV = Protein gain / Protein consumed

Digestibility trails

The apparent digestibility coefficient of nutrients and energy in the experimental diets was determined using acid-washed sand at a rate of 1 % of diet as indicator (marker). A total number of 150 fish from each fish species (tilapia, carp and catfish) with an average weight ranged from 50-60g/fish were stocked for 28 days in ten glass aquaria with size of 150 liters (60 x 50 x 50 cm). Each aquarium contain 15 fish (5 tilapia, 5 carp and 5 catfish) and supplied with 100 liters aerated and dechlorinated tap water. The fish were fed on the previous diets under the same feeding conditions. Faeces were collected daily from individual fish by hand stripping as described by Austerng (1978). The proximate analysis of diets and faeces were conducted to determine the dry matter (DM), crude protein (CP), ether extract (EE), crude fiber (CF) and ash content (AC). Nitrogen free extract (NFE) was calculated by differences and gross energy (GE) was estimated according to NRC (1993) equation. Acid-washed sand levels were determined in the diets and faeces according to Fenton & Fenton (1979). Apparent digestibility coefficient (ADC) for dry matter, nutrients and energy were calculated using Sales & Britz (2002) equations;

ADC (dry matter) = 100 x [1-(% marker in diet / % marker in faeces)]

ADCs (nutrients and energy) = 100 x [1-(% marker in diet / % marker in faeces) x (% nutrient or energy in faeces / % nutrients or energy in diet)]

Production and economical efficiency

The total fish production (TFP), net returns (NT) and profitability (P) of different reared fish in each treatment were calculated using these formulae;

TFP (kg /feddan) = Final weight per fish x fish number x 4200 /1000 x 20 (area of pond)

NT (LE /feddan) = Price of produced fish per feddan - Total costs per feddan

P (%) = Net returns (LE /feddan) / Total costs (LE /feddan)

(feddan = 2400 m^2, hectare = 10000 m^2, hectare = 2.38 feddans)

Proximate composition:

The proximate composition of the soft tissue (wet weight basis) of different fish species was carried out at the end of the rearing period using 30 fish (10 tilapia, 10 carp and 10 catfish) from each treatment. Water content (moisture) was determined by drying at 104°C for 24 hours (AOAC, 1995). For estimation the crude protein and lipid, 1g of tissue was taken from each fish in each treatment and homogenized in 5 ml cold distilled water and centrifuged at 3000 r.b.m. for 18 min. Protein was determined using a Bicon kit based on Biuret reagent as described by Lowry et al. (1951), while the total lipid was determined by means of chloroform / methanol extraction (Folch et al. 1957). Gross energy (GE), metabolizable (ME) energy and protein-energy ratio (P/E) was calculated according to equations described by NRC (1993).

GE (kj/g) = (5.65 x % protein + 9.45 x % fat) x 4.186 x 1000 /100

ME (kj/g) = (3.90 x % protein + 8.00 x % fat) x 4.186 x 1000 / 100

P/E (%) = Crude protein (mg/kg) / Gross energy (kcal/kg)

Statistical analysis

The present data were analysed using Duncan's multiple-range testing to compare the mean values of the factors measured as described by SAS (1996). The differences among means were tested by least significance difference (LSD) and the level of significance was accepted at $P < 0.05$.

RESULTS

Water quality of ponds

In the present study, the water quality included water temperature, pH value, dissolved oxygen, total alkalinity, nitrate, nitrite, ammonia and phosphorus. The water quality was nearly similar throughout the rearing period and was not significantly influenced by fermented fish silage levels in the diets. Water temperature ranged between 26 and 27°C, pH value between 7.0 and 8.2, dissolved oxygen between 6.0 and 6.5 mg/L, alkalinity between 302 and 385 mg/L, nitrate between 0.60 and 0.81 mg/L, nitrite between 0.75 and 0.93 mg/L, ammonia between 0.80 and 0.92 mg/L and phosphorus between 2.53 and 2.84 mg/L.

Table 1 Formulation of six diets with different levels of fermented fish silage (FFS) as replacement of commercial fish meal (CFM) and its chemical composition.

