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A SIMPLE APPROACH TO RECYCLE BROILER LITTER AS ANIMAL FEED

Makinde OA[1]*

Anthony Olukayode Makinde

*Corresponding author email: olukayodemakinde@yahoo.com
olukayodemakinde@oauife.edu.ng

[1]Faculty of Agriculture, Department of Animal Sciences, Obafemi Awolowo University, Ile-Ife, 220005, Nigeria

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ABSTRACT

Broiler litter (BL) is a major waste from poultry production that constitutes serious disposal and environmental pollution problems globally despite its potential as animal feed. Therefore, the objective of this study was to develop a simple procedure for converting broiler litter into animal feed using wheat offal (WO) and cattle blood (B) as absorbent and nutrient booster, respectively. Initially, broiler litter was mixed with increasing concentrations (w/w) of blood at 1:1 or 1:2 or 1:3, and then each to WO at 1:1 or 1:2 or 1:3, making nine different ratios/blends before sun drying for 4 h. Finally, three blends (BL:B - 1:1 or 1:2 or 1:3 each mixed to WO at 1:1) were selected for nutrient evaluation based on economic considerations and capacity to dry to ≤ 10% moisture content in 4 h. The blends and feces were analyzed for proximate composition. Birds were tube-fed respective blends, feces collected after 48 h and dried for 48 h at 60^{o}C. Dry matter, apparent and true crude protein digestibilities were determined. Soybean meal, considered as the standard protein, analyzed for dry matter, apparent and true crude protein digestibility was compared to the blends. The results showed that all the nine different blends dried to ≤ 10% moisture content in 4 h (range, 6 – 9%) and the blends with the highest WO content had the lowest ($P<0.01$) moisture contents. The three blends had crude protein and crude fiber ranging from about 19 – 28% and 8 - 12%, respectively. The blend with the highest blood concentration BL:B [1:3] to WO at 1:1) was superior ($P<0.01$) to soybean meal in dry matter, apparent and true crude protein digestibility by broiler chickens. A simple method was developed to recycle broiler litter as animal feed in combination with wheat offal and cattle blood. The resulting product showed good potential as feedstuff for broiler chickens.

Key words: Alternative feed, Blood, Poultry litter

INTRODUCTION

The most ready attraction towards the mitigation of disposal and pollution problems from broiler litter (BL) is land application [1]. Land application of BL provides valuable soil nutrients, enhances physical, chemical and biological fertility including organic matter content, water holding capacity, oxygen diffusion rate and aggregate stability [2, 3, 4, 5].

However, land application may create new problems due to nutrient and contaminant leaching depending on soil and climatic conditions [6]. In addition, dust, odours, bio-aerosols, greenhouse gases and volatile organic compounds from BL reduce air quality that can complicate the climate and respiratory well-being of animals and humans [7, 8, 9, 10].

Nevertheless, the value of broiler litter as animal feed and fuel source [1, 6, 11] provides viable opportunities for alternatives to BL land application disposal strategy. One example is the use of BL in vermiculture systems (organic matter biodegradation and stabilization by earthworm production) to produce vermi-cast (useful as organic fertilizer) and vermi-meal (protein-rich earthworm meal) [12, 13]. However, one limitation to BL utilization as animal feed is its high moisture content [6].

Similar to BL in environmental nuisance, are wastes from abattoir processes such as cattle rumen contents and blood, which are also potential nutrient sources but grossly underutilized especially in Nigeria as in many developing countries [14]. However, Makinde and Sonaiya [14] devised a simple disposal method using vegetable carriers (as moisture absorbents) to successfully convert cattle rumen contents and blood into animal feed. Wheat offal, a conventional and commonly utilized feed ingredient, was the notable vegetable carrier found to have high liquid absorbent properties [15], which can be exploited to value-add to high-moisture potential feed resources with environmental and disposal problems. This attribute makes such feed resources amenable to quicker drying in the sun. Blood has the potential to value-add to the nutrient content of low quality feed resources on account of its high protein content and amino acid profile, especially lysine [11, 14].

Therefore, considering the foregoing, the general objective was to investigate an alternative disposal of BL, by conversion into animal feed, in a simple combination with cattle blood and wheat offal in order to increase its nutritive value and ensure quick drying in the sun. This will contribute towards reduction in environmental and disposal problems of BL, provide sustainable waste management and potential source of income for poverty alleviation and alternative livestock feed.

