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Effect of Replacing Dietary Fish Meal with Silkworm (*Anaphe infracta*) Caterpillar Meal on Growth, Digestibility and Economics of Production of Starter Broiler Chickens

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Abstract: A total of one hundred and fifty day-old anak broiler chicks were used to investigate the replacement value of silkworm caterpillar meal (SCM) for fish meal (FM) on growth performance, nutrient digestibility and cost benefit of starter broilers. The birds were randomly allotted to five treatment groups of 30 birds with each treatment having two replicates of 15 birds each. Five isocaloric and isonitrogenous diets were formulated such that diet 1 which served as the control had 100% FM:0% SCM while diets 2, 3, 4 and 5, respectively) had: 75% FM:25% SCM;50% FM:50% SCM;25% FM:75% SCM and 0%FM: 00% SCM, respectively. The birds were given feed and water *ad-libitum.* The performance in terms of feed intake (29.51-31.66g), body weight gain (16.56-19.03g), feed conversion efficiency (FCR) (1.60-1.72), protein efficiency ratio (PER) (2.67-2.77) and nutrient digestibility of the chicks indicated no significant (P > 0.05) differences among the treatment means. Cost per kg gain gradually declined with increasing dietary level of SCM indicating higher economic benefit. The results of this study demonstrated that cheaper silkworm caterpillar meal can be an excellent substitute for fish meal in formulating diets for starter broiler chicks leading to increased economic gains.

Key words: Silkworm caterpillar, fish meal, amino acid, digestibility

INTRODUCTION

The importance of fish meal as feed ingredient in poultry production is quite enormous. It is a feed ingredient with very high nutrient density and high digestibility. Among the animal protein sources fish meal is particularly suited to meet the nutrient requirements of animals (Karimi, 2006). It contains high level of protein and appreciable quantities of fat and minerals. The protein in fish meal has high biological value because it is rich in essential amino acids particularly lysine and sulphur amino acids (Karimi, 2006). The presence of fish meal in a complete poultry diet will supplement any deficiency of the amino acids in vegetable protein such as soyabean, groundnut cake and cotton seed cake (Miles and Jacobs, 1997). Fish meal is fed to animals not only to improve productivity but also to protect health and welfare and reduce dependence on antibiotics and other drugs (Pike, 1999; Anonymous, 2002).

In Nigeria and indeed other developing countries of the world, fish meal is the most important conventional animal protein source, but its production, availability and cost is a major concern to animal nutritionists. Fish meal is very scarce and expensive and its inclusion in the diets for poultry hardly permits profitability. Fish meal is the only conventional animal protein source for poultry and poultry is in competition with human and other livestock for it which makes it very expensive and its inclusion in the diets results in less profitable poultry production (Agbede and Aletor, 2003; Karimi, 2006). Besides availability and high cost, the quality of fish meal is quite uncertain due to the use of different varieties, part of fish and different processing technologies in its production. In addition it is often contaminated with other ingredients such as sand, sawdust and fish bones and the use of chemicals for preservation often caused toxicity to poultry birds (Khatun *et al.,* 2003; Khatun *et al.,* 2005; Karimi, 2006). Consequently there has been recent research interest in the identification and utilization of alternative locally available feed resources in formulating poultry diets. Unconventional protein sources such as maggot meal (Atteh and Ologbenla, 1993), housefly pupae meal (El-Boushy and van der Poel, 1994), shrimp waste meal (Fanimo *et al*., 1996), meat meal (Ravinder *et al*., 1996), termite meal (Fadiyimu *et al*., 2003), leaf protein concentrate from *Glyricidia* (Agbede and Aletor, 2003), and grasshopper meal (Ojewola *et al*., 2005) have been used to replace fish meal in past or as a whole with remarkable results. In all these cases there has been reduction in feed cost and increased profitability without compromising the performance.

Silkworm *(Anaphe infracta)* caterpillar is the larva of moth butterfly. It is silvery white in appearance and about 7.5-10cm long when fully grown. Silkworm caterpillar is sparingly consumed by some local communities in Nigeria and picked up by scavenging domestic fowls in such communities. Analysis showed that silkworm caterpillar is rich in protein (48.25%), lipid (21-38%) as well as crude fibre and ash (8.42 and 8.34%, respectively) and has amino acid profile which compare favourable with that of fish meal (Solomon and Yusufu, 2005). However information on the usefulness of these insect species as feed ingredient in Nigeria in poultry production is passible.