Ingredients		Diet 1 (control) 100 % CFM	Diet 2 80 % CFM 20 % FFS	Diet 3 60 % CFM 40 % FFS	Diet 4 40 % CFM 60 % FFS	Diet 5 40 % CFM 60 % FFS	Diet 6 100 % FFS
Feed ingredients (g)							
Commercial fish meal		20.0	16.0	12.0	8.0	4.0	-
Fermented fish silage		-	4.0	8.0	12.0	16.0	20.0
Soybean		19.0	19.0	19.0	19.0	19.0	19.0
Wheat bran		33.0	33.0	33.0	33.0	33.0	33.0
Yellow corn		23.0	23.0	23.0	23.0	23.0	23.0
Sunflower oil		3.0	3.0	3.0	3.0	3.0	3.0
Vitamin and mineral premix *		2.0	2.0	2.0	2.0	2.0	2.0
Total weight (g)		100.0	100.0	100.0	100.0	100.0	100.0
Chemical analysis							
Crude protein	(%)	30.30	30.20	30.30	30.20	30.20	30.30
Crude fat	(%)	11.20	11.30	11.10	11.00	11.20	11.30
Ash content	(%)	9.50	8.40	8.60	9.00	8.70	8.50
Crude fiber	(%)	5.60	4.80	3.50	4.00	3.50	3.20

* Each kilogram of vitamin and mineral premix contained: 4.8 m IU Vit. A, 0.8 m IU Vit. D_3, 4.0g Vit. E, 0.8g Vit. B_{12}, 4.0g Vit. B_2, 0.6g Vit. B_6, 4.0g Pantothenic acid, 8.0 g Niotinic acid, 400 mg Folic acid, 20 mg Biotin, 200 g Choline chloride, 4.0 g Copper, 0.4 g Iodine, 12 g Iron, 22 g Manganese, 22 g Zinc and 0.4 Selenium.

Table 2 Growth performance and feed utilization of freshwater fish fed on levels of FFS as replacement for CFM at 180 days.

Experimental diets		Fish species	Growth performance				Feed utilization		
No	FFS levels		FBW[a]	TWG[b]	SGR[c]	NBI[d]	FCR[e]	PER[f]	PPV[g]
1	100 % CFM (Control)	*S. Galilaeus*	215.00 ± 4.12	161.00 ± 3.90	0.31 ± 0.22	1.65 ± 0.46	2.93 ± 0.66	1.14 ± 0.25	1.24 ± 0.36
		C. carpio	236.00 ± 5.03	181.00 ± 3.50	0.53 ± 0.14	1.81 ± 0.51	2.93 ± 0.65	1.14 ± 0.25	0.63 ± 0.11
		C. gariepinus	254.00 ± 5.15	197.00 ± 3.61	0.83 ± 0.22	1.97 ± 0.48	2.94 ± 0.66	1.15 ± 0.25	0.82 ± 0.13
2	80 % CFM 20 % FFS	*S. Galilaeus*	183.00 ± 4.00*	133.00 ± 3.21*	0.72 ± 0.20	1.33 ± 0.40	3.15 ± 0.68	1.08 ± 0.20	2.02 ± 0.50
		C. carpio	251.50 ± 4.82*	196.50 ± 4.00*	0.51 ± 0.12	1.97 ± 0.53	2.88 ± 0.60	1.16 ± 0.25	1.77 ± 0.38
		C. gariepinus	261.00 ± 5.55	204.00 ± 4.11	0.85 ± 0.24	2.04 ± 0.61	2.88 ± 0.60	1.16 ± 0.27	0.08 ± 0.30
3	60 % CFM 40 % FFS	*S. Galilaeus*	218.50 ± 4.00	168.50 ± 3.82	0.82 ± 0.23	1.69 ± 0.45	2.92 ± 0.65	1.14 ± 0.25	3.05 ± 0.67
		C. carpio	185.00 ± 3.60*	185.00 ± 3.60	0.54 ± 0.13	1.85 ± 0.52	2.92 ± 0.65	1.14 ± 0.25	0.93 ± 0.15
		C. gariepinus	274.00 ± 5.61*	217.00 ± 4.22	0.87 ± 0.25	2.17 ± 0.66	2.84 ± 0.61	1.17 ± 0.25	1.57 ± 0.35
4	40 % CFM 60 % FFS	*S. Galilaeus*	164.50 ± 3.15*	114.50 ± 3.00*	0.66 ± 0.15	1.15 ± 0.34	3.23 ± 0.72	1.03 ± 0.20	1.35 ± 0.37
		C. carpio	238.50 ± 6.00	183.50 ± 3.42	0.54 ± 0.11	1.84 ± 0.55	2.92 ± 0.61	1.14 ± 0.21	0.93 ± 0.15
		C. gariepinus	286.00 ± 5.11*	229.00 ± 4.50*	0.90 ± 0.25	2.29 ± 0.64	2.81 ± 0.61	1.19 ± 0.28	2.02 ± 0.51
5	20 % CFM 80 % FFS	*S. Galilaeus*	148.00 ± 3.00*	98.00 ± 2.85*	0.60 ± 0.15	0.98 ± 0.31	3.40 ± 0.70	0.98 ± 0.17	1.00 ± 0.16
		C. carpio	221.00 ± 4.50*	166.00 ± 3.21*	0.49 ± 0.08	1.66 ± 0.50	3.00 ± 0.70	1.11 ± 0.20	0.67 ± 0.11
		C. gariepinus	295.50 ± 6.21*	238.50 ± 4.65*	0.92 ± 0.26	2.39 ± 0.67	2.77 ± 0.62	1.20 ± 0.30	2.46 ± 0.55
6	100 % FFS	*S. Galilaeus*	125.00 ± 3.41*	75.00 ± 2.41*	0.51 ± 0.11	0.75 ± 0.21	3.75 ± 0.73	0.89 ± 0.15	0.49 ± 0.10
		C. carpio	220.50 ± 5.00*	165.50 ± 3.20*	0.49 ± 0.07	1.66 ± 0.51	3.00 ± 0.70	0.11 ± 0.21	0.34 ± 0.05
		C. gariepinus	277.00 ± 6.62*	220.00 ± 4.21*	0.88 ± 0.23	2.20 ±0.63	2.83 ± 0.1	1.18 ± 0.25	2.09 ± 0.50

