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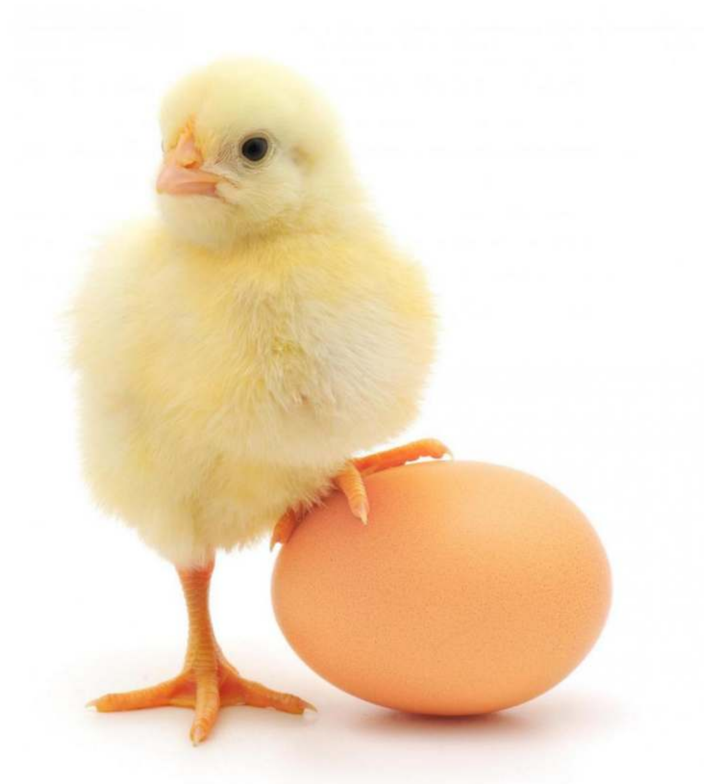

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The Effect of Feeding Elevated Levels of Tilapia (*Oreochromus niloticus*) By-product Meal on Broiler Performance and Carcass Characteristics

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Abstract: The tilapia industry has grown significantly. Considerable processing waste is generated by the tilapia industry because only the myomere (fillets) muscles are removed and marketed. This portion constitutes approximately 36% of the entire fish, leaving the remaining 64% of the fish as waste lost during the various processing operations. This waste recovered from the tilapia processing plant has the potential of being an alternative protein source in broiler rations. The objective of this study was to measure the effect of substituting elevated levels of tilapia by-product meal (TBM) for soybean meal (SBM) in broiler diets. Crude protein from TBM was substituted for SBM crude protein at a rate of 0, 25, 50, 75, and 100%. The control and four concentrations of TBM were used in a typical corn-soybean based diet and fed to chicks from 0-42 days of age. Chicks were randomly allocated to a ration using a randomized complete block design. Body weight, cumulative feed consumption, feed conversion ratio, and mortality was determined on a weekly basis. Processing carcass weights and yields were determined on a pre-chilled basis. The results showed that chicks fed 0, 25 and 50% TBM had significantly ($P < 0.01$) higher body weights, feed consumption and improved feed conversion throughout the 42 d growing period as compared to the other treatments. Carcass weights were also significantly ($P < 0.01$) higher. No significant differences were found for mortalities or yields for any of the treatments. In conclusion, the results show that TBM can be substituted for SBM crude protein up to a 50% level without negatively affecting bird performance or carcass quality.

Key words: Tilapia, tilapia meal, fish meal, broiler, soybean meal

Introduction

High quality fish meal is recognized by animal nutritionists as an excellent source of protein, energy, minerals and vitamins. It has been a popular poultry feed ingredient for many decades. Though considerable data have been accumulated concerning the high biological value and utility of fish meal, little has been published concerning the use of elevated concentrations using fresh water cultivated species.

