Journal of Animal and Veterinary Advances 7 (11): 1474-1479, 2008
ISSN: 1680-5593

Digestibility, Degradability and Dry Matter Intake of Deep-Stacked Poultry Litter by Sheep and Goats

Nuha Hamed Talib and Faisal Awad Ahmed
Animal Production Research Center, Hillat Kuku, P.O. Box 1355, Khartoum North, Sudan

Abstract: The objective of this research was to study the nutritive value of deep-stacked broiler litter (DBL) as ruminant feed. Further more, the effect of such diets on dry matter intake of sheep and goats was also studied. Four non castrated male sheep (38.4±3.90 kg/body/weight) were arranged into 4×4 Latin square design to 1 of the 4 dietary treatment groups that differed in DBL as a percentage of concentrate diet. The percentages in concentrate diet were 0, 20, 40 and 60%. The diets consist of concentrate mixture (0, 20, 40 and 60% broiler litter) plus ground sorghum stover at the rate of 2:1 on fresh basis to give complete diets of Control (Cont.), low level deep stacked broiler litter (LBL), medium level deep stacked broiler litter (MBL) and high level deep stacked broiler litter (HBL), respectively. Digestibility study revealed no significant difference in organic matter digestibility. Crude protein digestibility decreased gradually as the inclusion rate of DBL increased in the experimental diets. In addition to that all of the experimental diets degraded extensively and quickly in the rumen of the fistulated bulls decreasing the percentage of by bass protein. Dry matter intake of dietary treatments by sheep and goats was not affected by inclusion of DBL in their diets and they experienced no palatability problems. The previously mentioned results indicate that DBL could be safely used as a feed ingredient for ruminants without any effect on animal health. DBL as a feed ingredient for sheep and goats was also acceptable. Digestibility results rated the experimental diets as low to high quality hay in term of organic matter digestibility and metabolizable energy contents.

Key words: Digestibility, degradability, intake, poultry litter, sheep and goats

INTRODUCTION

Poultry wastes namely poultry manure contain high concentration of nitrogen, calcium and phosphorus than the waste of other animal species. Broiler litter is known as solid or semisolid waste composed of bedding material, excreta, wasted feed and feathers. Although, broiler litter can be used effectively and efficiently as a fertilizer, its greatest potential impact is a feed ingredient for ruminants when processed by an acceptable method. The main nutritional constitution of broiler litter for ruminant feeding are high level of protein (average 25% crude protein, 45% real protein and 55% NPN), minerals (25%, especially Ca and P), metabolizable energy (8.77-10.02 MJ kg^{-1} DM) and high crude fiber (Rankins, 1995).

Ruminants have the ability to digest low-cost feedstuffs that are not normally utilized by other livestock. However, protein is typically the most expensive ingredient in ruminant diets. Feeding poultry litter is a means of disposing of a waste in environmentally sound manner, while concurrently supplying a low-cost protein feed to ruminants. In Sudan poultry manure or litter is traditionally used as a fertilizer, its use as a feed ingredient in ruminant diets is recent and not very frequent (Elhag and Elhag, 1981; Abdalla *et al*., 1989, 2003; Alabedein, 1998; Mahmoud, 2004). This little involvement of poultry litter as a feed could be due to religious or health constraints. Poultry industry or especially poultry production was growing rapidly during the last years. The most recent survey of poultry farms in Khartoum state was done by Ministry of Agriculture, Animal resources and Irrigation (2005). The survey revealed that about 612 poultry farms are located in Khartoum state raising about 8, 197, 690 broiler chicken and 1, 313, 549 layers. These large numbers of growing chicks implies large amounts of poultry wastes viz poultry manure. Storage and proper disposal of poultry wastes is not well managed in Sudan.

The objective of this study was to evaluate the feeding value of broiler litter as a feed for ruminants and also to initiate an applicably environmentaly safe method to get rid of this poultry waste under Sudan condition.

Corresponding Author: Faisal Awad Ahmed, Animal Production Research Center, Hillat Kuku, P.O.Box 1355, Khartoum North, Sudan

The palatability and acceptability of this deep stacked litter as feed for small ruminants was also demonstrated.