[a] FBW = Final body weight
[b] TWG = Total weight gain
[c] SGR = Specific growth rate
[d] NBI = Normalized biomass index
* Difference from control is significant (P < 0.01).

[e] FCR = Feed conversion ratio
[f] PER = Protein efficiency ratio
[g] PPV = Protein productive value
The values expressed as Mean ± SE.

Table 3 Nutrients digestibility of freshwater fish fed levels of FFS as replacement for dietary CFM at 180 days.

Experimental diets		Fish species	Nutrients digestibility (%)				
No	FFS levels		Dry mater (DM)	Crude protein (CP)	Ether extract (EE)	Nitrogen free extract (NFE)	Gross energy (GE)
1	100 % CFM[a] (Control)	*S. Galilaeus*	52.50 ± 2.41	76.00 ± 3.50	74.50 ± 3.25	55.50 ± 2.44	65.50 ± 2.81
		C carpio	54.20 ± 2.80	78.50 ± 3.20	70.00 ± 3.50	57.00 ± 2.51	68.50 ± 2.75
		C. gariepinus	57.00 ± 3.00	81.00 ± 3.75	81.50 ± 3.64	60.00 ± 2.66	72.00 ± 3.00
2	80 % CFM 20 % FFS[b]	*S. Galilaeus*	53.00 ± 2.60	75.50 ± 3.12	74.00 ± 3.20	66.00 ± 2.45	64.50 ± 2.36
		C. carpio	55.50 ± 3.00	81.50 ± 3.70	71.00 ± 3.15	61.50 ± 2.62	73.50 ± 3.00
		C. gariepinus	56.00 ± 3.00	83.50 ± 3.75	82.50 ± 4.00	62.50 ± 2.70	75.50 ± 3.11
3	60 % CFM 40 % FFS	*S. Galilaeus*	50.50 ± 2.30	78.00 ± 3.22	76.00 ± 3.61	57.50 ± 2.40	67.50 ± 2.75
		C. carpio	52.00 ± 2.64	80.00 ± 3.64	73.50 ± 3.22	59.00 ± 2.55	70.00 ± 2.81
		C. gariepinus	57.00 ± 3.11	84.00 ± 3.76	81.50 ± 3.72	63.50 ± 2.70	76.00 ± 3.15
4	40 % CFM 60 % FFS	*S. Galilaeus*	54.50 ± 2.85	72.50 ± 3.21	71.50 ± 3.18	54.50 ± 2.33	62.50 ± 2.30
		C. carpio	56.00 ± 3.02	80.00 ± 3.65	70.00 ± 3.10	58.00 ± 2.43	70.00 ± 2.72
		C. gariepinus	58.00 ± 3.21	85.00 ± 3.82	82.50 ± 4.00	64.50 ± 2.81	78.50 ± 3.25
5	20 % CFM 80 % FFS	*S. Galilaeus*	54.00 ± 2.70	71.00 ± 3.11	70.50 ± 3.20	52.00 ± 2.20	60.50 ± 2.20
		C. carpio	57.00 ± 3.12	78.50 ± 3.15	68.50 ± 2.80	55.50 ± 2.36	68.00 ± 2.62
		C. gariepinus	58.50 ± 3.25	87.50 ± 4.02	84.00 ± 4.11	66.50 ± 3.11	80.50 ± 4.02
6	100 % FFS	*S. Galilaeus*	55.00 ± 2.90	68.50 ± 2.88	68.50 ± 2.72	50.50 ± 2.00	57.50 ± 2.10
		C. carpio	58.50 ± 3.30	75.00 ± 3.21	85.00 ± 2.61	53.50 ± 2.15	63.00 ± 2.25
		C. gariepinus	58.00 ± 3.30	84.50 ± 3.82	81.50 ± 3.28	64.00 ± 2.75	77.50 ± 3.20

[a] CFM = Commercial fish meal
[b] FFS = Fish fermented silage
The values expressed as Mean ± SE.