The literature describing the use of fish meal has been extensively reviewed by Robertson *et al.* (1940); Rhian (1941); Atkinson and Couch (1951); Heuser and Norris (1951); Menge *et al.* (1952); Branion and Hill (1953); Rosenburg *et al.* (1955); Almquist (1957); Rasmussen *et al.* (1957); Rand *et al.* (1958); Hinners and Scott (1960); Harms *et al.* (1961); Smith and Scott (1964); Waldroup *et al.* (1965); Waldroup *et al.* (1967); Anderson *et al.* (1968); Warnick and Anderson (1968); Rojas *et al.* (1969); Schumaier and McGinnis (1969); Miller *et al.* (1970); Proudfoot *et al.* (1971); Harrison and Coates, (1972); Avila and Balloun (1974); Wu *et al.* (1984); Hulan *et al.* (1988); Hulan *et al.* (1989); Ponce and Gernat (2002).

In commercial broiler diets, the amount of fish meal is usually limited due to the possibility of producing off-flavors or odors in the meat (Fry *et al.*, 1965). In certain regions or countries where large amounts of fish meal are produced, it may be economically feasible to use fish meal as the major protein supplement in the diet of broiler chicks.

Commercially available fish meals are produced from different species of fish but generally only two main types are utilized. These two categories of fish differ both in their volume of oil as well as where the oil is stored. The first category includes a group referred to as lean fish. This includes such species as cod and haddock. In these species the oil is stored primarily in the liver, whereas the flesh contains very little oil. The fillets are removed and used for human consumption while the fish meal produced from these lean fish are principally derived from the offal remaining after filleting. Fish meal from these species, better known as white fish meals constitute only 10% of the world fish meal production. Oil derived from the second category of fish is located in certain parts of the flesh. They are high oil fish and are not prized for their fillets. They are commonly referred to as “Industrial fish” Such species as herring, menhaden, anchovy, pilchard, sardines and mackerel fall in this category. Approximately 90% of the world fish meal production is from these high oil species, and there is considerable variation in their composition. Fish meal is usually marketed at 65% crude protein, but this can vary from 57 to 77% depending on the species of fish used.

Tilapia (*Oreochromus niloticus*) is a fresh water species originating from Africa and parts of the Middle East. Tilapia production has gained popularity and its industry has grown significantly over the past years due to the species fast growth rate, ease of reproduction, disease resistance, adaptability and a firm but mild flavored flesh. Considerable processing waste is generated by the tilapia industry because only the myomere muscles (fillets) are removed and marketed for human consumption. This portion constitutes approximately 36% of the entire fish. The remaining 64% of the fish constitutes a waste product that is generated during the various processing operations. For most fish meals the whole fish is used in the manufacturing of fish meal. In contrast, fish meal made from tilapia is a by-product that remains following the removal of the fillets.

The objective of this study was to determine the growth rate, feed efficiency and other production parameters of broilers receiving rations containing either a partial or total replacement of the soybean meal with a tilapia by-product meal.

Materials and Methods

Prior to formulation, a proximate analysis and other analyses (Table 1) were conducted on samples of commercially available soybean meal (SBM; solvent extracted) and tilapia by-product meal in accordance with the Association of Official Analytical Chemists (AOAC, 1990). Amino acid profiles were determined using an amino acid analyzer cation exchanger (Table 1). A true metabolizable energy was estimated from values for fish meals of similar composition from the National Research Council feed table for poultry (NRC, 1994). One-day-old male Arbor Acres x Arbor Acres®[1] chicks were received from a commercial hatchery and placed in an open-sided naturally ventilated broiler house using a daily photo-regimen of 24 h light.

