MEETING THE PROTEIN REQUIREMENTS OF BROILER CHICKENS THROUGH PLANT SOURCES

A. DONKOH, B.Sc, PhD
C.C. ATUAHENE, B.Sc, M.Sc
E. ACHEAMPONG, B.Sc.
Department of Animal Science,
Kwame Nkrumah University of Science and Technology,
Kumasi

ABSTRACT

A six-week feeding trial was conducted to determine whether a combination of groundnut cake (GC), soyabean meal (SBM) and brewer's dried yeast (BDY) can efficiently replace fishmeal in broiler diets. One hundred and eighty (180) 2-week old AF Bosbek commercial strain of broiler chickens were allotted to three dietary treatments in a completely randomised design. The dietary treatments were designated as T_1 (containing 180 g fishmeal kg^{-1} with no GC, SBM or BDY), T_2 (containing 90 g fishmeal kg^{-1} and 50 g each of GC, SBM and BDY kg^{-1}), and T_3 (containing 100 g each of GC, SBM and BDY kg^{-1} with no fishmeal). The experimental diets were formulated to be isonitrogenous and isoenergetic. Birds had free access to food and water throughout the study.

Replacement of fishmeal with the plant protein supplements, significantly decreased (P 0.05) body weight gain and feed conversion efficiency but not feed consumption, carcass dressing percentage, percentage blood and feathers. The dietary treatments had significant impact on the moisture, crude protein and ether extract (fat) levels of the meat.

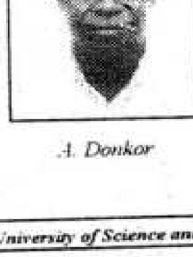
Feed cost kg as well as cost of feed to produce a kg liveweight reduced considerably as the levels of SBM, GC and BDY in the diets increased. Health-related problems or mortalities attributable to dietary treatments were not observed.

Keywords: *Plant proteins, Fishmeal, Broiler Chickens, Growth Performance.*

INTRODUCTION

One of the major problems facing the animal industry in most developing countries has been the unavailability of feed resources in high amounts for the feeding of farm animals. Feed represents the major item of expenditure in poultry production. The problem is worsened in situations where farm animals, for example, poultry tend to compete with man for feed ingredients such as maize and fish. Fish, which is the main protein source in poultry diets in Ghana is expensive. This brings about an equally high increase in the prices of poultry meat and eggs. It is envisaged that the situation with respect to fish can be remedied by substituting it with inexpensive high protein ingredients such as the oil seed cakes and meals that are readily available and which are not directly consumed by humans. Oil seed cakes and meals such as soyabean meal (SBM) and groundnut cake (GC) are very valuable poultry feeding-stuffs [1]. As a group the oilseed cakes and meals are high in crude protein, most being over 400 g kg^{-1} DM. Gohl [2] has reported that because of its low fibre and high protein content, decorticated GC is a valuable ingredient in poultry diets. According to Church and Pond [3], SBM is one of the best plant protein sources available and is a highly favoured feed ingredient as it is of high energy value, quite palatable, highly digestible and results in excellent performance when used for feeding different animal species. Brewer's dried yeast (BDY) is an excellent source of protein with high biological and digestibility values and has been found to be a very valuable component of poultry and pig rations [2].

Parkhurst and Mountney [4] have indicated that several different protein sources give a more



A. Donkor *C.C. Atuahene* *E. Acheampong* adequate amino acid balance than one alone. GC, SBM, and BDY have been used individually with fishmeal to meet the protein requirements of poultry. However, there is paucity of information on the effect of combining these ingredients to replace fishmeal in broiler diets.

This study was therefore undertaken to ascertain whether a combination of plant sources of protein such as GC, SBM and BDY can efficiently replace fishmeal in broiler diets and to provide poultry farmers with a feed package devoid of fishmeal at affordable prices.