MATERIALS AND METHODS

Mixing of broiler litter, cattle blood and wheat offal

Blend components: The experiment was conducted at the Teaching and Research Farm and Department of Animal Sciences, Faculty of Agriculture, Obafemi Awolowo University, Ile-Ife, Nigeria. Wheat offal was purchased from Eagle Flourmills,

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Ibadan, Nigeria. About 10 L of fresh cattle blood was collected from slaughtered cattle into a clean and dry 13-L plastic bucket at a slaughter slab near the university. The plastic bucket had a predetermined quantity of common salt (18 g/L blood) sufficient to prevent blood from coagulating for at least 6 h [15]. The blood and salt mixture was hand-mixed thoroughly using disposable latex gloves. Broiler litter (on which day-old Marshall broilers had been raised for 4 weeks) was collected from a deep litter house at a poultry farm. The litter was spread on the concrete floor of an open-sided covered shed for 7 days after which it was sieved (mesh size, 5 mm^2) to remove extraneous materials such as feathers, metal, stones and hard wood shavings.

Mixing: Nine sets of the blend, according to levels of blood and wheat offal, were tried initially in order to select the final blends for nutritional evaluation based on capacity to dry to ≤ 10% moisture content in 4 h, concentration of blood and projected cost of blend depending on wheat offal content, since wheat offal was the only component purchased. The decision criteria was to select blends having blood concentrations with the lowest wheat offal content that dried to ≤ 10% moisture content in 4 h. This is based on previous work that good quality broiler litter for use as animal feed should have between ≤ 12% [17] and ≤ 15% moisture content [16]. The following shows the combinations tried:

Category1
Low blood (w/w):
(a) Broiler litter and blood mixture (1:1) mixed with wheat offal (1:1), BBLW1;
(b) Broiler litter and blood mixture (1:1) mixed with wheat offal (1:2), BBLW2; and
(c) Broiler litter and blood mixture (1:1) mixed with wheat offal (1:3), BBLW3.
Category2
Medium blood (w/w):
(a) Broiler litter and blood mixture (1:2) mixed with wheat offal (1:1), BBMW1;
(b) Broiler litter and blood mixture (1:2) mixed with wheat offal (1:2), BBMW2; and
(c) Broiler litter and blood mixture (1:2) mixed with wheat offal (1:3), BBMW3.
Category 3
High blood (w/w):
(a) Broiler litter and blood mixture (1:3) mixed with wheat offal (1:1), BBHW1;
(b) Broiler litter and blood mixture (1:3) mixed with wheat offal (1:2), BBHW2; and
(c) Broiler litter and blood mixture (1:3) mixed with wheat offal (1:3), BBHW3.

The blends were sun-dried by spreading thinly on black polythene sheets (0.7 mm thickness) in two replicates each on the concrete roof (about 20.5 m high) of the Faculty of Agriculture building of the university. Ambient temperature range was 32-34^{o}C and drying surface temperature range was 42-48^{o}C. Drying started at about 11 a. m. Turning of the blends was once after 30 min of the first hour into drying, which involved rubbing handfuls together and spreading again; drying ended when the blends ran freely through the palms after rubbing together. Storage of dried and cooled blends was in translucent high-density polythene bags (0.8 mm thickness) and then in a freezer for subsequent use. Moisture was determined by drying blend samples 105^{o}C for 24 h. Therefore, based on the decision criteria mentioned previously, three blends resulting from the trial were as follows:

(a) Broiler litter and blood mixture (1:1) mixed with wheat offal (1:1) – BBLW1
(b) Broiler litter and blood mixture (1:2) mixed with wheat offal (1:1) – BBMW1
(c) Broiler litter and blood mixture (1:3) mixed with wheat offal (1:1) – BBHW1

These blends were nutritionally evaluated against soybean meal as a conventional protein source ingredient in broiler diets.

Nutrient digestibility of broiler litter, blood and wheat offal blend

The digestibility method utilized was the precision method for total tract digestibility, which involved the force-feeding of birds with feedstuffs of a particular weight at the Poultry Unit of the Teaching and Research Farm of the university. The digestibility test involved 30 ten-week-old male Hubbard broiler chickens allocated to five treatments comprising four-dietary groups (soybean meal (SB), BBLW1, BBMW1, BBHW1) and one feed-restricted group for estimation of fasting losses (FL). One bird occupied each compartment (40 x 33 x 41 cm; Length x Breadth x Height) at the third tier of a galvanized-steel 3-tier battery cage in an open-sided poultry house. Each treatment had six birds serving as replicates.