Each of the 15 pens (2.25 x 3m) used contained 81 chicks that were weighed individually and housed at a density of 12 birds per square meter. Five treatments were randomly assigned in blocks. Three replicates or blocks containing each treatment were allocated to the 15 pens in a randomized complete block design. Each pen was heated by a gas brooder and provided with nipple waterers and tube feeders. Experimental diets and water were provided for *ad libitum* consumption. The treatments consisted of substituting 0, 25, 50, 75, and 100% of the crude protein contributed by the SBM in the control diet with crude protein from the TBM (Table 2). Body weight, cumulative feed consumption, and feed conversion (feed:gain) were determined for each pen at 7, 14, 21, 28, 35, and 42 d of age. Deaths were recorded daily. Carcass weight and percentage carcass yield without giblets (WOG) was determined pre-chill. The WOG was calculated by dividing carcass weight (without the liver, heart, gizzard, and neck) by live weight. A second replicate trial was conducted using the same treatments and procedures.

Table 1: Analysis of tilapia by-product and soybean meal (as fed basis)

Components	Tilapia by-product meal%	Soybean meal%
Dry matter[1]	94.60	89.90
Crude protein[1]	63.50	46.00
Ether extract[1]	10.80	1.90
Ash[1]	18.50	6.00
Crude fiber[1]	0.58	3.50
Calcium[1]	5.73	0.26
Available phosphorus[1]	3.40	0.25
TME_n, kcal/kg	2,600	2,230
Amino acid, %[2]		
Methionine	1.58	0.75
Lysine	3.71	2.90
Arginine	5.01	2.71
Tryptophane	0.41	0.60
Threonine	2.44	1.89
Aspartic acid	5.30	5.48
Serine	2.86	2.07
Glutamic acid	8.36	8.36
Proline	1.81	2.48
Glycine	8.18	2.11
Alanine	4.87	2.16
Cysteine	0.99	0.74
Valine	3.14	2.43
Isoleucine	2.37	2.60
Leucine	4.16	3.80
Tyrosine	1.43	1.75
Phenylalanine	2.27	2.72
Histidine	1.14	1.80

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Statistical Analysis: Data from each trial were evaluated by ANOVA using the General Linear Models (GLM) procedure of SAS® (SAS Institute, 1991). Preliminary ANOVA indicated a non- significant trial effect; therefore, the data from the two trials were pooled. Percentage data were subjected to an arc sine square root of the percentage transformation and treatment means separated by the test of least significant difference. A probability of $P < 0.05$ was required for statements of significance.

Results and Discussion

Replacement of soybean meal (SBM) with tilapia by-product meal (TBM) resulted in significant differences

[1]Arbor Acres®, Glastonbury, CT 06033

Table 2: Composition of experimental diets

Ingredients and Analysis	Starter					Grower					Finisher				
	0%*	25%*	50%*	75%*	100%*	0%*	25%*	50%*	75%*	100%*	0%*	25%*	50%*	75%*	100%*
Ground corn	49.94	57.35	64.90	69.51	69.83	58.83	64.48	71.10	75.44	74.93	61.74	67.07	72.58	76.12	75.87
Soybean meal (46.0% CP)	41.20	30.00	18.20	7.00	0.00	30.92	22.50	13.50	5.00	0.00	28.20	20.50	12.50	4.80	0.00
Tilapia by-product meal (63.5%CP)	0.00	7.43	14.88	22.32	29.00	0.00	5.59	11.18	16.77	22.36	0.00	5.10	10.21	15.31	20.42
Dicalcium phosphate	1.52	0.40	0.00	0.00	0.00	1.43	0.60	0.00	0.00	0.00	1.35	0.59	0.00	0.00	0.00
Ground limestone	1.49	0.86	0.00	0.00	0.00	1.47	1.00	0.42	0.00	0.00	1.40	0.95	0.45	0.00	0.00
Salt (NaCl)	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Vitamin + mineral premix[1]	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Surmax® [2]	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Coban 60® [3]	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Vegetable oil	5.00	3.20	1.35	3.00	0.50	6.50	5.00	3.00	2.00	2.00	6.50	5.00	3.50	3.00	3.00
DL-Methionine	0.18	0.09	0.01	0.01	0.01	0.18	0.12	0.05	0.01	0.01	0.14	0.08	0.02	0.01	0.01
L-lysine	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.08	0.12	0.12	0.00	0.04	0.07	0.10	0.10
Calculated analyses															
Crude protein[4]	23.35	23.32	23.41	23.22	23.60	19.95	19.90	19.57	19.01	19.28	17.89	17.20	17.60	17.03	17.70
ME, kcal/kg	3,100	3,100	3,100	3,100	3,100	3,250	3,250	3,250	3,250	3,250	3,275	3,275	3,275	3,275	3,275
Calcium	0.85	0.94	1.02	1.42	1.66	0.85	0.90	1.06	1.27	1.68	0.77	0.80	0.82	1.04	1.30
Available phosphorus	0.69	0.76	0.78	0.92	1.01	0.66	0.73	0.77	0.94	1.13	0.48	0.58	0.63	0.74	0.85
Methionine	0.50	0.50	0.50	0.50	0.50	0.48	0.48	0.48	0.48	0.48	0.44	0.44	0.44	0.44	0.44
Lysine	1.20	1.20	1.2 0	1.20	1.20	1.05	1.05	1.05	1.05	1.05	0.98	0.98	0.98	0.98	0.98