MATERIALS AND METHODS

A series of experiments were conducted to elucidate the feeding value of deep stacked broiler litter as a ruminant feed. All experiments were done in Animal Production Research center, Khartoum North, Hillat kuku during the period from January to June 2005.

Feeds and feeding

Deep stacked broiler litter: Broiler litter collected from a commercial broiler house of Animal Production Research Center (poultry production department), bedded with wood shavings was used. The broiler litter was a mixture of bird excreta, wasted feed, bedding and feather. Deep stacking was prepared in an under ground silo pit (2×2.5×1.5 cm). The collected litter was spread on a plastic sheet and sprayed with water to bring its moisture contents to about 30% (Dry Matter (DM%) = 70%) using garden watering can.

Then, the sprayed litter was filled in plastic sacks and put in the underground pit and pressed manually. The pressed material was covered using plastic sheet. A thin layer of soil (3-5 cm) was placed over the plastic sheet. Three pits were prepared. The pit was opened after a period of at least 1 month. Representative samples of broiler litter were taken after deep stacking and proximate analysis was made on dried (65°C) ground samples as outlined by AOAC (1975).

Experimental feeds: Four concentrate mixtures were used comprising deep stacked broiler litter at a rate of 0, 20, 40 and 60% of concentrate in addition to other feed ingredients of molasses, urea, groundnut cake, wheat bran and salt (Table 1). All concentrate mixtures where prepared to be isonitrogenous (230 protein g kg^{-1}) and isoenergetic (10 ME MJ kg^{-1} DM). Sorghum stover (chopped) was used as a source of fiber. Complete diets were also preformed containing 0, 12, 24 and 36% deep-stacked broiler litter. Ground sorghum stover constitutes 40% of all the complete diet. All ingredients were mixed manually to make homogenous isonitrogenous and isenergetic diets (Table 2).

Digestibility experiment: Four non castrated male sheep (38.4±3.90 kg/body/weight) were arranged into 4×4 Latin square design. Sheep were kept in metabolism cages to enable accurate determination of feed intake and allow easy collection of feces and urine. They were given free access to fresh water and mineral salt licks. The diets consist of concentrate mixture (0, 20, 40 and 60% broiler litter) from Table 1 plus ground sorghum stover at the rate of 2:1 on fresh basis to give complete diets of Control (Cont.), low level deep stacked broiler litter (LBL), medium level deep stacked broiler litter (MBL) and high level deep stacked broiler litter (HBL), respectively. The animals were adapted to each diet for 2 weeks at the rate of approximately 2% of body weight followed by balance trial of 10 days. The first 3 days were to adapt to harnesses and bags and in the followed 7 days measurement of daily food intake and fecal excretion were made. The feces were collected in canvass bag secured by means of harnesses over body of sheep. Samples of feeds and feces (10%) were taken daily and kept in refrigerator waiting analysis.

Degradability study: Samples from digestibility study (Cont, LBL, MBL and HBL) after drying and grinding,

Table 1: Ingredients and chemical composition of the diets fed to sheep in digestibility experiment

Parameters	Broiler litter (%) in the concentrate diet 0	20	40	60	Deep stacked broiler litter	Sorghum straw
Diet composition (%)						
Molasses	45.00	43.00	39.00	36.00	-	-
Groundnut cake	8.50	8.00	4.00	1.00	-	-
Wheat bran	42.00	26.00	15.00	2.00	-	-
Urea	3.50	2.00	1.00	0.00	-	-
Processed broiler litter	0.00	20.00	40.00	60.00	-	-
Salt	1.00	1.00	1.00	1.00	-	-
Total	100.00	100.00	100.00	100.00	-	-
Chemical composition (g kg^{-1} DM)						
Dry matter	689.50	712.70	691.40	654.20	677.60	957.70
Crude protein	229.20	212.50	216.70	220.80	265.00	35.20
Ash	97.70	113.00	147.00	144.00	145.60	72.70
Crude fiber	72.00	60.00	96.00	118.00	236.60	380.00
Ether extract	18.00	14.00	10.00	18.00	34.40	12.60
Calculated ME[1] (MJ kg^{-1} DM)	11.01	10.78	9.97	9.95	9.12	6.69

