Vol.1, No.3, 106-111 (2011)
doi:10.4236/ojas.2011.13014

Open Journal of Animal Sciences

Utilization of sun-dried maize offal with blood meal in diets for broiler chickens

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Received 9 August 2011; revised 15 September 2011; accepted 28 September 2011.

ABSTRACT

Sun-dried blend of maize offal and blood (SDMBM) was analyzed and its effect on the performance of broiler chickens (Anak-2000 strain) evaluated. Fresh blood prevented from coagulation, mixed with maize offal, was sun-dried, ground, mixed again with blood and ground into a meal after drying again. The crude protein, fat, fibre, ash, ADF and gross energy contents of SDMBM were, 362.0, 45.5, 31.8, 69.3, 52.3 g/kg DM and 4.245 kcal/g, respectively. It was adequate in all essential amino acids for growing broiler chickens except methionine. Eighty 14-day-old commercial broiler chicks were randomly allocated to four dietary treatments (fed *ad libitum;* four replicates each) consisting the control diet (0 g SDMBM/kg diet), which contained fishmeal, groundnut cake and soybean meal, and three other diets (50, 100 and 150 g SDMBM/kg diet). In a feeding trial, the starter (14 to 35 d) and finisher (35 to 49 d) dietary treatments did not have significant impact (P > 0.05) on body weight gain, efficiency of feed conversion, mortality and final body weights. The control diet was inferior (P < 0.05) to 50, 100 and 150 g SDMBM/kg diets for feed cost per unit weight gain in the starter phase, 100 g SDMBM/kg diet in the finisher phase, and 100 and 150 g SDMBM/kg diets for the whole period (14 to 49 d). Overall, the 100 and 150 g superior (P < 0.05) to the control diet in cost of production per unit weight gain and all the SDMBM diets greater than control in economic benefit per unit weight gain. Results suggest that dietary SDMBM up to 150 g/kg diet has a positive effect on broiler performance and can totally replace more expensive fishmeal.

Keywords: Alternative Feedstuff; Blood Meal; Fishmeal Replacement; Maize Offal

1. INTRODUCTION

In Nigeria, as in most other developing countries in the tropics, the transformation and use of agricultural by-products in livestock diets may have become more imperative due to increasing prices of grains (especially maize and oil seeds) globally and environmental pollution issues. However, many agricultural crop by-products in the tropics are fibrous (Abdelsamie *et al.* 1983; Longe and Fagbenro-Byron 1990) and this limits utilization in poultry production (Onifade 1993; Bolarinwa 1998). Nevertheless, the focus of current research is on fibre nutrition because of the issue of removal of antibiotics from feed and diversion of grains for ethanol and biodiesel production (Leeson 2008; Farrell 2008). The attraction is the suggested prebiotic attribute of fibrous feedstuffs (Sundu *et al.* 2006) and need to reduce feed costs by utilizing alternatives to maize as source of feed energy (Leeson 2008). An example of such alternatives is maize offal or maize bran.

Maize offal is a by-product of maize milling processes, second to wheat offal as the most preferred and utilized conventionally in livestock feeds in Nigeria (Babatunde *et al.* 2002). Maize offal contains about 110 to 120 g/kg crude protein and 80 to 90 g/kg crude fibre (Onifade and Babatunde 1998; Makinde 2006). The relatively low crude fibre content compared to other by-products could be an advantage in fibre nutrition whereas the low protein content appears to be a limitation.

Cattle blood is an abattoir by-product that directly affects the environment in Nigeria. Most of the blood from a considerable number of slaughter-cattle is wasted, not efficiently utilized, and pollutes the environment on a daily basis (Adeniji 1995; Makinde 2006). Paradoxically, blood meal, obtainable from cattle blood after drying, contains 80% - 90% crude protein high in the essential amino acids, especially lysine (NRC 1994). Nevertheless, blood is very difficult to dry and is a good medium for microbial spoilage due to its high moisture content (Donkoh *et al.* 1999). Drying of blood requires high cost equipment coupled with facilities for central blood collection, which may be unaffordable and/or not applicable because the abattoir structure in Nigeria exists as small-scattered units. Moreover, previous work with blood involving sun drying in the development of alternative feedstuffs for poultry reported a long drying time of about three days (Adeniji 1995; Donkoh *et al.* 2002; Odunsi *et al.* 2004). However, previous studies by Sonaiya (1988) suggested the use of crop by-product materials as absorbents for blood in order to increase the surface area for quicker sun drying.