MATERIALS AND METHODS

Source of Plant Protein Supplements

Brewer's dried yeast (BDY) was obtained from Guinness (Ghana) Limited, Kumasi, while the soyabean meal (SBM) and groundnut cake (GC) were purchased from a commercial feed supplier in Kumasi.

Dietary Treatments

Three experimental diets were formulated. Diet 1, which was designated as T_1, served as the control diet and contained fishmeal (180 g kg^{-1}) as the main protein source with no plant protein supplement. Diet 2, designated as T_2, contained both fishmeal (90 g kg^{-1}) and plant protein supplements namely: SBM (50 g kg^{-1}), GC (50 g kg^{-1}) and BDY (50 g kg^{-1}). Diet 3, designated as T_3, contained 100 g each of SBM, GC, and BDY kg^{-1} diet but no fishmeal. The composition and analysis of the experimental diets are shown in Table 1. The experimental diets were formulated to be isonitrogenous and isoenergetic.

Chemical Analyses of Feed

Proximate analyses of diets (dry matter, crude protein, ether extract, ash and crude fibre) were carried out using the standard procedures of the Association of Official Analytical Chemists [5].

Experimental Animals and Management

A total of 180 unsexed 14-day-old commercial broiler chickens (AF Bosbek strain) were randomly divided into 3 triplicate groups of 20 chicks per replicate and allotted to the three dietary treatments, in a completely randomised design. Each replicate lot was placed and reared in a deep litter pen measuring approximately 3.0 x 1.7m, a floor space of 0.26m^2 per bird. The study was conducted for 42 days (2-8 weeks of age). Before the start of the feeding trial, the birds were weighed and subsequently allocated to the treatments in such a way that the mean weights differed as little as possible. Birds had free access to feed and water throughout the experimental period. Chickens were vaccinated against Gumboro and Newcastle diseases. They were protectively medicated for Coccidiosis at 3 days of age and again during the third week using Sulfadimidine Sodium 33% (Bremer Pharma GMBH, Germany) via the drinking water.

Parameters Measured

Feed consumption, liveweight changes and feed conversion ratios were recorded weekly for individual replicate of each dietary treatment. Records of mortality were also kept. All sick and dead chickens were sent to the Veterinary Laboratory for post-mortem examination. At the end of the feeding trial, 4 broilers (2 males and 2 females) per replicate were randomly selected, starved of feed for 18 h to empty their crops and killed by cutting the jugular vein to allow proper bleeding. Determination of percentage blood was by the difference between live weight and dead weight expressed as percentage of live weight. The slaughtered birds were defeathered and eviscerated. The weight of the feathers was calculated as the difference between the dead weight and the defeathered weight and expressed as a percentage of the liveweight. The carcass dressing percentage was calculated as the ratio of the eviscerated weight to the liveweight and expressed as a percentage.

The composition of carcasses was determined by removing the right thighs and peeling off the skins of two slaughtered birds in each replicate. The muscle of each bird was separated from the bone and ground separately 3 times in an electric grinder. After thorough mixing, aliquots were obtained for moisture, protein and ether extract analysis. The samples were prepared and analysed for moisture, protein and ether extract using the procedures described for meat and products by the Association of Official Analytical Chemists [5].

Economics of production was based on the feed cost per kg diet and feed cost per kg weight gain. Feed cost per kg live weight gain, i.e the cost of feed required to produce a kg of weight gain was calculated as a product of the feed cost kg^{-1} diet and feed conversion efficiency for individual dietary treatments.

Statistical Analysis

Data obtained were subjected to analysis of variance technique using the general linear models procedure of SAS [6] and differences between treatment means were determined by Duncan's multiple range test [7]. The probability level for determining significance was 0.05.

RESULTS AND DISCUSSION

The general performance of the experimental population is shown in Table 2. Feed intake by birds was not significantly ($P>0.05$) influenced by the dietary treatments. This suggests that birds will consume diets which the fishmeal portion has wholly been replaced by plant protein supplements. Table 1 indicates that the energy contents of the experimental diets were similar. Chickens generally eat to satisfy an inner metabolic need for energy and will therefore eat similar amounts of diets containing similar levels of energy.