This study was therefore designed to determine replacement value of SCM for FM on performance and the economics of production of starter broilers.

MATERIALS AND METHODS

This study was conducted at the Poultry Unit of the Department of Animal Production Teaching and research Farm, School of Agriculture and Agricultural Technology, Federal University of Technology, Minna, Niger State Nigeria.

Silkworm caterpillar occurs in large quantity at the on-set of raining season where they feed on the fresh leaves of shear butter trees. They were harvested while still fresh killed by putting in jute bags and dipping in hot water for three minutes and then sun dried for 3-5 days and milled into silkworm caterpillar meal (SCM).

A completely randomized design (CRD) was used for this experiment. A total of 150 day old anak broiler chicks were used for the experiment. The chicks were randomly allotted to five treatment groups with each treatment having two replicates. Each treatment was allotted 30 chicks with each replicate having 15 chicks. The birds were weighed collectively per replicate on the first day before being assigned to their individual treatment and the weights per chick calculated and recorded to form the initial body weight.

Five isonitrogenous and isocaloric (23% CP and 2900kcal/kg) diets were formulated such that silkworm caterpillar mea (SCM)l was used to replace different levels of fish meal (FM) thus: Diet 1 (control), 2, 3, 4 and 5 had 100:0; 75:25; 50:50; 25:75 and 0:100% FM:SCM, respectively (Table 3).

The birds were reared on deep litter made of wood shavings. Light to supply the required heat was provided using 200 watt electric bulb (24 hours) with controlled adjustment to regulate the heat. Water and feed were provided *ad-libitum*. All required routine medications were administered accordingly.

Production parameters were measured from feed intake, body weight and digestibility. The diets, FM and SCM were analyzed for proximate composition according to AOAC (1990) while the amino acid profile of FM and SCM were also determined according to Sparkman *et al.* (1958). Data were also collected on the production cost. All data were subjected to one way analysis using analysis of variance (ANOVA) and means were separated by Duncan's multiple range test using computer software package Statgraphics 2.0 (1987).

RESULTS AND DISCUSSION

Table 1 shows the result of the proximate composition of the fish meal (FM) and silkworm caterpillar meal (SCM) used in the study, while Table 2 shows the result of the amino acid profile (gN/100g protein) of the experimental FM and SCM. Silkworm caterpillar meal had slightly higher crude protein value of 50.30% than 48.25% reported by Solomon and Yusufu (2005) but this was quite lower than those reported by SNI (2005) (63.8%) and Loselevich *et al.* (2004) (56.8%). This disparity can be attributed to such factors as source, stage of harvesting, method of processing and storage as opined by Oduguwa *et al.* (2005) and Ojewola *et al.* (2005). The ether extract of SCM (16.43%) was higher compared to that of fish meal (10.26%) which is reflected in the apparently high NFE. This value agreed with the report of Habib and Hasan (1994). Also SCM had higher crude fibre (10.90%) content than the experimental fish meal (7.63%). This could be due to the high proportion of fibre in some parts of the silkworm caterpillar mainly exoskeleton which is made of chitin as is also evident in the high ash content (12.03%). High fibre content of most non-conventional feed ingredients had been reported by previous workers (Khatun *et al.,* 2003; Khatun *et al.,* 2005; Oduguwa *et al.,* 2005). The amino acids profile of SCM showed superiority over FM in most of the essential amino acids which is in line with that reported by Solomon and Yusufu (2005). The results of the initial and final weights, feed intake, daily gain, FCR, PER and economics of production are presented in Table 4. The final weight at the 28th day was highest at 50% SCM inclusion level and lowest at 100% substitution.

Birds fed diet 4 (25% FM: 75% SCM) had the highest intake per day (31:66g) while lowest intake (29.51g) was recorded in diet 5 (0% FM: 100% SCM). This low intake at 100% SCM inclusion level can be attributed to high fibre content of SCM as reflected in Table 1. Intake was depressed because of the inability of young chicks to effectively utilize the crude fibre inherent in the exoskeleton (made of chitin) of the silkworm caterpillar. This findings agrees with the report of Fagoonee (1983) who opined that complete substitution of SCM for FM in broiler chicks depressed consumption due to high oil and fibre contents of silkworm caterpillar.

