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PROCESSING AND NUTRITIONAL VALUE OF BROILER LITTER AS A FEED FOR BUFFALO STEERS

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ABSTRACT

Broiler litter was deep stacked in 1.2×1.2×1.2 m bins with 10%, 20% and 30% moisture for a period of 6 weeks. Following deep stacking all samples of broiler litter became negative for total, faecal CFU, *Salmonella, Shigella* and *Proteus*. Litter stacked with 30% moisture was used in a performance and digestibility trial. Twenty four buffalo steers were randomly assigned to four diets; i) basal diet (30% wheat straw, 29% wheat bran, 39% cotton seed cake and 1% mineral mix), ii) in the experimental diets cotton seed cake was replaced by deep stacked broiler litter to provide 13, 26, or 39% broiler litter in the total diet. Daily dry matter intakes were 8.76, 8.71, 8.27, and 7.95 kg/d for basal and waste containing diets, respectively. Dry matter intake and daily weight gain was lower ($P<0.05$) for the diets containing 39% broiler litter than basal and diets containing 13 and 26% broiler litter. The apparent digestibility values for DM and cell wall constituents were higher ($P<0.05$) for basal diet than broiler litter containing diets. Within litter containing diets higher digestibility values were for the diets containing 13 and 26% broiler litter than diet containing 39% broiler litter. Results from this study indicated deep-stacking is a safe method of eliminating pathogens from broiler litter and it can be used safely up to 26% in ruminant ration. However, it decreases the DM digestibility and DM intake when used at 39 % of the diet. Broiler litter has a potential to be used as a low-cost crude protein source for growing buffalo steers.

Key words: Pathogenic organism, Broiler litter, deep stacking, Protein degradability, Buffalo steers.

INTRODUCTION

Broiler litter consists of bedding material, excreta, wasted feed, feathers, and bacterial biomass (Ruffin and McCaskey, 1990). Poultry wastes are higher in nutritional value than other animal wastes and are especially rich in crude protein (CP) and minerals. The average CP value of broiler litter on dry matter basis varies from 25 to 30% (Ruffin and McCaskey, 1990). Approximately half of the CP is made up of true protein and remainder is non-protein nitrogen, which is primarily the uric acid excreted by poultry (Bhattacharya and Taylor, 1975). Due to high fiber and non-protein nitrogen contents of the litter, ruminants are best suited for utilization of litter. Nutritional value of broiler litter as feed for ruminants have considerable monetary value and is much more valuable as source of feed than for fertilizer or methane generation (Fontenot et al., 1983). Performance of cattle fed diets containing animal wastes is similar to that of animals fed conventional diets (Harvey et al., 1996).

Broiler litter must be processed prior to its use as an animal feed for the elimination of pathogens and enhancement of palatability (Fontenot, 1990). Martin et al., (1998) showed in their survey of 86 samples of poultry litter processed by different methods that no pathogenic bacteria are present in poultry litter regardless of its processing method. Other aspects of the safety of feeding broiler litter have been reviewed by Fontenot and Webb (1975).

Deep stacking of broiler litter results in increase in temperature usually up to 60 °C in the stack within 5 d that is enough to kill pathogens (Chaudhry et al., 1998). Properly stored deep-stack litter will have very little loss in quality for 5 yr or longer (Hopkins and Poore, 2001).

The objectives of this study were to: 1) evaluate the feeding value of deep-stacked broiler litter for buffalo steers and 2) determine the safety of broiler litter when used as a feed ingredient.

MATERIALS AND METHODS

Processing of broiler litter: Saw dust containing broiler litter was collected from commercial broiler house shortly after removal of first batch of birds and transported to experimental station. Broiler litter was mixed in horizontal mixer and spread on floor in a thin layer to avoid heating. The material was mixed in horizontal mixer for 30 min and stacked in 1.2x1.2x1.2 m bins with 30% moisture. The moisture levels were adjusted with the addition of water in broiler litter. Litter was deep stacked for a period of 6 weeks. Initial samples and samples at the end of deep stacking were composited and frozen for later analysis. Thermometers were placed at 60 cm from the surface and temperatures were recorded daily for 6 weeks.