[1]The vitamin and mineral premix provide the following quantities per kilogram of diet: vitamin A, 10,000 IU (*all-trans-retinal*); cholecalciferol, 2,500 IU; vitamin E, 10 IU (dl-α-tocopheryl); vitamin K_3, 2 mg; riboflavin, 5 mg; niacin, 35 mg; D-calcium pantothenic acid, 10 mg; choline chloride, 250 mg; vitamin B_{12}, 12 mg; folic acid, 0.75 mg; manganese, 70 mg; zinc, 50 mg; iron, 30 mg; copper, 10 mg, iodine, 1.5 mg; cobalt, 0.15 mg; selenium, 0.10 mg; mold inhibitor, 7 mg; antioxidant, 10 mg. [2]Surmax®, broad spectrum antibiotic, 0.4 g of Avilamycin/kg.[3]Coban 60® , prevention of coccidiosis in broiler, 0.54 g Monensin sodium/kg. [4]Determined analysis. *Percent TBM in the diets.

(P < 0.001) in broiler body weight, feed consumption and feed conversion from 7 to 42 d of age (Table 3). Birds on diets containing the 75 and 100% TBM had significantly lower body weights, feed consumption and poorer feed conversions as compared to the 0, 25 and 50% treatments. Schumaier and McGinnis (1969) reported that adding 4.8 to 12% additional protein from fish meal to a basal diet improved growth of chicks up to 30%. Scott *et al.* (1957) observed similar growth responses, but when using fish meal as the sole source of protein chick growth was poorer. However, Harms *et al.* (1961) reported that the addition of 3% fish meal in practical broiler diets had no significant effect on any of the measured production parameters. Waldroup *et al.* (1965) obtained similar results when 25 to 50% of SBM protein was replaced with fish meal protein. Rojas *et al.* (1969) also reported no significant changes in body weight, feed consumption, or feed efficiency when SBM was replaced at various levels with protein from Peruvian fish meal. Avila and Balloun (1974) found that different levels of Anchovy meal in broiler diets had no significant effect on body weights or feed efficiency, except when fish meal replaced all of the soybean protein. They detected a significant growth depression when 100% of the soybean protein was replaced. Wu *et al.* (1984) fed four different hydrolyzed fish meals to broiler chicks up to 7 wk of age and observed no significant differences among treatments for live body weight and feed conversion. Hulan *et al.* (1989) using Red fish meal at levels up to 12% in the ration found no significant effects on overall mortality or feed efficiency, but reductions in body weight and feed consumption occurred. When substituting up to 50% of the crude protein contributed by SBM with crude protein from TBM, Ponce and Gernat (2002) observed that TBM could partially replace the use of SBM in broiler diets without adversely affecting performance or carcass quality. Carcass weights were significantly higher (P < 0.001) for 0, 25, and 50% substitution of TBM for SBM, which was undoubtedly related to higher live weights detected for these treatments (Table 4). No significant treatment differences were observed for mortality or carcass yield. Our results with tilapia