Table 4 Total production and economically efficiency of freshwater fish fed on levels of FFS as replacement for dietary CFM at 180 days.

Experimental diets		Fish species	Total fish production	Price of fish produced	Total food consumed	Feeding costs	Other costs	Total costs	Net returns	Profitability
No	FFS levels		Kg/feddan	LE/feddan	Kg/feddan	LE/feddan	LE/feddan	LE/feddan	LE/feddan	%
1	100 % CFM (Control)	*S. Galilaeus*	1806.0	14448.0	4063.5	4876.2	2620.0	7496.2	6951.8	0.93
		C. carpio	1982.4	9912.0	4460.4	5352.5	1360.0	6712.5	3199.5	0.48
		C. gariepinus	2133.6	13869.4	4800.6	5760.0	2460.0	8220.0	5649.4	0.69
2	80 % CFM 20 % FFS	*S. Galilaeus*	1573.2	12297.6	3458.7	4150.4	2620.0	6770.4	5527.2	0.82
		C. carpio	2112.6	10563.0	4753.4	5704.1	1360.0	7064.1	3498.9	0.50
		C. gariepinus	2192.4	14250.6	4932.9	5919.5	2460.0	8379.5	5871.1	0.70
3	60 % CFM 40 % FFS	*S. Galilaeus*	1835.4	14683.2	4129.7	4955.7	2620.0	7575.7	7107.5	0.94
		C. carpio	2016.0	10080.0	4536.0	5443.2	1360.0	8003.2	3276.8	0.48
		C. gariepinus	2301.6	14960.4	5178.8	6214.6	2460.0	8674.6	6285.8	0.72
4	40 % CFM 60 % FFS	*S. Galilaeus*	1381.8	11054.4	3109.1	3730.9	2620.0	6350.9	4703.5	0.74
		C. carpio	2003.4	10017.0	4507.7	5409.2	1360.0	7897.4	2119.6	0.27
		C. gariepinus	2402.4	15615.6	5405.4	6486.5	2460.0	8946.5	6669.1	0.75
5	20 % CFM 80 % FFS	*S. Galilaeus*	1243.2	9945.6	2797.2	3365.6	2620.0	5976.6	3969.0	0.66
		C. carpio	1856.4	9282.0	4176.9	5012.3	1360.0	6372.3	2909.7	0.46
		C. gariepinus	2482.2	16134.3	5525.0	6702.0	2460.0	9162.0	6972.3	0.76
6	100 % FFS	*S. Galilaeus*	1050.0	8400.0	2362.5	2835.0	2620.0	5455.0	2945.0	0.53
		C. carpio	1852.2	9261.0	4167.5	5001.0	1360.0	631.0	2900.0	0.46
		C. gariepinus	2328.8	15124.0	5235.3	6282.4	2460.0	8742.4	6381.8	0.73

Price of one kg fish solid = 8.0 LE for tilapia, 5.0 LE for carp and 6.5 LE for catfish
Average price of one kg of different diets = 1 2 LE

Table 5 Proximate composition and energy content of freshwater fish fed levels of FFS as replacement for dietary CFM at 180 days.