Performance study: Forty eight buffalo steers weighing 125 to 155 kg were bought from open market and transported to the research centre. Prior to initiation of the 904-d study, steers were treated for internal and external parasites with Ivomec®, and vaccinated (hemorrhagic septicemia. Steers were stratified by weight and allotted randomly to one of four treatments; diets; i) a basal diet (31% wheat straw, 29% wheat bran, 39% cotton seed cake and 1% mineral mix), ii) in the experimental diets cotton seed cake was replaced gradually by broiler litter at a rate of 33, 66 and 100 %, respectively. They were then sorted by treatment and weight and allotted randomly to one of 16 pens (three steers per pen, four pens per treatment). Intermediate weights were taken every 15 d. Feed bunks were checked daily and pen intake adjusted to allow for 10% refusals. Steers were fed twice daily. Fresh water was available at all times. Feed samples were obtained weekly throughout the trial and analyzed for nutrient contents. Interim body weights were taken every 14 d and records of daily feed intake and bi-weekly weight gains for all the animals were maintained. Final body weights were measured before feeding on 3 consecutive days at the beginning and at the end of the trial. Feed and water were with held for approximately 12 h before buffalo steers were weighed in order to obtain shrunk body weight on the third day.

Digestibility study: Following performance trial, 24 out of 48 buffalo steers were used in digestibility study. Animals were assigned to six blocks of four animals, based on weight. For digestion trial, diets were given at a rate of 2.5 kg DM^{-1} body weight per day and animals were fed individually Experimental diets were given for 15 days and faeces were collected during last 10 days in canvas bags held by harnesses, as described by Fontenot and Hopkins (1965). The conduct of the digestion experiment followed the recommendations of Schiemann (1981). Faeces were collected each morning, weighed, sub-sampled and dried in forced draft oven at a maximum of 60 °C until equilibrium. At the end of trial, faeces were composited across days within animals, weighed, and sub-sampled. On the last day of experiment, ruminal fluid was collected via stomach tube approximately 2 h post feeding and blood samples were taken 6 h post feeding by jugular vein puncture.

Chemical analysis: Samples of ingredients, initial litter, deep stacked broiler litter, and feed were analyzed for nitrogen by kjeldahl method on wet feed samples and dry fecal samples (AOAC, 2000). Dry matter was determined by drying in duplicate, 200 g samples of each material in forced draft oven at a maximum of 60 °C for 48 h. Following equilibration with atmospheric moisture, the duplicate dried samples were composited, ground to pass a 1 mm sieve and subjected to analysis for DM, ash, (AOAC, 2000), NDF, ADF, cellulose and lignin (Van Soest et al. 1991).

Extracts of samples were prepared for analysis by homogenizing 25 g with 225 ml of distilled water in a blender for 2 min. The homogenate was filtered through four layers of cheesecloth and the filtrate was used for determining pH (electrometrically), lactic acid (Barker and Summerson, 1941), as modified by Pennington and Sutherland (1956) and water-soluble carbohydrates (Dubois et al., 1956) as adapted by Johnson et al., (1966).

The ruminal fluid was strained through four layers of cheese cloth, filtrate was used for determination of pH (electromagnetically) and volatile fatty acids using Vista 600 gas chromatograph (Erwin et al., 1961). Blood urea nitrogen (BUN) was determined by the method of Coulombe and Favreau (1963).

Biological analyses: The aseptic samples collected for microbial analyses were prepared by homogenizing 25 g of sample with 225 ml of distilled water in a blender for 1 min. Total (Anonymous, 1967) and fecal (Millipore Corp., 1973) Coliforms were determined in extracts of initial and deep stacked broiler litter samples.