Makinde and Sonaiya (2007, 2010) have reported a simple processing procedure, nutrient composition and optimum mixing ratios for crop by-products with blood including maize offal. The procedure resulted in quicker sun drying of blood (<4 h), enhancement of the crude protein content of maize offal by the blood mixed and a way to contribute towards reduction of environmental pollution from abattoirs.

However, nutritional information on the utilization of such a sun-dried maize offal blood meal (SDMBM) by broiler chickens was unavailable. Consequently, the objective was to provide data on the utilisation of SDMBM by broiler chickens when fed diets with increasing quantities of SDMBM.

2. MATERIALS AND METHODS

2.1. Preparation of SDBM and Nutrient Composition

Sun-dried maize offal blood meal was prepared and analysed for nutrient composition according to the procedures previously described by Makinde and Sonaiya (2007, 2010). Briefly, maize offal (source, Eagle Flour Mills, Ibadan, Nigeria) was hand-mixed (1:1 w/w) with fresh blood (prevented from coagulating for at least 6 hours by mixing with 18 g common salt/litre blood) collected from several slaughtered cattle at a commercial abattoir. This mixture was sun-dried for between 3 to 4 h, ground, mixed again with blood (5:4 w/w) and ground into a meal after drying again.

Nutrient composition (proximate composition and acid detergent fibre (ADF) inclusive of residual ash) of maize offal and SDMBM were determined using standard procedures of AOAC (1990). Gross energy was determined by oxygen bomb calorimeter (Gallenkamp Ballistic Bomb Calorimeter, Cambridge Instrument Co. Ltd, England). Meal samples were prepared and analysed for mineral concentrations following the methods described by Fick *et al.* (1979). Amino acid composition of SDMBM was determined following acid hydrolysis using a Technicon® Sequential Multisample Amino Acid Analyzer (TSM-1, model DNA 0209, Swords Co., Dublin, Ireland; reproducibility, ±3%) at the Zoology Department, University of Jos, Jos, Nigeria. Between 30-50mg of the defatted sample was weighed into glass ampoule. Seven millilitres of 6 N HCl was added and oxygen was expelled by passing nitrogen into the ampoule (this was to avoid or reduce possible oxidation of sulphur amino acids during hydrolysis). The glass ampoule was then sealed with bunsen burner flame and put in an oven preset at 105˚C ± 5˚C for 22 hours.

2.2. Experimental Procedure and Management of Birds

The experiment was in two phases, starter and finisher phases. Eighty 14-day-old commercial broiler chicks (Anak-2000 strain) were randomly allocated to one of four dietary treatments (**Table 1**) in a completely randomized block design. Each treatment was replicated four times with five birds per replicate. The dietary treatments consisted of the control diet, which contained fishmeal (starter diet only), groundnut cake and soybean meal as the main protein sources, and three other diets, which contained varying levels of SDMBM at 50, 100, and 150 g/kg diet. Two control diets were formulated, one for the starter phase containing no SDMBM but fishmeal at 30 g/kg diet, and the other for the finisher phase with no fishmeal or any other animal protein source. The test diets for the starter phase were formulated to be isocaloric and isonitrogenous containing 3000 kcal ME/kg and 22% crude protein (PTF 1992), and the finisher phase formulated to contain 2950 kcal ME /kg and 18% crude protein (PTF 1992). The starter diet was fed for 3 weeks, and the finisher diet for 2 weeks. The birds were confined in 20 floor pens (each measuring 1.52 m^2) which provided a floor space of 0.3 m^2 per bird. The pens were in a poultry house constructed from wood and wire gauze, with asbestos roof and concrete floor. Pens were covered with wood shavings for bedding. Plastic water drinkers and suspended metallic conical feeders were used to provide drink and feed, respectively, and were cleaned daily.

Birds were fed ad libitum with free access to water. Newcastle disease vaccine (NDV), infectious bursal disease vaccine (IBDV), coccidiostat (Embazin-Forte®: Sulfaquinoxaline-Diaveridine-Vitamin K complex), antibiotic (Keproceryl®: water-soluble mix of the antibiotics-oxytetracycline, erythromycin, and streptomycin with fat- and water-soluble vitamins), and a B-vitamin complex solution (Biovit®) as antistress were used to maintain chicks in good health. The coccidiostat, antibiotic, and B-vitamins drug were administered via the drinking water.

All five chickens in each pen were weighed individu-

Table 1. Gross and nutrient composition of experimental broiler starter and finisher diets.