Experimental diets No	FFS levels	Fish species	Moisture %	Protein %	Lipid %	Ash %	GE[a] Kj/g	ME[b] Kj/g	Protein / energy %
1	100 % CFM (Control)	*S. Galilaeus*	77.50 ± 2.61	23.80 ± 1.51	4.50 ± 0.81	2.20 ± 0.41	7.41 ± 0.86	5.34 ± 0.75	134.46 ± 6.15
		C. carpio	82.00 ± 2.70	21.00 ± 1.44	7.20 ± 0.88	2.00 ± 0.40	7.82 ± 0.87	5.84 ± 0.75	112.48 ± 5.22
		C. gariepinus	77.00 ± 2.60	22.50 ± 1.40	5.20 ± 0.36	3.10 ± 0.45	7.38 ± 0.85	5.41 ± 0.75	127.62 ± 6.00
2	80 % CFM 20 % FFS	*S. Galilaeus*	74.50 ± 2.52	24.50 ± 1.51	3.20 ± 0.75	2.40 ± 0.40	7.06 ± 0.80	5.07 ± 0.70	145.31 ± 6.52
		C. carpio	80.00 ± 2.76	23.00 ± 1.44	6.50 ± 0.82	3.30 ± 0.43	8.01 ± 0.85	5.93 ± 0.75	120.17 ± 5.25
		C. gariepinus	83.00 ± 2.71	23.00 ± 1.42	4.60 ± 0.80	3.50 ± 0.46	7.26 ± 0.80	5.30 ± 0.75	132.56 ± 6.11
3	60 % CFM 40 % FFS	*S. Galilaeus*	73.00 ± 2.63	26.50 ± 1.55	3.00 ± 0.77	2.40 ± 0.40	7.46 ± 0.85	5.33 ± 0.74	148.79 ± 6.50
		C. carpio	81.50 ± 2.75	21.5 ± 1.35	6.80 ± 0.86	2.50 ± 0.44	7.77 ± 0.85	5.79 ± 0.75	115.78 ± 5.21
		C. gariepinus	81.50 ± 2.75	24.00 ± 1.45	4.40 ± 0.80	3.70 ± 0.46	7.42 ± 0.80	5.39 ± 0.70	135.44 ± 6.17
4	40 % CFM 60 % FFS	*S. Galilaeus*	72.00 ± 2.44	23.50 ± 1.41	3.50 ± 0.77	2.50 ± 0.41	6.94 ± 0.80	5.01 ± 0.70	141.65 ± 6.50
		C. carpio	80.00 ± 2.77	21.50 ± 1.36	7.00 ± 0.85	3.00 ± 0.42	7.85 ± 0.85	5.86 ± 0.75	114.61 ± 5.21
		C. gariepinus	79.00 ± 2.77	25.00 ± 1.42	4.50 ± 0.72	4.00 ± 0.41	7.96 ± 0.85	5.59 ± 0.75	136.02 ± 6.20
5	20 % CFM 80 % FFS	*S. Galilaeus*	70.00 ± 2.32	23.00 ± 1.42	3.60 ± 0.71	2.20 ± 0.40	6.78 ± 0.80	4.94 ± 0.70	140.24 ± 6.55
		C. carpio	77.50 ± 2.40	21.00 ± 1.31	7.00 ± 0.86	3.00 ± 0.45	7.74 ± 0.80	5.77 ± 0.75	113.64 ± 6.12
		C. gariepinus	76.50 ± 2.75	26.00 ± 1.51	4.50 ± 0.80	4.20 ± 0.46	8.13 ± 0.86	5.92 ± 0.76	133.88 ± 6.20
6	100 % FFS	*S. Galilaeus*	70.00 ± 2.51	22.50 ± 1.34	3.50 ± 0.71	2.00 ± 0.41	6.71 ± 0.80	4.85 ± 0.70	140.45 ± 6.55
		C. carpio	77.00 ± 2.42	20.50 ± 1.22	7.00 ± 0.82	3.00 ± 0.43	7.62 ± 0.83	5.69 ± 0.74	112.64 ± 5.40
		C. gariepinus	76.00 ± 2.75	25.00 ± 1.50	4.80 ± 0.80	4.20 ± 0.47	7.97 ± 0.83	5.82 ± 0.74	131.30 ± 6.00

[a] GE = Gross (total) energy.
[b] ME = Metabolizable energy.
The experimental results expressed as Mean ± SE.
The body protein of fish at the start of the experiment was 22.0 % for tilapia, 20.0 for carp and 21.1 for catfish.

Growth and feed utilization

The final body weight (FBW), total weight gain (TWG), specific growth rate (SGR) and normalized biomass index (NBI) reached their highest values (218.5g, 168.5 g, 0.82 and 1.69) for *S. galilaeus* when fed diet containing 60 % commercial fish meal (CFM) and 40 % fermented fish silage (FFS). These growth parameters had their maximum values (183.0 g, 133.0g, 0.72 and 1.33 respectively) for *C. carpio* at 80% CFM and 20 % FFS in diet. Feeding *C. gariepinus* on diet containing 20 % commercial fish meal and 80 % fermented fish silage showed highest growth performance (295.5g for FBW, 238.5 g for TWG, 0.92 for SGR and 2.39 for NBI). On the other hand, the feed conversion ratio (FCR) had its optimum values (2.92, 2.88 and 2.77) for *S. galilaeus, C. carpio* and *C. gariepinus* at dietary fermented fish silage (FFS) levels of 40 %, 20 % and 80 % respectively. At same FFS levels the highest values of protein efficiency ratio and protein productive value (1.14, 3.05 for tilapia; 1.16, 1.77 for carp and 1.20, 2.46 for catfish) were obtained (Table 2). The results of these parameters were statistically analyzed and showed a significant differences ($P < 0.01$).