Statistical analyses: Data were subjected to analysis of variance using general linear model procedure of SAS (1982). Performance data were analyzed assuming completely randomized design and pen and treatment was included in model. For digestibility experiment, blocks and treatment were included in the model. Orthogonal polynomials were run to test the treatment effect. In performance and digestion trials the contrast were basal diet vs diets containing deep stacked broiler litter; diet containing 13 and 26% broiler litter vs diet containing 39 % broiler litter and diet containing 13 vs 26% broiler litter.

RESULTS AND DISCUSSION

Chemical and analyses: Results indicated that litter contained 25 % crude protein on dry matter basis (Table 1), higher than earlier findings (Alrokayan et al., 1998 and Chaudhry et al., 1998), but lower than the values reported by Harmon et al., (1975) and Bhattacharya and Taylor (1975). Ash value of the broiler litter was similar to the values reported by Casewell et al., (1975) and Abdelmawla et al., (1988) but lower than the values reported by Flachowsky and Henning (1990). These differences in composition could be due to differences in bedding material, the number of batches of birds housed on the litter, broiler house management, method of litter removal, and moisture content (Fontenot and Webb, 1975). No difference was found in the chemical composition of initial and deep stacked broiler litter. Broiler litter contained 335, 267, 345 and 90 g kg^{-1} of NDF, ADF, cellulose and lignin, respectively.

Temperature of Deep stacked Broiler Litter: Deep stacking affected the temperature of the litter (Fig 1).

Maximum temperature noted was 66 °C on day 8. The decline in temperature after maximum started on day ten and continued to decrease until the temperature reached at 46 °C on day 24. The temperature remained at 45 °C for the rest of the period, which was slightly higher than ambient temperature. These results differ from those reported by Dana et al. (1978) they found a maximum temperature of 54 °C after 7 days of deep stacking of broiler litter. The results are in line to findings of Chaudhry et al. 1998. They found similar trend in increase and decline in deep stacked broiler litter and found maximum temperature of 64 °C on day 7 and temperature declined to 42°C after 21 days and remained the same for the rest of the period.

Biologic analyses: Total number of colony forming units (CFU) and fecal colony forming units for untreated broiler litter was 9.35×10^7 g^{-1} of DM and 0.07×10^5 $g^{-1}$of DM (Table 2). *Salmonella, Shigella* and *Proteus* were present. Following deep stacking all samples of broiler litter became negative for total, faecal CFU, *Salmonella, Shigella* and *Proteus.* In an earlier experiment, Chaudhry et al., (1998) found that temperature of deep stacked broiler litter ranges from 45 to 58 °C and the majority of pathogenic organisms were killed at this temperature (Van Soest, 1982). Similar findings have been reported by Lober et al., (1992). Heat production during deep stacking contributes to the inhibition of Colifrom bacteria, *Salmonella, Shigella* and *Proteus* (Chung and Geopfert, 1970 and Chaudhry et al., 1998). However, the overheating of stack can be reduced by stacking the litter in an air-tight manner (Carter and Poore, 1995; Rankins, 1995 and Ruffin and McCaskey, 1990).

Some *lactobacilli* species produce sufficient hydrogen peroxide to inhibit Coliforms and *Salmonella* organisms (Dahiya and Speck, 1969). McCaskey and Anthony (1979) reported that bacteria isolated from ensiled animal waste inhibit the growth of Coliform bacteria, *Salmonella*, *Streptococci* and *Staphylococci* by mechanisms of other than acid production.