There was little difference in average chick weight after selection at 2 weeks of age, for birds on the various dietary treatments. There were significant ($P<0.05$) differences among the treatment means for weight gain. There was, however, no statistical difference in body weight gains during the period of 2 to 8 weeks of age between birds on dietary treatments 1 (T_1) and 2 (T_2), with those under treatment 3 (T_3) gaining significantly ($P<0.05$) less weight. The efficiency of feed utilisation (feed conversion ratio) was significantly ($P<0.05$) affected by the dietary treatments. Efficiency of feed utilization favoured birds on dietary treatments 1 and 2, with those on dietary treatment 3 being the least efficient. The differences observed in the body weight gains could be attributed to many factors. Firstly, proteins from plant sources are of poor quality and are deficient in certain essential amino acids compared to those of animal origin. The limitation of amino acids associated with plant proteins, particularly for the sulphur-containing amino acids, has been reported by several authors [1, 4, 8]. It is therefore probable that for dietary treatment 3 certain amino acids were below the physiological optimum level and this consequently affected protein synthesis and hence body weight gain. The enhanced performance by broilers fed on the dietary treatments 1 and 2 could be explained on the basis of a greater efficiency in the conversion of feed into tissue which in turn was the result of adequate amounts of the various nutrients required for proper growth, particularly amino acids, such as lysine, which is the first most limiting amino acid. Akiwande and Bragg [9] have noted that the response of body growth in the chick is directly related to the amount of lysine available for tissue protein synthesis and liver cell multiplication. The data in Table 1 indicated that as the concentration of the plant protein supplements increased and the fishmeal content decreased, the lysine contents of the diets decreased. The broiler diets containing fishmeal (i.e. T_1 and T_2) for example, were calculated to contain 11.32 and 10.70 g lysine kg^{-1}, respectively, which were above the value of 10.5 g kg^{-1} reported to be adequate for broiler chickens by Shingari et al. [10]. On the other hand, dietary treatment 3, which contained only plant protein supplements as the sole source of protein, was calculated to contain 9.97 g lysine kg^{-1}. The dietary requirement for poultry is actually a requirement for amino acids. Thus, the lower growth rate observed for birds fed on the diet containing only plant protein supplements as the sole source of protein might be caused by the decreased amount of lysine available for growth when true growth is considered as deposition of amino acids (of which lysine is the most critical under practical conditions of feed formulation). This ultimately affected the efficiency of feed conversion into tissue.

Another probable reason for the differences observed in the growth performance is that feedstuffs of animal origin are good sources of vitamin B_{12} (cyanocobalamin), whereas feedstuffs of plant origin are either devoid of this vitamin or are extremely poor sources of it [11]. Vitamin B_{12} is involved in the synthesis of red blood cells, deoxyribonucleic acid (DNA) and methionine as well as fat and carbohydrate metabolism. Consequently, probable lack of this vitamin in dietary treatment 3 (T_3) could have been a contributory factor to the reduced growth rate of the birds fed on this diet. Furthermore, plant proteins are more often resistant to breakdown in the alimentary tract than animal proteins [12, 13] and consequently could have contributed to the decreased growth performance as a result of a reduction in the amount of amino acids available for growth for birds fed on the diet which contained only plant protein supplements as sole protein source.

There were, however, no health-related problems nor mortalities during the experiment that could be attributed to the various dietary treatments.

Dietary treatments had no significant impact on dressing percentage, percentage blood and percentage feathers.