Nutrients and energy digestibility

The nutrients and energy digestibility in the three fish species were highly affected with different fermented fish silage (FFS) levels in the diets. The highest percents of protein, fat, carbohydrate and energy digestibility (78.0 %, 76.0 %, 57.5 % and 67.5 %) were observed for *S. galilaeus* fed diet containing 60 % fish meal and 40 % fermented fish silage, correspondence a significantly ($P < 0.05$) decreasing in dry matter digestibility (50.5 %). The maximum apparent digestibility coefficients of protein, fat, carbohydrate and energy (81.5 %, 71.0 %, 61.5 % and 73.5 %) for *C.carpio* were recorded at 80 % CFM and 20 % FFS in the diet. The best digestibility of protein, fat, carbohydrate and energy in *C.gariepinus* body were 87.5%, 84.0%, 66.5 % and 80.5 % when in fish fed diet containing 20% commercial fish meal and 80% fermented fish silage as shown in Table 3.

Production and economical efficiency

Maximum fish production, net returns and profitability (1835.4 kg/feddan, 7107.6 LE/feddan and 0.94 %) for tilapia species were obtained with feeding diet containing 60 % commercial fish meal (CFM) and 40 % fermented fish silage (FFS). While, in carp species, the best production, net returns and profitability (2112.6 kg/ feddan, 3498.9 LE/feddan and 0.50 %) were observed at 80 % CFM and 20 % FFS levels in diet. The total fish production, net returns and profitability of catfish reached their highest values (2482.2 kg/feddan, 6972.3 LE/feddan and 0.76 %) when fed diet composed of 20 % CFM and 80 % FFS (Table 4).

Proximate composition (wet weight basis)

The effects of fermented fish silage levels (as replacement of dietary fish meal) on the proximate composition of soft tissue (wet weight basis) of experimental fish muscles are presented in table 5. The moisture content of fish bodies (three fish species) were significantly ($P < 0.05$) decreased with increasing the fermented fish silage levels in the diets of fish. The maximum body protein was 26.5 ± 1.55 % for *S. galilaeus* when fed diet containing 40 % fermented fish meal (FFS), 23.0 ± 1.44 % for *C. carpio* at diet with 20 % FFS and 26.00 ± 1.51% for *C. garipinus* at 80 % FFS level in the diet. In correspondence the lipid was significantly ($P < 0.05$) decreased to 3.0 ± 0.77%, 6.5 ± 0.82 % and 4.50 ± 0.80 % for three fish respectively at previous FFS levels. While the ash and energy contents (GE, ME and P/E ratio) were not affected by different fermented silage levels (as fish meal replacement) in the diets.

DISCUSSION

Development of fish farming in different countries depends greatly on availability of reliable fish feeds. Formulating high quality fish feeds is required, but reducing the cost of feeds is also the ultimate goal of fish nutrition researches particularly in the developing countries including Egypt. Replacement of dietary fish meal protein with alternate sources of protein could be of considerable economic advantage, even if this approach was associated with a moderate reduction in feed utilization (Hajen et al., 1993). One of such alternative is fish silage which is prepared either by organic acid (acid silage) or by microbial fermentation (fermented silage). The latter is preferred because it is cheaper to produce and possesses good storage properties (Dong et al., 1993).

Effects of acid and fermented fish silage in diets on different fish species were studied by various investigators among them, Hardy et al. (1984) on *Salmo gairdneri*; Wee et al. (1986) on *Clarias battrachus*; Lapie & Bigueras-Benitez (1992) on *Oreochromis aureus* and Fagbenro and Jauncey (1993a and 1993b) on *Clarias gariepinus* and *Oreochromis niloticus*.

