EFFECT OF VARIOUS PROTEIN SOURCES ON EGG PRODUCTION IN A TROPICAL ENVIRONMENT

O C Onwudike

Department of Animal Science, University of Ife,
Ile-Ife, Nigeria

240 laying hens of the Harco breed were used to study the effects of protein source on the rate of egg production, egg weight and the economy of egg production in the tropics. The protein sources used were: fish meal, fish meal plus groundnut cake or blood meal mixture, blood meal, groundnut cake or a blood meal and groundnut cake mixture. The trial lasted 6 months. The complete replacement of fish meal with either groundnut cake or blood meal significantly decreased egg production ($P < .05$). Partial replacement of fish meal with either groundnut cake or blood meal did not significantly affect the egg production rate ($P <.05$). The complete replacement of fish meal with a combination of groundnut cake and blood meal did not significantly reduce egg production ($P >.05$). All the sources of protein proved equally satisfactory in the maintenance of egg weight, and with the exception of the blood meal supplemented diet the protein sources were equally efficient in terms of egg production expressed as feed (kg) per 12 eggs laid. Protein sources significantly affected ($P <.05$) the feed cost per dozen eggs. The results emphasize thee it is possible to do away with fish meal from the diets of laying birds without reducing laying performance.

Key words: Laying hens, egg production, fish meal alternatives, protein source, egg production, production costs, tropical poultry

One of the major problems of poultry production in Nigeria is the high cost of feeds. This problem has tended to reduce the rate of expansion of the poultry industry and has added to the low level of animal protein nutrition of its people. A possible way of increasing the supply of poultry products at cheaper prices is by reducing the cost of production through the use of cheaper, locally available sources of protein such as groundnut cake and blood meal in place of imported fishmeal. There is some evidence showing that the complete replacement of fishmeal by other protein sources does not significantly affect egg production (Lansbury 1961;Aitken et al 1969; Datta and Bose 1974). This is in contrast to the reports of others who have shown that the complete absence of fishmeal from the diet of laying birds will significantly reduce egg production and that there is a critical limit to the level of substitution (Deaton and Quisenberry 1964; Smith and Chancey 1967; Opstvedt and Gjefsen 1975). This study was therefore carried out to compare the performance of laying birds fed protein from fish meal, blood meal, groundnut cake or a combination of these.

Materials and Methods

A total of 240 laying birds of the Harco breed which were approximately 38 weeks old and about 5 months in lay were selected for this experiment. Individual performance of the layers was not known at the time of selection. Selection was therefore completely random. The birds were divided into six equal treatment groups of 40 birds in each and these were further subdivided into four replicate groups of 10 birds each. The birds were paired in cages.

A total of six isocaloric and isonitrogenous diets were prepared from different protein sources as follows: ration 1 - fish meal, ration 2 - groundnut cake, ration 3 - blood meal, ration 4 - fish meal and blood meal, ration 5 - fish meal and groundnut cake and ration 6 - blood meal and groundnut cake. In the three diets where two of the protein sources under test were used, each source of protein contributed an equal amount of protein. Each treatment group was randomly assigned one of the six diets, the composition of which appears in Table 1.

Table 1:
Composition of the experimental diets (%)

Ingredients (%DM)	Protein supplement					
	Fish meal	Groundnut cake	Blood meal	Fishmeal + blood meal	Fishmeal + ground nut cake	Blood meal + ground nut cake
Yellow maize	61.55	64.00	61.55	61.55	61.97	61.77
Groundnut cake	-	18.50	-	-	6.67	6.67
Fish meal	8.00	-	-	4.00	4.61	-
Blood meal	-	-	8.00	4.00	-	4.61
Brewers' grains	20.00	6.50	19.00	19.50	16.00	16.00
Oyster shell	7.50	7.95	8.00	7.50	7.50	7.75
Dicalcium phosphate	1.90	2.00	2.40	2.40	2.20	2.20
Agricare premix[a]	0.50	0.50	0.50	0.50	0.50	0.50
Salt	0.50	0.50	0.50	0.50	0.50	0.50
Amprolium (coccidiostat)	0.05	0.05	0.05	0.05	0.05	0.05
Analysis:						
Crude protein (%)	16.35	16.30	16.29	16.22	16.20	16.17
Calculated ME (kcal/kg)	2827	2803	2802	2814	2810	2802
Calculated calcium (%)	3.72	3.52	3.65	3.63	3.61	3.51
Calculated available phosphorus (%)	0.64	0.50	0.53	0.63	0.61	0.50
Crude fibre (%)	7.45	7.32	7.81	7.89	7.75	7.92