Table 3: The effect of tilapia by-product meal (TM) on broiler body weight, feed consumption, and feed conversion when substituted for soybean meal at different levels in broiler diets

Variable	0% TBM	25% TBM	50% TBM	75% TBM	100%TBM	SEM
Body weight, g						
Day 7	132.4[a]	139.5[a]	141.8[a]	121.6[ab]	111.6[b]	2.01
Day 14	356.1[a]	371.3[a]	369.9[a]	302.5[b]	255.3[c]	3.98
Day 21	725.6[a]	751.9[a]	725.5[a]	615.8[b]	530.0[c]	6.63
Day 28	1168.8[b]	1260.3[a]	1173.9[b]	974.7[c]	923.4[c]	8.98
Day 35	1775.8[a]	1782.7[a]	1679.4[a]	1483.6[b]	1398.9[b]	17.20
Day 42	2262.7[a]	2289.1[a]	2240.1[a]	1884.5[b]	1842.9[b]	31.19
Feed consumption, g/bird						
Day 7	123.8[a]	126.5[a]	118.5[a]	106.8[ab]	94.6[b]	1.23
Day 14	445.1[ab]	476.8[a]	460.4[b]	417.9[b]	341.9[c]	12.36
Day 21	970.9[a]	1033.9[a]	1010.1[a]	970.2[a]	810.8[b]	17.34
Day 28	1722.7[a]	1781.3[a]	1745.1[a]	1616.7[b]	1541.5[b]	22.54
Day 35	2720.0[a]	2679.4[a]	2718.2[a]	2577.1[b]	2448.9[b]	45.21
Day 42	3787.5[a]	3731.4[a]	3678.7[a]	3414.7[b]	3303.0[b]	89.91
Feed conversion, g feed:g body weight						
Day 7	0.94[a]	0.90[ab]	0.83[b]	0.89[ab]	0.86[b]	0.017
Day 14	1.25[a]	1.28[a]	1.25[a]	1.38[b]	1.34[b]	0.041
Day 21	1.33[b]	1.37[a]	1.34[a]	1.57[b]	1.54[b]	0.032
Day 28	1.47[ab]	1.41[a]	1.48[ab]	1.66[b]	1.67[b]	0.018
Day 35	1.53[a]	1.51[a]	1.62[ab]	1.74[b]	1.75[b]	0.030
Day 42	1.67[a]	1.63[a]	1.64[a]	1.82[b]	1.80[b]	0.039

[abc]Means within rows without a common superscript are significantly different ($P < 0.001$).

Table 4: The effect of tilapia by-product meal (TM) on broiler mortality, carcass weight, and percentage carcass yield when substituted for soybean meal at different levels in broiler diets

Variable	0% TBM	25% TBM	50% TBM	75% TBM	100% TBM	SEM
Mortality	2.84	5.35	4.74	4.98	3.46	0.024
Carcass weight, g	1561.2[a]	1593.2[a]	1687.50[a]	1450.7[b]	1395.8[b]	36.11
Carcass yield, %	69.0	69.6	69.5	68.6	67.4	0.009

[ab]Means within rows without a common superscript are significantly different ($P < 0.001$).

meal agree with other studies that have shown that different types of fish meal can successfully replace SBM up to a certain concentration without causing adverse effects on broiler production parameters.

Because of the potential economic losses from undesirable off-flavored meat (Carlson *et al.*, 1957; Fry *et al.*, 1965; Waldroup *et al.*, 1965) and growth depression effects caused by adding high levels of fish meal in broiler diets, the inclusion of fish meal is usually limited. However, in the case of tilapia meal production costs are reduced because the meal is generally manufactured locally resulting in no importation or handling costs.

In conclusion, TBM could partially replace the use of SBM in broiler diets up to 50% without negatively affecting growth performance or carcass quality.

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