The present study revealed that S. galilaeus prefer diet containing 60 % commercial fish meal and 40 % fermented fish silage, where the growth parameters (FBW, TWG, SGR and NBI) and feed utilization (FCR, PER and PPV) reached their highest values. Similarly, the nutrient digestibility (CP, EE and NFE) and production (TFP, NR and P) had its best values at same diet. Furthermore, the carcass protein had its highest value at 40 % dietary fermented fish silage level at which the moisture and lipid decreased, while ash and energy contents not influenced. Fagbenro et al. (1994) replaced of dietary fish meal by fermented fish silage at a levels of 25 %, 50 % and 75% for feeding tilapia and catfish, they noticed that the growth rate (FBW, DWG and SGR) and feed utilization (FCR, PER and PPV) of tilapia were slightly improved at 25 - 50% fermented fish silage (FFS), while their differences between treatments were not significant ($P > 0.05$). They added that the apparent digestibility coefficient (ADC) of protein in tilapia fed 25-50 % FFS had a value near to the control group. Further, they reported that the highest carcass protein was also obtained from fish fed 25-50 % fermented fish silage and the lipid decreased, while ash content not affected. Fagbenro & Jauncey (1995) mentioned that an excellent apparent digestibility for dry matter, crude protein and lipid were obtained at feeding trials for FFS-based diets when fed to *O.niloticus*. Wassef et al. (2001) replaced the dietary fish meal of tilapia species with 25 %, 50 %, 75% and 100% fermented fish silage (FFS) and mentioned that the growth parameter (FBW, SG and TWG) and feed utilization (FCR, PER and PPV) reached their optimum values at 25-50% FFS as a fish meal replacer. They added that the proximate composition and total production had its highest values at the same FFS level.

With respect to *C. carpio*, the final body weight (FBW), total weight gain (TWG) specific growth rate (SGR) and normalized biomass index (NBI) reached their highest values when fed diet containing 80 % CFM and 20 % FFS at which the feed utilization (FCR, PER and PPV) had the optimum values. The nutrients digestibility (CP, EE, NFE) and total production of carp were also improved at 20% fermented fish silage in diet. Similarly, the carcass protein reached to maximum value at 20% fermented fish silage level in the diet, while the lipid was slightly decreased and the ash and energy contents not affected with different FFS levels. The common carp preferred the lowest fermented fish silage level (20 %), this may be attributed from one side to its feeding habit as described by Crivelli (1981) who mentioned that the adult common carp were generally omnivorous bottom feeders as is exemplified by the high proportion of benthic insects, crustacea and detritus. From other side, *C. carpio* prefer the lowest dietary protein level in the diets (Viola et al., 1981) and depending on algal meal in most feeding (Hepher & Sandbank, 1984).

As shown in the present results, it was noticed that *C.gariepinus* fed diet containing low commercial fish meal (20 %) and high fermented fish silage (80 %) clear highest growth parameters (FBW, TWG, SGR and NBI) and best feed utilization (FCR, PER and PPV). Similarly, the apparent digestibility coefficient of nutrients and energy of catfish were gradually increased with increasing the fermented fish silage (FFS) levels in the diets. The maximum production and economical efficiency of catfish were also obtained from fish fed 80 % FFS levels. The highest carcass protein in fish muscles was also observed at same FFS level and carcass lipids decreased, while ash and energy contents not affected with different FFS levels in diets. *C.gariepinus* favored the highest level of fermented fish silage in diets due to catfish is carnivorous bottom feeders fish, prefer highest levels of animal protein in diets and tends to the wastes and detritus materials in its feeding. Hogendoorn (1983) mentioned that the growth rate, feed utilization and proximate composition of *C. gariepinus* reached their maximum values when fish fed dietary protein level above 40 %. Same observations were also found by Machiels & Henken (1985) and Degani et al. (1989), they reported that the best growth rate, feed efficiency and proximate composition of *Clarias gariepinus* were obtained from fish fed a high-protein diet (40 %) rather than a low-protein diet (25 %, 30 %, 35 %). Fagbenro et al. (1994) noticed the optimum growth performance (final weight, weight gain and SGR) and feed utilization (FCR, PER and PPV) of *C. gariepinus* were observed when replaced the dietary fish meal with highest level of fermented fish silage (50-75 %). They added that the apparent coefficient digestibility of protein in catfish body was higher in fish fed diet containing highest level of fermented fish silage (50-75 %). Further, the carcass protein were increased with increasing the fermented fish silage level in the diets, while lipid and moisture decreased and ash content not affected.

CONCLUSION

In conclusion, the fermented fish silage appeared to be a best alternative protein feedstuffs as replacer for fish meal which is more expensive ingredient in aquaculture feeds. The fermented fish silage is also considered a promising feed materials for substituting dietary fish meal at 20 % for *C. carpio,* 40 % for *S. galilaeus* and 80% for *C. gariepinus.* Replacing of commercial fish meal with fermented fish silage in fresh water fish showed an increase in growth rate, production and profitability of reared fish in fish farms. The feed utilization and nutrients digestibility of reared fish were also improved with different fermented fish silage levels in the diets. The preoximate composition of three fish species was significantly influenced by fermented fish silage levels as replacement for fish meal in the diets.