Performance study: Chemical composition of diets fed in feeding and digestibility trial is given in table 3. All rations were formulated to contain about 15% CP. Increasing levels of broiler litter in the diets caused decrease in the values of DM, and NDF. However, the ash, ADF, cellulose and lignin contents increased linearly with the increase of broiler litter in the diets. Daily matter intakes were 8.76, 8.71, 8.27, and 7.95 kg d^{-1} for treatments 1 through 4, respectively (Table 4). Daily dry matter intake and daily weight gain decreased linearly with the increase of broiler litter. Among litter containing diets decrease was more significant for the diet containing 39% broiler litter than diets containing 13 and 26% broiler litter. A decrease in DMI was also observed in animals when broiler litter replaced SBM (Blackwelder et al., 1998). There was no difference in dry matter intake and daily weight gain for animals fed 13 and 26% broiler litter. Although average weight gain for buffalo steers fed broiler litter were lower than animals fed basal diet alone. Similar results have been reported by Hopkins and Poore (2001) when deep-stacked broiler litter contributed crude protein up to 66 % in the rations of growing heifer.

Apparent digestibility: The apparent digestibility values for DM, OM and cell wall constituents were higher for basal diet than broiler litter containing diets (Table 5). The apparent digestibility values for DM, OM and cell wall constituents decreased linearly ($P<0.05$) with increased level of broiler litter in the diets. Within litter containing diets higher ($P<0.05$) digestibility values were for the diets containing 13% broiler litter. The results are in agreement with the findings of earlier researchers (Hopkins and Poore, 2001, Chaudhry et al., 1998, Casewell et al., 1975). There was a no difference in digestibility of CP values for the litter containing diets. Because of the higher values of NPN in the deep stacked broiler litter, one would anticipate it to be highly degradable. However, during deep stacking, broiler litter undergoes heating to a variable degree, often reaching to temperatures of 50°C (Chaudhry et al., 1998) for extended periods of time. Excessive heating may result in a high level of unavailable CP (Carter and Poore, 1995), so it is reasonable to assume that heat during deep stacking caused a decrease in protein degradability to some extent. However these effects have not been investigated and measuring the degradability of the protein found in deep stacked broiler litter heated to different intensity merits further research.

Animals fed deep stacked broiler litter received high levels of trace minerals due to the higher trace mineral concentration in the broiler litter. However, no adverse clinical health effects were noted in these animals. This may have been due the relatively short duration of this trial. Webb et al., (1980) reported increased liver copper level when beef brood cows were fed litter-based diets containing approximately 150 mg kg^{-1} of copper during the winter feeding season, but returned to normal during the grazing season when no litter was fed. Despite the lack of clinical health problems in study, caution should be used when feeding deep stacked broiler litter continuously for longer period (Fontenot, 1990).

Volatile fatty acids, rumen ammonia, blood urea nitrogen and rumen pH: The concentration of total VFA increased with the increased levels of broiler litter in the diets ($P<0.05$). The molar percentage of acetic acid increased ($P<0.05$) with increased levels of litter, but those of other acids decreased ($P< 0.05$). Cross and Jenny (1976) fed varied levels of litter and corn silage to dairy

Table 1: Chemical Composition of the ingredients[ab]

Items	WS	BL	CSC	WB
DM g kg^{-1}	922	848	915	900
CP g kg^{-1}	38	248	250	135
Ash g kg^{-1}	69	208	78	63
Cell wall constituents				
NDF g kg^{1}	815	335	384	450
ADF g kg^{1}	550	267	225	180
Cellulose g kg^{1}	410	345	125	120
Hemicellulose g kg^{1}	265	68	159	270
Lignin g kg^{1}	180	90	64	20

DM= dry matter, CP= crude protein, WS=Wheat straw, BL=Broiler litter, CSC=Cotton seed cake, WB=wheat bran, NDF= Neutral detergent fiber, ADF= Acid detergent fiber

[a]Each value represents the mean of six samples. [b]Dry matter basis.