The digestibility procedure was a modification of the method of Adeola *et al.* [18], where birds fed dextrose (30 g/100 mL water) during the trial in order to alleviate stress to birds. Specifically, all birds fasted for 24 h (but given dextrose after 8 h into the fast) before they were force-fed 30 g of each blend to the crop through the esophagus. The feed-restricted birds that served as controls for estimation of fasting losses had access to dextrose (30 g/100 mL water) throughout the duration of the trial. Each bird was weighed before force-feeding and again after the 48 h period to determine weight loss. Birds fed *ad libitum* on a broiler finisher diet prior to force-feeding. The blends were finely ground (0.5 mm screen) and mixed with distilled water in a glass beaker to make a wet mash. Thirty grams of each feedstuff, mixed with 80 mL distilled water, was force-fed to birds, and 20 mL distilled water used to wash down particles adhering to the tube of the force-feeding apparatus. This had a plastic tube (25 cm long, 1.4 cm outer diameter, and bore 0.9 cm) with copper wire (with pointed end bent back to form a rounded end) inserted in the bore to aid feed delivery and remove any that may stick to the sides of the tube, and a plastic funnel for loading the blend.

Fecal samples were collected daily at 24-hour intervals for 48 h after force-feeding, stored in a freezer at -15^{o}C before they were oven-dried in a forced-air oven at 60^{o}C for 48 h, equilibrated to ambient conditions, weighed and ground [19]. Dry matter of the blends and fecal samples were determined by drying at 105^{o}C for 24 h, cooled in desiccators and weighed again until constant weight was attained. For feed samples, ash was determined after ignition in a Gallenkamp muffle furnace at 600^{o}C for 3 h. Crude protein (CP) was estimated as Kjeldahl N × 6.25 using a Kjeltec 2300 Analyser Unit (FOSS Analytical AB, Sweden) after samples were digested in concentrated sulfuric acid. Ether extract was determined by using petroleum ether (bp 40 –60^{o} C) extraction in a Soxhlet extractor (Phillip Harris, Birmingham, England). The apparent and true CP digestibility values were determined by adapting the method described by Sibbald [20] according to the following calculations:

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% Apparent nutrient digestibility = 100 x (NI – NO) / NI
% True nutrient digestibility = 100 x (NI – NO) / NI + FNL/NI
Where, NI = Nutrient intake; NO = Nutrient output in voided feces; FNL = fasting nutrient loss

Analysis of data

The differences in the moisture contents of the nine blends and data on dry matter and crude protein digestibility were analyzed with the 2-way analysis of variance using the General Linear Models procedure of SAS® [21]. The data were treated as a completely randomized block design with blend type as the main treatment effect and replicate within blend as another factor. The replicate was considered as another factor in order to increase the sensitivity of the experiment by reducing the residual error. The model used was:

$Y_{ijk} = \mu + B_i + R_j + \varepsilon_{ijk}$

Where: Y ijk = percentage weight loss, moisture content, dry matter and crude protein digestibility; μ = overall mean, Bi = Blend effect, Rj = Replicate effect and ε ijk = residual error.

Differences in the dependent variables were resolved by Duncan's multiple range test of the SAS® (2000) statistical package. Statistical significance was established when probability was less than 5% level of significance.

RESULTS

Table 1 shows the effect of different combinations of broiler litter, blood and wheat offal on final moisture contents of the blend before and after sun drying. Moisture loss, initial and final moisture contents of the blends were highly significantly different ($P<0.01$) decreasing as the wheat offal content increased regardless of the blend category (with low, medium or high blood).

Table 2 shows the proximate composition of the blends and soybean meal used for nutrient digestibility by broilers. The proximate composition of the blends show similarity for all components except relatively higher crude fiber (CF) in BBLW1 and lower ether extract in BBHW1. All the blends had higher CF and nitrogen free extract but lower ether extract (EE), crude protein (CP) and ash than soybean meal.

Table 3 shows the effect of the blends or soybean meal on live weight changes and crude protein and dry matter digestibility. There were no significant differences ($P>0.05$) in the weight lost by broilers between the feedstuffs. Highly significant differences ($P<0.01$) were obtained for dry matter, apparent and true crude protein digestibility between blends and soybean meal. Specifically, BBHW1 was superior to soybean meal and other blends on these counts. However, soybean meal was superior ($P<0.01$) to both BBMW1 and BBLW1 in nutrient digestibility.