Chemical analyses of the meat of birds indicated that the various dietary treatments significantly ($P<0.05$) influenced the moisture, protein and ether extract (fat) contents. There was, however, no statistical difference in moisture, protein and ether extract (fat) contents of meat from birds on dietary treatments 1 and 2, but those from dietary treatment 3 contained significantly the least moisture (water) and protein as well as the most fat. The differences observed in the chemical composition of the meat could be due to the poor quality of the proteins supplied by the plant protein supplements. Protein or amino acid content of a diet is directly related to the moisture level of the carcass, which is inversely related to the carcass fat level. Hence when a low protein diet or a diet deficient in certain essential amino acids is fed, carcass moisture level declines resulting in a concomitant rise in carcass lipid levels. This is in agreement with the findings of Marion and Woodroof [14]. Several authors such as Leenstra [15], Marks [16] and Wang et al. [17] have reported that dietary protein level is one of several non-genetic factors that influence the amount of body fat.

Feed cost per kg as well as feed cost per kg liveweight gain declined as the amount of fishmeal in the diet was decreased by replacement with plant protein supplements, GC, SBM and BDY. The decline in feed cost as well as feed cost per kg liveweight gain as the amount of fishmeal in the diet was reduced by replacement with the plant protein supplements, was due solely to the huge price disparities between fishmeal and the plant protein supplements. Based on the results obtained in this study, it appears that under some feed price conditions, slower and less efficient gains from diets containing only plant protein supplements as the main protein source may be more economical than fast and more efficient gains from high cost diets based on fishmeal.

Findings of this study indicate that plant protein supplements should be used in combination with fishmeal or any other animal protein source, such as blood meal to meet the protein requirements of broiler chickens because of their deficiency in certain amino acids. A combination of high quality protein sources might appear to be a sound policy, since one protein source can compensate for the inadequacies or the excesses of another. However, if a combination of only plant protein supplements such as GC, SBM and BDY are to be included in broiler diets, then the diet should be supplemented with synthetic amino acids such as DL-methionine and lysine and also vitamin premix to make up for the possible amino acid and cyanocobalamin (vitamin B_{12}) deficiencies.

ACKNOWLEDGEMENT

The authors thank Dr. E.L.K. Osafo for the statistical analysis, Herbert Dei for the chemical analyses and Ms. Gladys A. Ndziba for secretarial assistance.

REFERENCES

1. Abrams, J.T. Animal Nutrition and Veterinary Dietetics, 4th Ed. W Green and Son, Limited, Edinburgh. pp. 231 – 347, 1961.
2. Gohl, B. Tropical Feeds. Feed Information Summaries and Nutritive Values. FAO Animal Production and Series. No.12, 1981.
3. Church, D.C. and Pond, W.G. Basic Animal Nutrition and Feeding. 3rd ed., John Wiley and Sons, New York, 1988.
4. Parkhurst, C.R. and Mountney, G.J. Poultry Meat and Egg Production. Avi Nostrand Reinhold Company Inc., New York. pp. 110 – 125, 1988.
5. Association of Official Analytical Chemists. Official Methods of Analysis, 15th edn., A.O. A.C., Arlington, Virginia, USA, 1990.
6. Statistical Analysis Systems Inc. Procedures Guide for Personal Computers, Version 6 ed., SAS Institute Inc., Cary, NC., 1987.
7. Steel, R.G.D., Torrie, J.H. and Dickey, D.A. Principles and Procedures of Statistics. A Biometrical Approach, 3rd edn., McGraw-Hill Inc., New York, 1997.
8. McDonald, P., Edwards, R.A., Greenhalgh, J.F.D. and Morgan, C.A. Animal Nutrition, 5th edn., Addison Wesley Longman Ltd., Essex, United Kingdom. pp. 284 – 312, 1996.
9. Akinwande, A.I. and Bragg, D.B. Effects of dietary lysine on body growth of the chick. Poultry Sci. 53: 134 – 143, 1974.
10. Shingari, B.K., Lodhi, G.N. and Ichponam, J.S. Methionine requirement of broiler chicks under different climatic conditions. Indian J. Anim. Sci. 46: 431 - 432, 1976.
11. Titus, H.W. and Fritz, J.C. The Scientific Feeding of Chickens. 5th edn. The Interstate, Danville, Illinois, 1971.
12. Pusztai, A. Constraints on the nutritional utilization of plant proteins. Nutrition Abstracts and Reviews (Ser. B). 15: 363 – 369, 1985.
13. Begbie, R. and Pusztai, A. The resistance to proteolytic breakdown of some plant (seed) proteins and their effects on nutrient utilization and gut metabolism. In: Friedman, M. (editor). Absorption and Utilization of Amino Acids. Vol. III. CRC Press, Boca Raton, F 1, 244 – 263, 1989.
14. Marion, J.E. and Woodroof, J.G. Composition and stability of broiler carcasses as affected by dietary protein and fat. Poultry Sci. 45: 241 - 247, 1966.
15. Leenstra, F.R. Effect of age, sex, genotype and environment on fat deposition in broiler chickens – a review. World Poult. Sci. J. 42: 12 – 25, 1986.
16. Marks, H.L. Genotype by diet interactions in body and abdominal fat weight in broilers. Poultry Sci. 69: 879 – 886, 1990.
17. Wang, L.Z., McMillian, and Chambers, J. R. Genetic correlation among growth, feed and carcass traits of broiler sire and dam populations. Poultry Sci. 70: 719 – 725, 1991.