Table 2: Total and fecal colony forming units (CFU), *Salmonella, Shigella and Proteus* of initial and deep stacked broiler litter[ab]

Pathogens	Pre-stacked broiler litter	Deep stacked broiler litter
Total CFU (10^5)	9.35	0.00
Fecal CFU (10^5)	0.07	0.00
Salmonella	+	-
Shigella	+	-
Proteus	+	-

CFU= colony forming units, += indicates presence, - indicates absence

[a]Each value represents the mean of six samples [b]CFU, g^{-1} dry basis.

Table 3: Chemical Composition of diets fed to buffalo steers[ab].

Items	Diets containing " % broiler litter"				
	Control Diet	13	26	39	SEM
DM g kg^{1}	898	890	881	873	0.21
CP g kg^{1}	148	148	148	148	0.01
Ash g kg^{1}	70	87	104	121	3.17
Cell wall constituents					
NDF g kg^{-1}	527	521	514	508	1.19
ADF g kg^{-1}	306	312	317	322	1.21
Cellulose g kg^{-1}	207	236	264	320	3.15
Hemicellulos g kg^{-1}	221	209	197	186	2.77
Lignin g kg^{-1}	85	88	92	95	1.27

DM= dry matter, CP= crude protein, NDF= Neutral detergent fiber, ADF= Neutral detergent fiber

[a]Each value represents the mean of six samples. [b]Dry matter basis.

Table 4: Dry matter and crude protein intakes, average daily gain (ADG), and gain/feed ratio, by animals fed broiler litter feeding[ab].

	Diets containing " % broiler litter"				
Items	Control Diet	13	26	39	SEM
DM^{cde}, kg d^{-1}	8.76	8.71	8.27	7.95	0.44
CP^{cde}, kg d^{-1}	1.30	1.29	1.23	1.17	0.16
Shrunk ADG^{cde}, kg d^{-1}	0.89	0.875	0.825	0.765	0.07
Shrunk ADG DMI^{-1cde}, kg kg^{-1}	0.102	0.10	0.099	0.096	0.03
Full ADG^{cde}, kg d^{-1}	0.920	0.910	0.850	0.790	0.14
Full ADG^{cde} DMI^{-1}, kg kg^{-1}	0.105	0.105	0.104	0.099	0.04

DM= dry matter, CP= crude protein, DMI= dry matter intake, ADG= average daily gain, SEM= standard error of means.

[a]Each value represents the mean of six animals/treatment. [b] Dry matter basis.

[c]Linear effect (P<0.05) [d]Basal diet vs litter containing diets differ (P<0.05)

[e]Diet containing 39% broiler litter vs diets containing 13 and 26% broiler litter differ (P<0.05).

Table 5: Apparent digestibility of deep stacked broiler litter by buffalo steers[ab] (g kg^{-1})

Items	Diets containing "% broiler litter"				
	Control Diet	13	26	39	SEM
DM[cdef]	683	680	678	610	2.27
OM[cdef]	710	699	692	659	2.10
CP	728	725	723	721	0.25
Cell wall constituents					
NDF[cdef]	554	540	535	505	1.82
ADF[cdef]	369	340	309	299	2.57
Cellulose[cdef]	495	490	465	406	2.35
Hemicellulose[cdef]	776	781	770	702	3.37

DM= dry matter, CP= crude protein, SEM= standard error of means, NDF= Neutral detergent fiber, ADF= Neutral detergent fiber, SEM= SEM= standard error of means.
[a] Each value represents the mean of six animals/treatment. [b]D M basis except dry matter.
[c]Linear effect (P<0.05) [d]Basal diet vs litter containing diets differ (P<0.05)
[e]Diet containing 39% broiler litter vs diets containing 13 and 26% broiler litter differ (P<0.05).
[f]Diets containing 13% broiler litter vs diets containing 26% broiler litter differ (P<0.05).

Table 6: Volatile fatty acids rumen ammonia nitrogen and blood urea nitrogen in buffalo steers fed deep stacked broiler litter containing diet[ab].