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Josem Trust Place, Bunyala Road, Upper Hill, Nairobi
P.O. Box 29086-00625 Tel: +254-20-2351785 Fax: +254-20-4444030, Nairobi, KENYA
Email: oniango@iconnect.co.ke OR info@ajfand.net www.ajfand.net

DISCUSSION

The contents of blood and wheat offal in the blends influenced their drying characteristics (Table 1). Expectedly, the blends with medium to high blood concentrations and lowest wheat offal content were the wettest (i.e., BBMW1 and BBHW1). This underscores the effectiveness of wheat offal as an absorbent. Makinde and Sonaiya [15] identified wheat offal to have high liquid absorbent properties. Final moisture contents and percentage moisture loss after sun drying followed the same trend. Blends that had higher initial moisture contents ended with higher final moisture contents and higher moisture loss regardless of blend category. Congruently, the final moisture contents and percentage moisture loss decreased as the wheat offal content increased. In fact, wheat offal reduced the moisture content of broiler litter in the blend by at least 60% (23 – 9%) and all the blends dried to ≤ 10% moisture content in 4 h. These results probably suggest that absorbency of wheat offal increases uniformly and in direct proportion to increases in its quantity. However, this hypothesis will need further investigation. Nevertheless, results probably imply the potential of wheat offal as absorbent in the processing of underutilized wet feed resources into more useful products.

The novelty of the blends makes contemporary comparison with results on nutrient content from other studies difficult. Therefore, comparison with soybean meal as a standard conventional feedstuff commonly used in animal diets seems justified. Soybean meal rates highly nutritionally as a feed ingredient in terms of palatability, acceptability, protein quality, energy value and value for satisfactory livestock performance [22]. In fact, the CP content of soybean meal was about double that of the blends (Table 2). However, the quality of any protein supplement depends on amino acid composition and digestibility apart from content [23, 24]. This is important to proper and economical diet formulation and reduction in nutrients excreted to the environment [25]. The proximate composition of the blends show similarity for all components except relatively higher crude fiber (CF) in BBLW1 and lower ether extract in BBHW1. This is probably a reflection of the varying blood content in the blends. The fiber content of BBLW1 may limit its utilization by non-ruminant animals.

Probably none of the birds was disadvantaged due to feedstuff because there were no significant differences (P>0.05) in the weight lost by broilers between the feedstuffs (Table 3). Provision of dextrose for the birds throughout the trial period may have reduced variations in fasting energy losses [18]. Birds may lose weight in digestibility studies due to fasting energy losses occasioned by the inadequacy of the feedstuff force-fed to meet nutritional requirements completely during the trial period [18]. However, such birds have been observed to regain the weight lost 7 to 21 days after the trial [18, 26, 27].

The superiority of BBHW1 over soybean meal and other blends in dry matter, apparent and true crude protein digestibility probably indicate a higher feeding value. The high blood content in the blend probably accounted for this. Donkoh and Attoh-Kotoku [28] reported higher digestibility for animal proteins than plant proteins when

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Email: oniango@iconnect.co.ke OR info@ajfand.net www.ajfand.net

compared and amino acids in blood meal had the highest digestibility. However, superiority of soybean meal to other blends in nutrient digestibility probably resulted from their lower blood and higher CF contents (Table 2). Fiber limits feed utilization in poultry production [29, 30]. However, these blends may be suitable for finisher broiler, cockerel and layer chickens since they tend to tolerate nutritionally lighter feed.

Despite the good potential recorded for a blend of broiler litter, blood and wheat offal, concerns remain about the desirability and safety for use as feed due to contaminants such as pathogens, antibiotics, coccidiostats and arsenicals in unprocessed poultry waste [6]. However, Association of American Feed Control Officials (AAFCO) defines safe 'Dried Poultry Litter' as containing ≤ 15% moisture content, ≥ 18% crude protein, and not more than 25% crude fiber, 20% ash and 4% feathers [16]. In addition, it should be free of extraneous materials such as metal, glass, nails or other harmful matter [6]. The alternative feedstuff developed in this study meets and exceeds these requirements.

CONCLUSION

This study demonstrates a simple approach to converting broiler litter into a useful product and that a blend of broiler litter, blood and wheat offal can be a good alternative feedstuff to soybean meal to supply the protein requirements for broiler chickens.