	SDMBM[1] (g/kg diet)							
	Starter				Finisher			
Ingredients	0	50	100	150	0	50	100	150
Maize	589.4	580.5	600	541.5	614.2	610.5	610	607.9
Soya bean meal	160	127	28	32	158	120	100	96
Groundnut cake	145	203	237	228	70	85	73.5	48
Fishmeal	30	0	0	0	0	0	0	0
SDMBM	0	50	100	150	0	50	100	150
Wheat offal	40.6	4.5	0	0	122.8	99.5	81.5	63.1
Bone meal	27	27	27	27	27	27	27	27
Premix[3]	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Salt	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Lysine	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Methionine	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Calculated composition[3]								
ME in kcal/kg	3000.52	3000.22	3000.78	3000.98	2950.2	2950.47	2950.29	2950.1
%CP	22.19	22.03	22.2	22.06	18.02	18.35	18.35	18.38
%CF	3.32	3.48	3.45	3.76	3.65	3.71	3.82	3.95
%Ca	1.26	1.08	1.07	1.07	1.07	1.06	1.06	1.06
%P	0.96	0.75	0.67	0.68	0.79	0.75	0.73	0.72
%Lysine	1.15	1.09	1	1.09	0.97	1.03	0.98	1.02
%Methionine	0.48	0.45	0.45	0.46	0.42	0.42	0.42	0.42
Cost of diet (N/kg)	60.79	55.73	51.58	50.21	54.06	53.4	53.33	53.72

[1]SDMBM = sun-dried maize offal blood meal. [2]Provides per kg of diet: Vitamin A, 12,500 IU; Vitamin D, 2,500 IU; Vitamin E, 40 mg; Vitamin K, 2 mg; Vitamin B1, 3 mg; Vitamin B2, 5.5 mg; Niacin 55 mg; Calcium pantothenate, 11.5 mg; Vitamin B 6, 5mg; Vitamin B 12, 0.025 mg; Choline chloride, 500 mg; Folic acid, 1 mg; Biotin, 0.08 mg; Manganese, 120 mg; Iron, 100 mg; Zinc, 80 mg; Copper, 8.5 mg; Iodine, 1.5 mg; Cobalt, 0.3 mg; Selenium, 0.12 mg; Anti-oxidant, 120 mg. [3]ME = metabolizable energy; CP = crude protein; CF = crude fibre; Ca = calcium; P = phosphorous (total).

ally at the beginning of the experiment, then weekly, and at the end of the experiment. Feed consumption per pen was recorded weekly after the total feed given per week was corrected for feed left over. Average daily gain (ADG), average daily feed intake (ADFI), feed conversion ratio (FCR), were calculated from the data obtained. Records of mortality were kept and all dead chickens examined post-mortem by veterinarians. At the end of the experiment, three birds were selected randomly from each pen, starved of feed for 24 hours to empty their crops, killed by cutting the jugular vein, exsaguinated, defeathered and eviscerated. Carcass yield calculated as dressed weight per unit live weight excluded all the organs, head, feathers, neck and shanks. Economics of production were evaluated in terms of feed cost/kg feed, feed cost/kg gain, cost of production/kg gain, and benefit/kg gain.

2.3. Statistical Analysis

Data were analyzed as completely randomized block design using the General Linear Means procedure of SAS (2000) for analysis of variance (ANOVA). The effects of the four dietary treatments (0, 50, 100, and 150 g SDMBM/kg diet) were tested on broiler performance at both starter and finisher phases, and overall. The four replicates per treatment were considered as blocks in order to increase the sensitivity of the experiment by reducing the residual error. Differences between means were resolved by Duncan's multiple range test of the SAS statistical package. Statistical significance was established when probability was less than 0.05 level of significance.

3. RESULTS AND DISCUSSION

It was observed that when maize offal was hand-mixed with blood it soon became viscous or thick and then rubbery. Therefore, the mixture needed to be mixed quickly and sun-dried very soon after. This attribute will be important in the scaling up of the procedure regarding the design of a mechanical mixer for small-, medium- or large-scale application. In addition, there will be need for suitable ovens that could be applied in the wet season when sunshine hours are critically reduced.