[a] A Pfizer supplement supplying the following nutrients per kg of ration: Vitamin A, 8000 i.u.; D3, 2000 i.u.; riboflavin, 4.20 mg; pantothenic acid, 5.0 mg; nicotinic acid, 20.0 mg; folic acid, 0.5 mg; choline, 300.0 mg; vitamin B_{12}, 0.01 mg; vitamin K, 2.0 mg; vitamin E, 2.5 i.u.; manganese, 56.0 mg; iodine, 1.0 mg; iron, 20.0 mg; copper, 10.0 mg; zinc, 50.0 mg; cobalt, 1.25 mg and methionine, 225 mg.

Feed and water were provided ad libitum throughout the six months duration of the study. Feed samples were analysed for proximate composition according to the methods outlined in the AOAC methods of analysis (1975). The calculated amino acid values expressed as percentages of the crude protein of the diets appear in Table 2. These values were calculated from the mean values of several batches of the ingredients determined at the University of Ibadan, Nigeria (Hitachi-Perkin-Elmer Automatic Amino Acid Analyser Model KLA 3B.)

Table 2:
Calculated amino acid composition as percent of crude protein content of diets

Amino acids	Protein supplement					
	Fish meal	Groundnut cake	Blood meal	Fishmeal + blood meal	Fishmeal + ground-nut cake	Blood meal + ground nut cake
Arginine	5.81	8.50	6.68	5.56	6.62	6.56
Histidine	3.87	3.88	4.50	4.18	3.75	4.19
Lysine	5.19	3.38	5.00	5.06	4.37	4.37
Methionine + cystine	3.56	2.31	2.43	2.94	3.00	2.75
Threonine	4.81	3.81	4.68	4.75	4.37	4.37
Valine	6.00	4.87	6.87	6.37	5.56	6.13
Leucine	11.90	10.00	13.18	12.62	11.19	12.06
Isoleucine	5.61	4.12	4.31	5.00	5.06	4.44
Phenylalanine tyrosine	16.12	15.75	16.62	16.31	16.00	16.37
Tryptophan	1.00	0.94	0.88	0.94	1.00	1.00

Eggs were collected daily and the records of daily egg production for all the replicate groups were kept throughout the experimental period. Average hen-day production percentages were calculated from the total number of eggs actually collected, expressed as percentages of the expected number of eggs for each group per month over the six-month period. Eggs laid during the last seven days of each month were kept together and weighed on a replicate basis. The records of replicate group feed consumption were kept for each month. From the records of feed consumed and eggs laid the feed consumed per dozen eggs laid was also calculated for the six treatment groups.

The prevailing market prices of the feed ingredients were used to estimate feed cost of producing a dozen eggs using each of the diets. Data collected were statistically analysed to test the significance of differences obtained, following the Duncan's Multiple Range Test as outlined by Steele and Torrie (1960), wherever significant differences were indicated.

Results

The average hen-day production percentage, feed consumption, feed/ dozen eggs and the average egg weight as influenced by the different sources of protein are shown in Table 3.

Average hen-day production percentage: The complete replacement of fish meal with either groundnut cake or blood meal (rations 2 and 3 respectively), significantly ($P < 0.05$) decreased the average hen-day production percentage. The diet with groundnut cake as the major protein source was significantly ($P < 0.05$) better than the

Table 3:

Effects of different protein sources on egg production, feed consumption, feed/dozen eggs laid and egg weight

Characteristics	Protein supplement						
	Fish meal	Groundnut cake	Blood meal	Fishmeal + blood meal	Fishmeal + ground-nut cake	Blood meal + ground nut cake	± SE
Average hen-day production (%)	65.48^{a}	59.13^{b}	$52,37^{c}$	64.81^{a}	64.34^{a}	62.54^{a}	1.59^{*}
Average feed intake/ bird/day (g)	146.79^{ab}	139.27^{c}	143.52^{bc}	143.21^{bc}	151.38^{a}	143.09^{bc}	1.57^{**}
Average feed/dozen eggs (kg)	2.69^{b}	2.84^{b}	3.29^{a}	2.66^{b}	2.84^{b}	2.78^{b}	0.08^{**}
Average egg weight (g)	61.62^{a}	61.24^{a}	60.63^{a}	61.31^{a}	60.82^{a}	61.14^{a}	0.69

^{abc} Means in the same line not superscripted by the same letters are significantly different from one another.