[1]ME of concentrate diet was calculated according to the equation; ME (MJ kg^{-1} DM) = 0.012 CP + 0.031, EE + 0.014, NFE + 0.005, CF (MAFF *et al*., 1975); The ME for sorghum straw was 6.69 MJ kg^{-1} DM as reported by Sulieman and Mabrouk (1999); The ME for deep stacked broiler litter was calculated according to the equation TDN (%) = 75- Ash (%) (Jacob *et al*., 1997) and then ME (MJ kg^{-1} DM) = TDN kg×4.4×4.18×0.82 (NRC, 1996)

Table 2: Chemical composition of diets containing different levels of broiler litter fed to sheep in digestibility trial

	Experimental diets			
Parameters	Control[1]	LDBL[2]	MDBL[3]	HDBL[4]
Chemical composition (g kg^{-1}DM)				
Dry matter	606.2	606.6	617.5	568.6
Crude protein	143.8	168.8	159.4	150.0
Ash	102.5	121.4	136.8	139.4
Crude fiber	202.0	214.0	220.0	240.0
Ether extract	24.0	16.0	18.0	12.0

[1]The diet without broiler litter; [2]Low level of deep stacked broiler litter; [3]Medium level of deep stacked broiler litter; [4]High level of deep stacked broiler litter

were weighed (2 g) into nylon bags tied and incubated into 2 fistulated bulls (250-300 kg body weight) for a series of time, namely 3, 6, 9, 12, 24, 36 and 48 h. The dry matter loss was recorded for each sample for each time. The residue in the bag was subjected to analysis of nitrogen (Kjeldahl method) to calculate the nitrogen loss of the tested diets at different incubation times. DM and CP losses on degradability study were fitted to the model of Ørskov and McDonald (1979) as:

$$p = a + b\,(1 - \exp^{-ct}) \qquad (1)$$

where:

p = Degradation at time t.
t = Incubation time.
e = The basis of the natural logarithm.
a = Y axis intercept at time 0. Represent soluble and completely degradable substrate that is rapidly washed out of the bag.
b = The difference between the intercept (a) and the asymptote. Represents the insoluble but potentially degradable substrate which is degraded by the micro-organisms according to first-order kinetics.
c = Rate constant of b function.
1 - (a + b) = The undegradable portion of a sample.
a, b, c = Constants fitted by an iterative least squares procedure.

$$\text{Effective degradability (P)} = a + b\,(c/(c + k) \qquad (2)$$

where:

a, b, c = As defined for Eq. (1).
k = Rumen small particle outflow rat.

Feed intake trial of sheep and goats: A trial was conducted to determine palatability and acceptability of the diets containing different levels of broiler litter to sheep and goats through measurement of daily dry matter intake. Twelve male sheep (33±5.7) and 12 female goats (25±6.5 kg/body/weight) with no significant milk production were arranged into complete randomized design in a 2 simultaneous experiments to measure the feed intake. Each experiment lasted for 21 days of which 2 weeks adaptation period followed by 1 week for data collection on intake. The animals were housed individually with free access to water and mineral blocks. Diets were prepared as shown in Table 3 and offered daily at 8 am. The refusals were collected the second day and the dry matter intake was calculated as the difference between the offered and the refused quantity on dry matter basis.

Table 3: Ingredients and chemical composition of the diets fed to sheep and goats in feed intake trial

	Dietary broiler litter (%)			
Parameters	0	12	24	36
Diet composition (%)				
Molasses	18.7	25.8	23.4	21.6
Groundnut cake	6.0	4.0	2.4	0.6
Wheat bran	33.4	16.4	9.0	1.2
Urea	1.3	1.2	0.6	0.0
Deep stacked broiler litter	0.0	12.0	24.0	36.0
Salt	0.6	0.6	0.6	0.6
Sorghum Stover	40.0	40.0	40.0	40.0
Total	100.0	100.0	100.0	100.0
Chemical composition (g kg^{-1}DM)				
Dry matter	775.0	759.0	746.0	702.0
Crude protein	161.6	152.0	159.8	142.8
Ash	103.3	128.6	139.9	138.6
Crude fiber	172.0	166.0	188.0	160.0
Ether extract	22.0	22.0	18.0	20.0
Calculated ME[1] MJ kg^{-1} D.M	9.3	9.1	8.9	8.7

Proximate analysis was performed according to AOAC (1975) methods; [1]ME of the complete diet was calculated according to the equation; ME (MJ kg^{-1} DM) = 0.012 CP + 0.031 EE + 0.005 CF + 0.014 NFE (MAFF *et al.*, 1975)

Chemical analysis: Samples of diets from digestibility trial, degradability study and palatability and acceptability trial were analyzed for their proximate components (Dry matter, crude protein, ether extract and crude fiber) by AOAC (1975). Neutral detergent fiber (NDF) and acid detergent fiber (ADF) contents were determined according to Van Soest (1982).