The chemical composition of maize offal, SDMBM, and vat-dried blood meal are shown in **Table 2**. In comparison with maize offal and vat-dried blood meal, SDMBM was drier as indicated by the moisture content (76 vs. 96.7 and 80 g moisture/kg, respectively). According to Rozis (1997), a moisture content of between 100 to 120 g moisture/kg is satisfactory for most agricultural products. The gross energy contents of SDMBM and maize offal were comparable; whereas crude protein was three times higher and crude fibre three times lower for SDMBM. This indicates that mixing blood to maize offal improved its nutrient quality and potential usefulness in livestock feeding especially monogastrics. Further, the amino acid composition of SDMBM compared with NRC (1994) amino acid requirements for broiler chickens (0 to 8 weeks of age) shows that it is adequate in all essential amino acids except methionine (4.0 vs. 5.0 g/kg). Moreover, SDMBM had very marginal content of mineral elements when compared with vat-dried blood meal. However, the use of synthetic methionine sources, mineral element supplements and premixes, conventionally used in diets, should overcome these deficiencies

Data showing the effect of dietary SDMBM on the growth performance of the broiler chickens at the starter phase (days 14 to 35), finisher phase (days 35 to 49), and overall (days 14 to 49) is shown in **Table 3**. In both the starter and finisher phases, average final body weights (AFBW), average daily body weight gain (ADG), and feed conversion ratio (FCR) varied between diets but were not significantly different ($P > 0.05$), as well as for average final body weight (AFBW), feed conversion ratio (FCR) and carcass yield in the whole period (days 14 to 49). These results suggest that the SDMBM diets were not inferior to the control diet with fishmeal. This appears to attest to the quality of SDMBM as possessing additive attributes of blood as a high quality protein. A significant ($P < 0.05$) depression in average daily feed intake (ADFI) was obtained for the 100 g SDMBM/kg diet compared with the control in the starter phase (**Table 3**). This was probably due to the inexplicable poor growth of one of the birds in one replicate pen observed the penultimate week of the starter period, which after culling eventually died same week. However, post-mortem autopsies indicated no specific causes for deaths

Table 2. Chemical composition of maize offal, sun-dried maize offal blood meal, and vat-dried blood meal[1].

	Maize	SDMBM[2]	Vat dried[3]
Composition (g/kg DM)	offal		blood meal
Dry Matter	903.3	924.0	920
Gross energy, kcal/g	4.273	4.245	5.21
Crude protein	111.6	334.0	771.0
Arginine	NA	14.3	33.4
Histidine	NA	10.4	50.6
Isoleucine	NA	10.7	9.1
Leucine	NA	30.7	109.9
Lysine	NA	11.0	70.4
Methionine	NA	4.0	9.9
Phenylalanine	NA	14.2	53.4
Threonine	NA	8.3	40.5
Valine	NA	11.7	70.5
Alanine	NA	10.1	NA
Aspartic acid	NA	23.3	NA
Cystine	NA	5.7	NA
Glutamic acid	NA	26.0	NA
Glycine	NA	11.0	45.9
Proline	NA	8.8	NA
Serine	NA	6.8	31.4
Tyrosine	NA	1.0	20.7
Tryptophan	NA	NA	NA
Crude fibre	87.6	31.8	5.5
ADF[4]	285.0	52.3	18.0
Ether extract	65.0	45.5	16.0
NFE	596.0	511.8	NA
Ash	42.7	69.3	NA
Ca, mg/kg	NA	0.08	3700.0
P, mg/kg	NA	4.4	2700.0
Mg, mg/kg	NA	37.0	1100.0
Fe, mg/kg	NA	6.8	1,922.0
Mn, mg/kg	NA	0.79	6.0
Cu, mg/kg	NA	3.19	11.0
Zn, mg/kg	NA	0.01	38.0

[1]Values are means of duplicate samples; NA = Not analysed. [2]SDMBM = sun-dried maize offal blood meal (Makinde and Sonaiya 2010). [3]Values obtained from from NRC (1994) and NRC (1998). [4]ADF = neutral detergent fibre.

Table 3. Live performance (14 to 35, 35 to 49, and 14 to 49 d) of broiler chickens fed diets with graded levels of sun-dried maize offal blood meal.