** Highly significant differences among the means ($P < 0.01$).

* Significant differences among the means ($P < 0.05$).

diet with blood meal as the major protein source. Partial replacement of fish meal with either groundnut cake or blood meal did not significantly affect average hen-day egg production. Similarly the complete replacement of fish meal with a combination of groundnut cake and blood meal did not significantly reduce egg production. The control diet in which fish meal supplied most of the dietary protein, however, had a slightly higher but non-significant production rate than the other diets in which fish meal was partially replaced by blood meal or groundnut cake or completely replaced by a combination of blood meal and groundnut cake.

Average feed consumed/bird/day: The results indicate a significant effect of the different sources of protein on feed intake ($P < 0.01$). The highest feed intake value was obtained from birds on the fish meal/groundnut cake mixture. This value was, however, not significantly different from the feed intake value obtained from the feeding of fish meal alone as the major protein source. Diets with the other sources of protein were not significantly different from one another in intake terms.

Average feed consumed/dozen eggs laid: All the sources of protein with the exception of blood meal were equally efficient and not significantly different from one another. However, the complete substitution of fish meal with blood meal significantly reduced feed efficiency ($P < 0.01$).

Influence of protein source on egg weight: The different sources of protein did not significantly affect egg weight. All the protein sources proved equally satisfactory in the maintenance of egg weight.

Feed cost/dozen eggs: A summary of the economic considerations of the different protein sources appears in Table 4. The ration containing the fish meal and blood meal mixture as the major source of protein had the lowest feed cost per dozen eggs produced and this was significantly ($P < 0.05$) better than all the other rations except

Table 4:
Economic data for egg production

	Protein supplement						
	Fish meal	Groundnut cake	Blood meal	Fishmeal + blood meal	Fishmeal + groundnut cake	Blood meal + groundnut cake	±SE means[1]
Total food consumption (kg)	346.6	234.0	241.1	240.6	254.3	340.4	
Feed cost (₦)[2]	69.4	76.4	56.6	62.8	75.3	63.6	
Cost/kg feed (₦)	0.28	0.33	0.23	0.26	0.29	0.26	
Total number of eggs produced (dozens)	91.7	82.7	73.4	90.7	90.0	87.5	
Cost of producing a dozen eggs (₦)	0.76^{b}	0.92^{d}	0.77^{b}	0.70^{a}	0.84^{c}	0.74^{ab}	0.02*
Estimated gross revenue (₦)	146.7	132.4	117.4	145.1	144.0	140.0	
Gross revenue less feed cost (₦)	77.3	55.9	60.7	82.3	68.7	76.40	
Revenue/feed cost (₦)	2.11	1.73	2.07	2.31	1.91	2.20	

[1] Only the cost of producing a dozen eggs analysed statistically in this set of data
* Significant differences among the treatment means ($P < 0.05$)
[2] Naira (₦) = US$ 1.53
abcd Means in the same line not superscripted by the same letters are significantly different from one another

that containing the blood meal and groundnut cake mixture. The feed cost/dozen eggs from the ration in which fish meal was the major source of protein was not significantly different from the rations in which the major protein sources consisted of blood meal alone or a mixture of blood meal and groundnut cake. The highest feed cost per dozen eggs produced was obtained from the diet in which groundnut cake completely replaced fish meal. This was followed by that in which groundnut partially replaced fish meal.