The highest daily weight gain (19.03g) was recorded in diet 3 (50%:50% FM/SCM, respectively) while the lowest gain (16.56g) was recorded in birds fed diet 5 (0% FM: 100% SCM). The mean daily gain was however not affected ($P > 0.05$) by any level of inclusion of SCM in the diets although the data gave an impression that dietary 100% SCM level (D5) had little effect on weight gain. The similarity in weight gain indicated that the diets were equally efficient with no superiority of fish meal over SCM. This result agrees with findings of Ichhponani and Malik (1971), Khatun *et al.* (2003) and Loselevich *et al.*

Table 1: Proximate Composition of Experimental Fish Meal and Silkworm Caterpillar Meal

Components	CP (%)	EE (%)	CF (%)	ASH (%)	NFE (%)	DM (%)	Ca	P
Fish meal	60.04	10.26	7.63	19.80	2.27	93.74	4.53	1.33
SCM	50.30	16.43	10.90	12.03	10.34	94.90	2.77	1.05

SCM: Silkworm caterpillar meal: CP: Crude Protein; EE: Ether extract; CF: Crude fibre; NFE: Nitrogen free extract; DM: Dry Matter; Ca: Calcium; P: Phosphorus.

Table 2: Amino Acids (gN/100g Protein) profile of Experimental Fish Meal and Silkworm Caterpillar Meal

Amino acid	Lysine	Histidine	Arginine	Aspartic acid	Threonine	Serine	Glutamic acid	Proline
Fish meal	4.56	2.45	5.01	7.02	2.15	3.15	11.06	2.09
SCM	5.02	3.00	4.50	9.31	2.81	4.65	13.90	2.35

Table 2: Continue

Amino acid	Glycine	Alanine	Cysteine	Valine	Methionine	Isoleucine	Leucine	Tyrosine	Phenylalanine
Fish meal	4.03	2.69	1.09	3.02	2.20	3.01	6.90	2.89	3.45
SCM	4.10	4.46	1.56	3.68	3.02	3.32	7.25	3.41	4.11

Table 3: Inclusion Levels of Ingredients and Proximate Composition of Experimental Diets %

	Diets (FM: SCM)				
Ingredients	1 (100:0)	2 (75:25)	3 (50:50)	4 (25:75)	5 (0:100)
Maize	54.99	54.55	54.09	53.79	52.66
Groundnut	26.26	26.59	26.93	27.05	28.01
Fish meal	8.75	6.65	4.49	2.29	0.00
Silkworm caterpillar meal	0.00	2.21	4.49	6.89	9.33
Rice bran	5.00	5.00	5.00	5.00	5.00
Bone meal	4.00	4.00	4.00	4.00	4.00
Lysine	0.25	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25	0.25
Premix*	0.25	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00	100.00
Determined analysis					
Dry matter %	93.35	92.97	94.42	92.84	93.63
Crude protein %	23.60	23.37	24.88	22.56	22.45
Crude fibre %	15.30	18.62	11.83	14.40	18.67
Ether extract	5.07	5.49	4.80	4.52	5.30
Ash	10.25	9.14	9.80	6.92	10.43
Nitrogen free extract %	45.78	43.39	48.69	51.70	43.15
Calcium	4.05	2.80	3.04	2.69	2.29
Phosphorus	1.07	1.01	0.89	0.89	0.89
Calculated analysis					
Crude protein %	23.01	22.96	22.96	23.00	23.01
Crude fibre	13.19	16.17	13.24	13.36	18.08
Ether extract	5.30	6.54	5.75	4.52	4.47
Ash	12.17	10.90	18.73	7.40	8.12
Calcium	3.98	3.59	3.80	3.44	3.54
Phosphorus	1.81	1.13	1.62	1.63	1.77
Metabolizable energy (Kcal/kg	2974.87	2962.23	2949.15	2953.03	2922.86

*Supplied per kg: Vit A: 7500iu; D:500,000iu; E:1000iu; B_1: 375mg; B_2:12mg; B_3:500mg; B_6: 150mg; B_{12}: 25mg; K: 15mg; C: 10mg and Folic acid: 150mg; Ca: 0.25mg; Choline: 250mg; Panthotenic acid: 14.4mg; Lysine, Methonine and terramycin (Broad-spectrum antibiotics and growth promotants).

(2004). The authors reported that silkworm pupae meal constitute a high quality replacement for fish meal in poultry with no reduction in final weight.