Item	Diets containing " % broiler litter"				
	Control Diet	13	26	39	SEM
Total VFA[c], µmol/ml	84.44	90.70	94.29	99.37	2.61
Acetic acid[c], mole/100moles	67.84	68.92	69.30	69.50	0.63
Propionic acid[c], mole/100moles	24.44	23.65	23.21	23.08	0.49
Butyric acid[c], mole/100moles	7.96	7.87	7.59	7.55	0.16
Isobutyric acid[c], mole/100moles	3.16	3.06	3.03	3.01	0.10
Isovaleric acid[c], mole/100moles	5.37	5.32	5.33	5.31	0.09
Valeric acid[c], mole/100moles	3.59	3.35	3.30	3.25	0.28
Rumen pH[c]	6.60	6.68	6.70	6.95	0.54
Rumen NH3-N[c], mg/litre	129.8	151.6	169.5	191.6	0.70
Blood urea nitrogen[c], mg/litre	22.15	29.11	33.50	35.5	1.97

SEM= standard error of means, VFA= volatile fatty acids
[a]Each value represents the mean of six animals/treatment. [c]Linear effect (P<0.05).

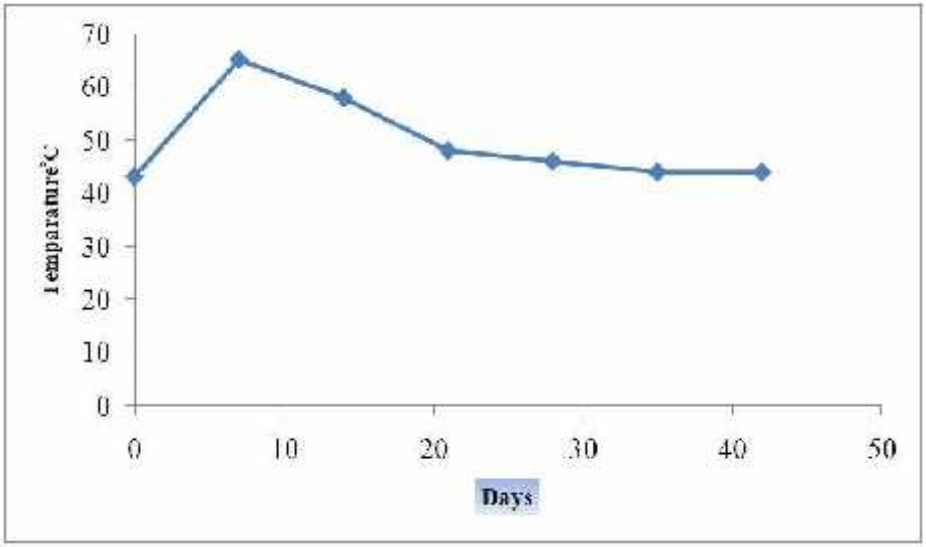

Fig. 1. Temperature of Deep Satcked Broiler Litter

heifers and found no effect on ruminal acetate but reported higher ruminal propionate concentrations when turkey litter was fed. Harvey et al., (1996), found only minor changes in VFA when deep stacked broiler litter replaced 50 or 100% of soybean meal.

Rumen pH, concentrations of ruminal ammonia and blood urea nitrogen increased linearly ($P<0.05$) as the level of broiler litter increased (Table 6). Ruminal ammonia and blood urea nitrogen are positively related to CP degradability (National Research Council, 1989), because deep stacked broiler litter is a very degradable protein source. This is contrary to the findings of Harvey et al., (1996) who reported decreased blood urea nitrogen and rumen ammonia when deep stacked broiler litter or deep stacked turkey litter were substituted for soybean meal.

Conclusion: Deep stacking is a safe processing method of broiler litter to be used as feed ingredient for ruminants. Cotton seed cake can be replaced with deep-stacked broiler litter up to 26 % in ruminant rations. Dry matter intake and daily BW gain decreased linearly with the levels of litter in the ration.

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