Table 1: Composition and Nutrient Analysis of Experimental Diets

	Dietary Treatment		
	T_1	T_2	T_3
Ingredients (gkg^{-1})			
Maize	620	620	620
Fishmeal	180	90	0
Groundnut cake	0	50	100
Soyabean meal	0	50	100
Brewer's dried yeast	0	50	100
Wheat bran	170	110	50
Oyster shell	20	20	20
Salt	5	5	5
Vitamin/mineral premix[a]	5	5	5
Chemical Composition ($g\ kg^{-1}$)			
Crude protein	205.90	207.50	209.10
Crude fibre	43.40	47.20	50.90
Lysine	11.32	10.70	9.97
Methionine	5.00	4.00	3.00
Calcium	15.00	13.80	12.00
Phosphorus	7.50	5.40	4.50
Metabolisable energy ($MJ\ kg^{-1}$)	11.56	11.61	11.65

[a]Premix supplied (kg^{-1} diet): vitamin A, 10000 IU; vitamin D_3, 2000 IU; vitamin E, 10 IU; vitamin K, 3 mg; riboflavin, 2.5 g; cobalamin, 0.05 mg; pantothenic acid, 5 mg; niacin, 12.5 mg; choline, 175 mg; folic acid, 0.5 mg; Mg, 2.8 mg; Fe, 0.5 mg; Cu, 50 mg; Zn, 25 mg; Co, 62.5 mg.

Table 2 Effect of different protein sources on growth performance, carcass characteristics and economy of gain of broiler chickens from 14 to 56 days of age

	DIETARY TREATMENTS			
PARAMETER	T_1	T_2	T_3	SEM
Growth Performance				
Feed intake (kg)	3.53^a	3.70^a	3.60^a	0.092
Initial body weight (kg)	0.23^a	0.23^a	0.24^a	0.007
Total weight gain (kg)	1.43^a	1.43^a	1.20^b	0.041
Feed conversion ratio	2.47^a	2.59^a	3.00^b	0.048
Mortality	1	0	0	-
Feed cost/kg (¢/kg)	701.05	629.01	557.09	-
Feed cost/ kg weight gain (¢)	1731.59	1629.14	1671.27	-
Carcass Characteristics				
Dressing percentage	72.98^a	73.36^a	72.41^a	0.509
Percentage blood	4.39^a	4.42^a	4.40^a	0.231
Percentage feathers	7.30^a	7.58^a	7.27^a	0.741
Meat Composition				
Moisture ($g\,kg^{-1}$)	701.5^a	705.0^a	678.2^b	10.33
Crude protein ($g\,kg^{-1}$)	181.0^a	177.2^a	162.4^b	3.05
Ether extract (fat) ($g\,kg^{-1}$)	94.0^a	95.4^a	125.4^b	12.55

SEM: Standard Error of Mean
Means within each row bearing different superscripts are significantly different ($P>0.05$)