Statistical analysis: Statistical analysis was done using computer program (SAS, 1990). For digestibility experiment analysis of variance was also conducted considering the effect of period and animal beside the main effect of the experimental diets. Data on feed intake of sheep and goats was analyzed using one-way analysis of variance (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Digestibility experiment: Ingredients and chemical composition of the diets fed to sheep in digestibility experiment are showed in Table 1. The crude protein

Table 4: Digestibility (g kg^{-1}), total digestible nutrients (TDN) percentage and metabolizable energy (MJ kg^{-1} DM) of sheep fed different levels of broiler litter

	Experimental diets					
Parameter	Control	LDBL	MDBL	HDBL	Standard error[1]	Level of significance
Number of animals	4	4	4	4	-	-
Digestibility (g kg^{-1})						
Dry matter	605.70	594.30	590.00	561.50	25.910	ns
Organic matter	624.50	621.70	618.60	605.50	24.550	ns
Crude protein	571.0^a	578.0^a	627.6^a	467.3^b	27.910	**
Ether extract	342.8^c	645.1^b	635.6^b	780.7^a	41.340	***
Crude fiber	414.40	355.50	385.00	378.70	39.270	ns
Total digestible nutrients	57.06	55.91	54.83	53.54	2.302	ns
Metabolizable energy*(MJ kg^{-1} DM)	8.61	8.43	8.27	8.08	0.348	ns

*ME (MJ kg^{-1} DM) = TDN kg×4.4×4.18×0.82 (NRC, 1996)

Table 5: Dry matter and crude protein degradation characteristics (g kg^{-1}) of diets containing different levels of broiler litter fed to sheep in digestibility experiment

	Experimental diets			
Parameters	Control[1]	LDBL[2]	MDBL[3]	HDBL[4]
Dry matter				
a	51.600	50.000	53.900	55.500
b	38.000	38.400	44.500	48.300
a+b	89.600	88.400	94.400	100.000
1- (a+b)	10.400	11.600	5.600	0.000
C	0.019	0.021	0.014	0.010
ed (k = 0.02)	72.000	71.600	73.100	71.900
ed (k = 0.05)	65.800	65.600	66.000	65.400
ed (k = 0.08)	64.000	63.800	64.100	63.700
Crude protein				
A	66.700	67.400	64.300	70.400
B	20.600	22.700	24.800	25.100
a+b	87.400	90.200	89.100	95.500
1- (a+b)	12.600	9.800	10.900	4.500
C	0.066	0.047	0.065	0.018
ed (k = 0.02)	82.600	83.400	83.200	82.500
ed (k = 0.05)	78.500	78.500	78.200	77.200
ed (k = 0.08)	76.100	75.900	75.300	75.100

[1]The diet without broiler litter; [2]Low level of deep stacked broiler litter; [3]Medium level of deep stacked broiler litter; [4]High level of deep stacked broiler litter

content of the deep-stacked broiler litter reported in this study, was a bit higher while ash contents and crude fiber contents were lower than values (254, 268 and 244 g kg^{-1} DM, respectively) reported by Wang and Goetsh (1998). This was most likely due to the higher ratio of bedding to wasted feed, excreta and feathers. The prepared experimental rations blended well with deep-stacked broiler litter and other feed ingredients perhaps because of molasses (>35% of molasses in concentrate rations). In line with previous studies (Fontenot, 1981; Hadjipanayiotou *et al*., 1993; Hadjipanayiotou, 1994) no disease problems were encountered in this study, from including processed broiler litter in rations of small ruminants.