There was increase in feed conversion ratio with increase dietary SCM up to 50% inclusion. Generally, there were no significant (P > 0.05) differences in the efficiency of feed utilization between the treatment means which is in line with the report of Sengupta *et al.* (1995) and Khatun *et al.* (2003). The efficiency of utilization of the protein in feed increase with increase in SCM inclusion levels indicating better utilization of the protein in the SCM. The reason for this performance can be linked to the better amino acid, profile of SCM shown from its determined analysis which agrees with the findings of Fadiyimu *et al.* (2003) who reported that the quality of protein of feed ingredient is determined by the

Table 4: Performance and Cost Analysis of Broiler Starter Chicks Fed Varying Replacement Levels of Silkworm Caterpillar Meal for Fish Meal

	Diets (FM:SCM)						
Parameters	1 (100:0)	2 (75:25)	3 (50:50)	4 (25:75)	5 (0:100)	SEM	LOS
Initial body weight (g)	59.30	59.00	59.30	59.40	59.00	4.88	NS
Initial body weight (g)	581.84	573.37	592.12	550.79	523.12	5.12	NS
Average daily feed intake (g)	30.83	30.33	30.47	31.66	29.51	3.99	NS
Average daily weight gain (g)	18.68	18.55	19.03	18.41	16.56	2.00	NS
Feed conversion ratio	1.64	1.64	1.60	1.70	1.72	0.05	NS
Protein efficiency ratio	2.67	2.69	2.72	2.75	2.77	0.31	NS
Cost of feed (N/kg)	38.83	38.76	37.37	34.42	32.22		
Cost of intake (N/g)	1.20	1.18	1.13	1.07	0.95		
Cost/kg gain (N/)	64.24	63.58	59.38	58.12	57.38		

NS: Not significant (P>0.05); SEM: Standard error of the mean; LOS: Level of significant.

Table 5: Apparent Nutrient Digestibility of Broiler Starter Chicks Fed Varying Levels of Silkworm Caterpillar Meal for Fish meal

	Diets (FM:SCM)						
Constituents %	1 (100:0)	2 (75:25)	3 (50:50)	4 (25:75)	5 (0:00)	SEM	LOC
Dry matter	83.06	83.41	83.44	83.16	79.13	0.57	NS
Crude protein	86.01	86.26	86.10	85.41	83.44	0.39	NS
Ether extract	91.40^{a}	87.96^{b}	87.88^{b}	89.35^{ab}	91.53^{a}	0.51	*
Crude fibre	83.17^{a}	81.19^{a}	77.16^{a}	69.62^{c}	83.89^{a}	1.15	*
Ash	58.89^{a}	37.63^{a}	57.25^{a}	46.09^{b}	38.49^{a}	2.21	*
Nitrogen free extract	87.38^{a}	89.94^{a}	85.53^{c}	88.92^{ab}	85.14^{c}	0.48	*

FM: Fish meal; SCM: Silkworm caterpillar meal; SEM: Standard error of the mean; LOC: Level of significance; NS: Not significant (P>0.05); * Significant (P<0.05). abc: means on the same row with the same alphabet are not significantly (P>0.05) different.

level of amino acids it furnishes and not the actual quantity of protein in it.

There was higher economics of production of birds with higher levels of SCM in the diets (Table 4). Total cost of intake as well as total cost per kg gain gradually declined on increasing inclusion level of SCM. This findings agrees with the observations of Habib *et al.* 1992; Choudhury *et al.,* 1998; Khatun *et al.,* 2003; Khatun *et al.,* 2005. The least cost per kg of feed (N32.22) observed in diet 5 (100% SCM) is as a result of lower cost of SCM which is also reflected in least cost (N57.38) per kg of gain in diet 5.

The apparent nutrient digestibility of dry matter (DM), crude protein (CP), either extract (EE), crude fibre (CF), ash and nitrogen free extract (NFE) of SCM substituted diets shown in Table 5 compared favourably with the control diet 1 (100% FM: 0% SCM). Significant ($P < 0.05$) differences in the apparent digestibility of NFE, CF, EE and ash can be attributed to the fact that the digestibilities of feed by chicks is low at high fibre and fat content which is evident in SCM. Many authors have indicted high level of chitin in SCM and other ingredients as being responsible for poor nutrient utilization in chicks (Fanimo *et al.,* 1998; Khatun *et al.,* 2003; Ojewola *et al.,* 2005; Oduguwa *et al.,* 2005).

Conclusion: The results of this study revealed that SCM can completely replace the scarce and expensive FM in a complete starter broiler diet without compromising performance and economic returns.

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