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Table 1: Moisture characteristics of different blends of broiler litter, blood and wheat offal before and after sun drying[1]

	Blend[2]										
Moisture (%)	BBLW1	BBLW2	BBLW3	BBMW1	BBMW2	BBMW3	BBHW1	BBHW2	BBHW3	SEM	P value
Initial	24.9^{bc}	19.6^{ed}	14.7^{f}	33.2^{a}	21.7^{cd}	17.8^{ef}	32.0^{a}	25.2^{b}	21.5^{cd}	1.43	<0.0001
Final	8.20^{ab}	7.14^{cd}	6.63^{d}	8.66^{a}	7.50^{bc}	6.50^{d}	9.04^{a}	7.54^{bc}	6.39^{d}	0.23	0.0005
Loss[3]	16.6^{bc}	12.5^{de}	8.16^{f}	24.6^{a}	14.1^{cde}	11.3^{ef}	23.0^{a}	17.6^{b}	15.2^{bcd}	1.24	<0.0001

^{abcdef}Duplicate mean values in the same row for each parameter with different superscripts are significantly different ($p < 0.05$).

[1]Drying surface temperature range = 42-48^{o}C and ambient temperature range = 32-34^{o}C (approximated to the nearest ^{o}C); fresh broiler litter average % moisture = 23.40%; wheat offal average % moisture = 9.20%.

[2]BBLW1 = broiler litter and blood mixture (1:1) mixed with wheat offal (1:1); BBLW2 = broiler litter and blood mixture (1:1) mixed with wheat offal (1:2); BBLW3 = broiler litter and blood mixture (1:1) mixed with wheat offal (1:3); BBMW1 = broiler litter and blood mixture (1:2) mixed with wheat offal (1:1); BBMW2 = broiler litter and blood mixture (1:2) mixed with wheat offal (1:2); BBMW3 = broiler litter and blood mixture (1:2) mixed with wheat offal (1:3); BBHW1 = broiler litter and blood mixture (1:3) mixed with wheat offal (1:1); BBHW2 = broiler litter and blood mixture (1:3) mixed with wheat offal (1:2); BBHW3 = broiler litter and blood mixture (1:3) mixed with wheat offal (1:3).

[3] % Moisture loss = initial % moisture (blend) – final % moisture (after drying for 4 h).

Table 2: Proximate composition of soybean meal and different blends of broiler litter, blood and wheat offal (dry matter basis)[1]

	Feedstuff[2]			
Variables(%)	BBLW1	BBMW1	BBHW1	Soybean meal
Dry matter	90.7	90.3	90.1	91.9
Crude protein	19.2	23.8	28.0	42.3
Crude fiber	12.6	9.23	8.08	3.26
Ether extract	4.20	3.67	0.48	17.3
Ash	4.80	5.66	5.63	5.87
Nitrogen free extract	49.9	47.9	47.9	23.2

[1]Values are means of duplicate samples.
[2]BBLW1 = broiler litter and blood mixture (1:1) mixed with wheat offal (1:1); BBMW1 = broiler litter and blood mixture (1:2) mixed with wheat offal (1:1); BBHW1 = broiler litter and blood mixture (1:3) mixed with wheat offal (1:1).

Table 3: Weight change, dry matter and crude protein utilization by broilers fed different blends of broiler litter, blood and wheat offal

	Feedstuff[1]					
Variables	BBLW1	BBMW1	BBHW1	Soybean meal	SEM	P value
Initial body weight, kg	2.20	1.72	2.10	1.94	0.07	
Final body weight, kg	2.14	1.66	1.96	1.86	0.06	
Weight loss, kg	0.06	0.06	0.14	0.08	0.02	
Weight loss, %	2.60	3.14	6.30	3.90	0.86	0.25
DMD[2], %	42.4^{d}	56.2^{b}	76.5^{a}	54.6^{c}	3.70	<0.0001
APD[3], %	42.8^{d}	63.2^{c}	83.8^{a}	82.8^{b}	5.10	<0.0001
TPD[4], %	58.3^{d}	75.8^{c}	94.6^{a}	89.9^{b}	4.30	<0.0001

[abcd]Mean values (from six chickens) in the same column for each parameter with different superscripts are significantly different ($p< 0.05$)

[1]BBLW1 = broiler litter and blood mixture (1:1) mixed with wheat offal (1:1); BBMW1 = broiler litter and blood mixture (1:2) mixed with wheat offal (1:1); BBHW1 = broiler litter and blood mixture (1:3) mixed with wheat offal (1:1).

[2]DMD = dry matter digestibility.

[3]APD = apparent crude protein digestibility.

[4]TPD = true crude protein digestibility.

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