Further more, crude protein contents of diets used in digestibility study (Table 2) were within the normal range of sheep feeds in such weight and condition (NRC, 1985) for normal growth and production. As shown in Table 4 apparent digestibility values for DM and OM tended to be lower for diets containing the highest inclusion rate of broiler litter (HLBL). The difference was especially large (p<0.01) for CP digestibility. Also, lower CP digestibility values for diets containing processed poultry litter were reported by Holzer and Levy (1976). The reason for lower CP digestibility for HLBL diet might be due to the Maillard type reactions which involves the irreversible binding of certain aminoacid residues in proteins with sugars at the high temperature (60°C) during deep stacking (Chaudhry *et al*., 1996). Generally, the apparent digestibility values for DM and OM reported in this study, agrees with the findings of many researchers (Bhattacharya and Fontenot, 1966; Harmon *et al*., 1975; Casewell *et al*., 1978; Chaudhry *et al*., 1996; Al-Rokayan *et al*., 1998), who used processed broiler litter by deep stacking or ensiling with green forages to form complete diets for ruminants. The energy values (TDN% and Metabolizable energy as MJ kg^{-1} DM) calculated from *in vivo* digestibility showed a decreasing trend by increasing the inclusion rate of processed broiler litter suggesting that the energetic value of processed litter was lower than that of other feed ingredients included in the tested diets. Generally the energy values of the tested diets reported in this study, classified them as medium to high quality hay.

Degradability experiment: Both DM and CP degradation characteristics of diets containing different levels of processed broiler litter were very high (Table 5) and agree with other results reported by Turke (2002) and Salim (2003) using molasses based diets (molasses consistituted >40 or 50% of ration, respectively). There was also evidence that processed broiler litter is very soluble where proportion (a) was >30% for DM and >75% for CP as stated by Hadjipanayiotou (1994). However, Mahmoud (2004) reported lower values of the soluble portion of CP (a) (<23%) for diets containing up to 30% sun-dried poultry manure. The last result maybe due to higher inclusion rate of sorghum grain (>35%) in the tested diets and sorghum as a cereal is known to have a low degradable protein fraction (Huntington, 1997).

Table 6: Dry matter intake of sheep and goats offered diets containing variable levels of poultry litter

Parameters	Dietary broiler litter level (%) 0	12	24	36	Standard error	Level of significance
Sheep						
No. of animals	3.00	3.000	3.00	3.00	-	-
Period (days)	21.00	21.000	21.00	21.00	-	-
Mean live weight (kg)	29.25	27.250	26.75	27.25	1.490	ns
Metabolic body weight ($W^{0.75}$)	12.57	11.920	11.76	11.92	0.487	ns
Dry matter intake (kg day^{-1})	1.58	1.300	1.23	1.09	0.184	ns
Dry matter intake (live weight (%))	5.39	4.750	4.58	3.99	0.537	ns
Dry matter intake (g kg^{-1} $W^{0.75}$ per day)	125.43	108.610	104.10	91.32	12.846	ns
Goat						
Number of animals	3.00	3.000	3.00	3.00	-	-
Period (days)	21.00	21.000	21.00	21.00	-	-
Mean live weight (kg)	27.50	27.920	28.33	29.42	1.791	ns
Metabolic body weight ($Wt^{0.75}$) kg	12.57	11.920	11.76	11.92	0.487	ns
Dry matter intake (kg day^{-1})	1.20^{b}	1.26^{ab}	1.57^{a}	1.07^{b}	0.147	*
Dry matter intake (live weight (%))	4.34^{ab}	4.53^{ab}	5.59^{a}	3.62^{b}	0.481	*
Dry matter intake (g kg^{-1} $Wt^{0.75}$ per day)	99.46^{ab}	103.95^{ab}	128.42^{a}	84.35^{b}	12.180	*