	Starter (14 to35 d)					Finisher (35 to 49 d)					Overall (14 to 49 d)				
	Levels of SDMBM[1] (g/kg diet)					Levels of SDMBM (g/kg diet)					Levels of SDMBM (g/kg diet)				
Parameters	0	50	100	150	SE[2]	0	50	100	150	SE	0	50	100	150	SE
AIB (g/bird)[3]	227.25	212.35	221	210.55	-	948.18	936.54	858.6	941.7	-	227.25	212.35	221	210.55	-
AFBW (g/bird)[4]	948.18	936.54	858.6	941.7	9.10	1639.16	1715.24	1549.7	1667.3	17.50	1639.16	1715.24	1549.7	1667.3	17.50
ADG (g/bird)[5]	34.33	34.49	30.36	34.82	0.30	49.36	55.62	49.36	51.83	1.30	40.34^{ab}	42.94^{a}	37.96^{b}	41.62^{ab}	0.55
ADFI (g/bird)[6]	81.20^{a}	76.98^{ab}	72.47^{b}	76.55^{ab}	0.58	163.80^{a}	163.45^{a}	139.86^{b}	154.11^{a}	1.44	110.82^{a}	111.57^{a}	99.43^{b}	107.56^{a}	0.86
FCR[7]	2.37	2.25	2.4	2.21	0.02	3.32	2.95	2.88	2.98	0.08	2.75	2.61	2.64	2.59	0.03
Carcass yield (%)	-	-	-	-	-	-	-	-	-	-	62.01	65.54	64.16	63.71	0.41
Mortality (number)	1	0	1	0	-	0	0	0	0	-	1	0	1	0	-
FC/kg (₦)[8]	60.79	55.73	51.58	50.21	-	54.06	53.4	53.33	53.72	-	57.43	54.57	52.46	51.97	-
FC/kg gain (₦)	143.88^{a}	125.6^{b}	123.89^{b}	111.08^{b}	1.90	179.75^{a}	157.69^{ab}	157.18^{b}	160^{ab}	2.70	157.83^{a}	142.49^{ab}	138.40^{b}	134.42^{b}	1.7
CP/kg gain[9] (₦)	-	-	-	-	-	-	-	-	-	-	341.83^{a}	326.49^{ab}	322.40^{b}	318.42^{b}	1.7
Benefit/kg[10]gain (₦)	-	-	-	-	-	-	-	-	-	-	58.17^{b}	73.03^{a}	77.60^{a}	81.56^{a}	1.7

[ab]Means on the same row with the same superscripts are not significantly different (P > 0.05). [1]SDMBM = sun-dried maize offal blood meal. [2]SE= standard error of means. [3]AIB = average initial body weight. [4]AFBW = average final body weight. [5]ADG = average daily gain. [6]ADFI = average daily feed intake. [7]FCR = feed conversion ratio (g feed/g gain). [8]FC = feed cost (N = Naira). [9]CP = cost of production/kg gain(N) = FC/kg gain + Total common costs for 49 days (brooded chicks; drugs; equipment; wood shavings; transportation; poultry house repair and maintainnance; labour and miscellaneous-10% of total common costs). [10]Benefit/kg gain (N) = price of broiler/kg (N) when study was conducted (N400.00) minus cost of production/kg gain (N); 1 US$ = N150.

that can be attributable to the diet. The depression in feed consumption for the 100 g SDMBM/kg dietary treatment in the finisher phase is obscured to this study. It is possible that the birds in the pen where mortality occurred had unidentified sub-clinical level infection, which depressed feed intake. The same reason could be advanced for the feed consumption that was significantly (P < 0.05) depressed and the least ADG overall for the 100 g SDMBM/kg diet compared with other diets.

Economically, the SDMBM diets were generally superior to the control for all growth periods in terms of feed cost per kg (FC/kg), feed cost per kg live weight gain (FC/kg gain), cost of production per kg live weight gain (CP/kg gain), and profit or benefit per bird. The 150 g SDMBM/kg dietary treatment had the highest profit compared with the control, which was least (P < 0.05). Khawaja *et al.* (2007) and Donkoh *et al.* (2003) obtained similar results on superior economic benefits for blood meal and a blend of blood and ground maize cob in broilers, respectively.

4. CONCLUSIONS

The findings under the conditions of this study show that there are no adverse effects on growth performance by incorporating SDMBM, a simple suitable alternative protein source to fishmeal, up to 150 g SDMBM/kg in the starter and finisher diets of broiler chickens. Further investigations are needed concerning a scaling up of the production process and possible effects of mechanical drying on nutritional quality of SDMBM.

5. ACKNOWLEDGEMENTS

Raw Materials Research and Development Council (RMRDC), Abuja, Nigeria provided funding for the research reported in this article. Mr J. O. S. Adeyeye and the workers at the Araromi Abattoir, Ile-Ife, Osun State, Nigeria are also appreciated for their cooperation and assistance.

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