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تأثير استبدال جزئي وكلي لمسحوق سمك العلائق بسيلاج السمك المخمر علي النمو والإنتاجية والهضم لانواع مختلفة من أسماك المياه العذبة

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** كلية العلوم - جامعة بنها

تم دراسة التأثيرات الكلية والجزئية لاستبدال مسحوق السمك التجاري في العليقة بسيلاج السمك المخمر علي أداء النمو والهضم والتركيب الجسدى لثلاثة أنواع من الأسماك هى البلطى الجاليلى والمبروك العادى والقرموط الأفريقى. الأسماك المرباه أخذت أوزان ابتدائية هى ٥٠، ٥٥، ٥٧ جرام تم تربيها في أحواض خرسانية (مساحة الحوض ٢٠ متر مربع) بمعدل ٦ سمكات للمتر بنسبة متساوية من الأسماك المستخدمة لمدة ١٨٠ يوما. فكانت العليقة المحتوية علي ٦٠٪ مسحوق سمك تجاري مع ٤٠٪ سيلاج سمك مخمر هى أفضل عليقة لأسماك البلطى حيث أظهرت أقصى وزن مكتسب (١٦٨.٥٠جرام) وأحسن تحول غذائى (٢.٩٢). كما أخذت نسبة هضم المواد الغذائية أفضل قيم لها (٧٨٪ للبروتين و٧٦٪ للدهون و ٥٧.٥٪ للكربوهيدرات) عند نفس العليقة. وبالتالى وصلت الإنتاجية والربح أقصى قيمة لهم (١٨٣٥.٤ كيلو جرام للفدان و ٩٤،٠٪) كما تحسن التركيب الجسدى للبلطى عند هذه العليقة.

وفضلت أسماك المبروك العليقة رقم ٢ (٨٠٪ مسحوق سمك و ٢٠٪ سيلاج مخمر) والتي عندها أخذ الوزن المكتسب الكلي ومعدل النمو النوعي والمعدل الحيوي المعيارى أعلي قيم لهم (١٩٦.٥ جرام ، ٥٧، ١.٠٩٧ علي التوالي)، كما أظهرت التغذية علي نفس العليقة أعلى هضم للبروتين والدهون والكربوهيدرات (٨١.٥٪ ، ٧١٪ ، ٦١.٥٪) في جسم الأسماك. وكذلك زادت الانتاجية الكلية والربح إلي ٢١١٢.٦ كيلو جرام للفدان و ٥٠٪ عند مستوي السيلاج ٢٠٪ في العليقة. كما تحسن التركيب ومحتوي الطاقة لأسماك المبروك عند ٨٠٪ مسحوق سمك مع ٢٠٪ سيلاج مخمر حيث زادت قيم البروتين والرماد والطاقة الكلية وعلاقة البروتين بالطاقة إلى ٢٣٪ ، ٣.٣٪، ٨.٠١ كيلو جول للجرام ، ١٢٠.١٧٪ على التوالى. بينما انخفض محتوي الدهون إلى ٦.٥٪.

أما فى القرموط الأفريقي فكان أفضل أداء نمو عندما تغذت الأسماك بالعليقة المحتوية علي ٢٠٪ مسحوق سمك و ٨٠٪ سيلاج سمك مخمر حيث أخذ الوزن المكتسب الكلي ومعدل النمو النوعي والمعدل الحيوي المعيارى القيم الأتية ٢٥٨.٥جرام ، ٩٢،. ٢.٣٩ علي التوالى وأيضا أخذ معدل النمو الغذائي ومعدل كفاءة البروتين وقيمة استيفاء البروتين أفضل قيم لهم (٢.٧٧ ، ١.٢ ، ٢.٣٩). وعند نفس العليقة هضم كل من البروتينات والدهون والكربوهيدرات والطاقة أقصى لهم (٨٧.٥٪ ، ٨٤.٥٪ ، ٦٦.٥٪ ، ٨٠.٥٪) وبالتالى سجلت كل من الانتاجية ومعدل الربح أفضل قيمة لهم (٢٤٨٢.٢ كيلو جرام للفدان و ٧٦.٠٪). كما تأثر التركيب الجسدى فى أسماك القراميط تأثيرا معنويا بمستويات سيلاج السمك المخمر بالعلائق حيث زادت محتويات البروتين والرماد والطاقة وقل المحتوي الدهنى فى جسم الأسماك.