Feed intake trial of sheep and goats: Dry matter intake of sheep in this study, as kg per day or as a proportion of body weight (Table 6) are consistent with many studies using poultry litter as feed ingredient (Gaber *et al*., 1993; Mahmoud, 2004; Hadjipanayiotou *et al*., 1993) or using other feeds (Elmahi *et al*., 2005). However, the dry matter intake of sheep reported in this study, was a bit higher than that stated by NRC (1985) (1-1.3 kg/day/animal) having the same average live weight. That was expected since, the energy density of feed in NRC 1985 was higher (ME = 2.8-2.7 Mcal kg^{-1} DM = 11.7-11.3 MJ kg^{-1} DM) than feeds used in this study. The same was true for goats as the values for dry matter intake as kg per day or as a proportion of body weight recorded in this study (Table 6), lies between the normal limits reported by other workers feeding molasses based diets (Gubartalla, 1998) or sorghum based diets (Ibrahim, 1996) to Nubian goats. Again, the dry matter intake of goats reported in this study, was higher than that reported by NRC (1981) (445-715 g/day/animal), having the same average live weight. That was expected since, the energy density of feed in NRC (1981) was higher (ME = 2.73-2.22 Mcal kg^{-1} DM = 11.4-9.3 MJ kg^{-1} DM) than feeds used in this study. Generally, goats appeared to be more adapted to increasing level of dietary deep-stacked broiler litter.

CONCLUSION

The digestibility and degradability experiment ranged poultry litter from medium to high quality hay that could support ruminants for maintenance or even production if supplemented with the proper source of energy for example molasses. Small ruminants were found to be well adapted to inclusion of deep-stacked broiler litter in complete diets up to 36% without causing any health problems or remarkable decrease in daily feed intake. Further studies may be needed to elucidate the effect of long term feeding of small ruminants on poultry litter and its effect on their performance.

REFERENCES

Abdalla, S.A., A.H. Suleiman, M.E. Mansour and H.E. Ahmed, 1989. Anote on utilization of poultry litter in rations of fattening lambs. Sudan J. Anim. Prod., 2 (1): 47-50.

Abdalla, S.A., A.H. Suleiman and M.E. Mansour, 2003. Utilization of diets containing Dura (*Sorghum vulgare*) grain, husk and poultry litter in rations of fattening lambs. Sudan J. Anim. Prod., 16: 1-8.

Al-Rokayan, S.A., Z. Naseer and S.M. Chaudhry, 1998. Nutritional quality and digestibility of sorghum-broiler litter silages. Anim. Feed Sci. Technol., 75: 65-73.

AOAC, 1975. Association of Official Analytical Chemists, Official Methods of Analysis. 12th Edn. AOAC, Washington, DC.

Bhattacharya, A.N. and J.P. Fontenot, 1966. Protein and energy value of peanut hull and wood shaving poultry litters. J. Anim. Sci., 25: 367-371.

Caswell, L.F., J.P. Fontenot and K.E. Webb, 1978. Effect of processing method on pasteurization and nitrogen components of broiler litter and on nitrogen utilization by sheep. J. Anim. Sci., 40: 750-755.

Chaudhry, S.M., J.P. Fontenot, Z. Naseer and C.S. Ali, 1996. Nutritive value of deep stacked and ensiled broiler litter for sheep. Anim. Feed Sci. Technol., 57: 165-173.

Elhag, M.G. and G.A. Elhag, 1981. Further studies on effect of supplementing ground nut hulls with dried poultry excreta or cotton seed cake on performance of Sudan Desert sheep. World Rev. Anim. Prod., 17: 9-14.

Elmahi, M.I., N.H. Talib, M.A. El Haj and H.E. El Awad, 2005. Effect of sodium hydroxide treatment on voluntary intake and digestibility of sorghum straw by sheep. U of K J. Agric. Sci., 13 (2): 326-337.

Fontenot, J.P., 1981. Recycling of animal wastes by feeding. In: New Protein Foods, Academic Press, Inc., 4: 277-304.

Gaber, A.A., M.Y. El-Ayek and A.Z. Mehrez, 1993. Effect of long term feeding of rations containing dried poultry litter on digestibility and growing lambs performance. J. Agric. Sci. Mansoura Universiy, Egypt, 18 (12): 3437-3556.

Gubartalla, K. Adel-Wahab, 1998. Effect of energy sources on some productive and reproductive potentials of Sudan Nubian Goats. Ph.D, Faculty of Animal Production, University of Khartoum.

Hadjipanayiotou, M., 1994. Laboratory evaluation of ensiled olive cake, tomato pulp and poultry litter. Livestock Research for Rural Development, 6 (2). http://www.cipav.org.co/lrrd/lrrd6/2/cyprus1.htm.