Discussion

The significant reduction in hen-day production when blood meal was fed as the major source of protein could be due to problems of amino acid deficiency, imbalance and some other peculiar problems of blood meal. Grau and Almquist (1944) reported that the serum and fibrin fractions of beef blood meal are of much better quality than the blood cell fractions which go to form the blood meal. Also, blood meal is not readily digested and this can bring about low amino acid availability resulting in amino acid deficiency and the consequent reduction in egg production (Hill 1969). Carpenter (1974) noted that the availability factor for blood meal is about 65% as compared to 90% availability factor for fish meal (Combs and Nott 1967). Studies by Fetuga et al (1973)have indicated that the disproportionate ratio of leucine to isoleucine of 12.8

g/16 g of N to 1.17 g/16 g of N, respectively, and the low sulphur amino acid levels of blood meal are among the factors responsible for the poor utilization of blood meal. From this study, the amino acid compositions of the diets (Table 2) show that the complete replacement of fish meal with blood meal gives very low levels of the sulphur amino acids. The levels of the other amino acids are comparable to to the levels seen in the fish meal based diets. The poor performance of the birds fed blood meal as the major protein source may, therefore, be related to the low level of sulphur amino acids, leucine-isoleucine antagonism, poor digestibility and poor availability of amino acids.

The equally poor performance of birds fed the groundnut cake supplemented diet could also be related to amino acid deficiencies. A number-of workers (Waldroup and Harms 1963; Anderson and Warnick 1964 ; Daghir et al 1969; Fetuga et al 1973) have reported very low levels of lysine, methionine, cystine and threonine in groundnut cake when compared to fish meal. The calculated amino acid values for this diet show low levels of lysine, methionine plus cystine, threonine and leucine when compared to the other diets. In terms of the calculated amino acid values, this diet is poorer than the blood meal diet. However, the higher digestibility and availability of groundnut cake might have allowed for the slightly higher production rate on this diet. The fact that birds which received some fish meal in their diet had significantly better production rates than the birds on only groundnut cake or blood meal as the major protein source may be related to the ability of fish meal based diets to supply most of the required amino acids and also to the better digestibility and availability of fish meal. This result would tend to support the view that fish meal is indispensable in the diet of laying birds. However, the results obtained from the complete substitution of fish meal by a combination of blood meal and groundnut cake nullifies the view that fish meal must be present in the ration for maximum egg production. This result is in agreement with the results of Lansbury (1961). It emphasizes that the superiority of fish meal is due to its better amino acid balance. While the major limitations in the use of groundnut cake are methionine and lysine deficiencies, the major limitation in blood meal is isoleucine deficiency. From this study it appears that a combination of groundnut cake and blood meal produces a complementary effect which raised the quality of the diet.

The lowest feed intake value occurred in birds fed the diet in which groundnut cake completely replaced fish meal and appears also to be related to the amino acid pattern of the diet. The calculated amino acid values show that this diet was lower than all the other diets in lysine and methionine plus cystine. This agrees with the work of Hill (1969) which shows that methionine and lysine are required for optimum feed intake. With respect to the amount of feed consumed per dozen eggs, a number of workers (Deaton and Quisenberry 1964; Carlson and Guenther 1969; Fetuga et al 1973) have shown that feed consumed per dozen eggs produced becomes lower at higher protein levels. One can, therefore, infer from this that a higher amount of amino acid will improve the efficiency of utilization of feeds. This probably explains the results obtained in this study. The observations that all the sources of protein were equally effective in the maintenance of egg weight agrees with the findings of Brant and Carver (1947) and Cooper and Hughes (1974), but is contrary to the findings of Deaton and Quisenberry (1964) and Opstvedt and Gjefsen (1975), who observed a significant reduction in egg weight when fish meal was fed to layers. The economic

benefit from the blood meal based diets when compared to the diet in which groundnut cake was the major source of protein and that which contained the groundnut cake and fish meal mixture is related to the price differential between groundnut cake and blood meal (N 540 ($US 830) and N 170 ($US 260) per tonne respectively). Even though fish meal costs N 840 ($US 1290) per metric ton its economic benefit stems from the high rate of production and tee high efficiency of conversion when it is used as the major source of protein.

Conclusion

The conclusion of this study is that fish meal can be partially replaced by either blood meal or groundnut cake without adversely affecting egg production, egg weight or the average feed intake per dozen eggs produced. Also, a mixture of blood meal and groundnut cake can completely replace fish meal in the diet of laying birds without reducing performance .

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Received 21 January 1981