Hadjipanayiotou, M., L. Verhaeghe, L.M. Labban, A. Shurbaji, A.E.R. Kronfoleh, M. Al Wadi, T. Naigm, H. El-Said and A.K. Al-Haress, 1993. Feeding ensiled poultry excreta to ruminant animals in Syria. Livestock Research for Rural Development, 5 (1). http://www.cipav.org.co/lrrd/lrrd5/1/syria1.htm.

Harmon, B.W., J.P. Fontenot and K.E. Webb, 1975. Ensiled broiler litter and corn forage 1. Fermentation characteristics. J. Anim, Sci., 40 (1): 144-155.

Holzer, Z. and D. Levy, 1976. Poultry litter as a protein supplement for beef cattle fed fibrous diets. World Rev. Anim. Prod., 12 (1): 91-96.

Huntington, G.B., 1997. Starch utilization by ruminants: from basics to the bunk. J. Anim. Sci., 75 (3): 852-867.

Ibrahim, S. El-Fadel, 1996. The effect of different dietary energy levels on finishing goats. M.Sc., Faculty of Animal Production, University of Khartoum.

Jacob, J.P., W.E. Kunkle, R.S. Tervola, R.D. Miles and F.B. Mather, 1997. Broiler litter: Part 1. A feed ingredient for ruminants (Acrobat version). Factsheet PS-13 of the Department of Animal Sciences, University of Florida.

MAFF, DANS and DANI, 1975. Ministry of Agriculture, Foods and Fisheries (MAFF), Department of Agriculture of Scotland (DANS) and Department of Agriculture for N o rthern Ireland (DANI). Energy Allowances and Feeding Systems for Ruminants. Technical Bulletin, pp: 33. HMSO-London. ISBN: 011240894X.

Mahmoud, Z.E.N., 2004. The use of sun-dried poultry litter in diets for fattening desert sheep. M.Sc. Thesis, University of Khartoum.

NRC, 1985. National Research Council, Nutrient Requirements of Sheep. 6th Rev. Edn. Washington. D.C: National Academy Press.

NRC, 1996. National Research Council, Nutrient Requirements of Beef Cattle. 6th Rev. Edn. National Academy Press. Washington D.C.

NRC, 1981. National Research Council, Nutrient requirements of goats Number 15, National Academy Press. Washington D.C.

Ørskov, E.R. and I. McDonald, 1979. The estimation of protein degradability in the rumen from incubation measurements weighed according to rate of passage. J. Agric. Sci., 92: 499-503.

Rankins, D.L., 1995. Processing options for broiler litter. Feed Mix, 3 (1): 8-11.

Salim, M.B., 2003. The use of Guar for fattening Western Baggara cattle. M.Sc. Thesis, University of Khartoum.

SAS, 1990. Statistical Analysis System user'guide, vols. 1 and 2, version 6. 4th Edn. SAS Institute, Inc., Cary, USA.

Steel, R.G.D. and J.H. Torrie, 1980. Principles and Procedures of Statistics. 2nd Edn. McGraw-Hill Book Company, Inc., New York, pp: 633.

Sulieman, Y.R. and A. Mabrouk Abd/RA, 1999. The nutrient composition of Sudanese Animal Feeds (Bulletin III). Animal Production Research Centre Publications. Khartoum North. Sudan.

Turke, I.Y., 2002. The effect of different dietary protein sources on fattening performance and carcass characteristics of Western Baggara cattle. PhD. Thesis, Faculty of Animal Production, University of Khartoum.

Van Soest, P.J. and J.B. Robertson, 1985. Anlysis of Forage and Fibrous foods. A laboratory manual for Animal Science, Cornell University, Ithaca, New York, USA, pp: 613.

Wang, Z.S. and A.L. Goetsch, 1998. Intake and digestion by Holstein steers consuming diets based on litter harvested after different numbers of broiler growing periods or with molasses addition before deep-stacking. J. Anim. Sci., 76: 880-887.

Z/Alabedein, I.T., 1998. Replacement of cotton seed cake by chicken manure for growing Frisian dairy heifers. M.Sc., Faculty of Animal Production, University of Khartoum.