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Development of feeding regimes with some crop residues: maize offal, cowpea husk, poultry litter and groundnut haulms in a semi-arid environment of Nigeria

***[1]Millam, J.J., [2]Kosontyav, J., [3]Mohammed, I.D., [1]Abbaya, H.Y., [4]Bello, S.S., and [4]John, P.A.**

[1]Department of Animal Production, Adamawa State University, Mubi;
[2]Feedmill Department, Grand Cereals Limited, Jos;
[3]Department of Animal Science, University of Maiduguri, Maiduguri;
[4]Department of Animal Science, Ahmadu Bello University, Zaria.

Corresponding Author: jacobjafiya@gmail.com; ***Phone No.:***+2348061504098

Target audience: Ruminant nutritionist; Livestock farmers

Abstract

The experiment was designed to develop a feeding regime using 4 local feedstuffs and to determine their rumen degradation at different time interval. The feed ingredients used where maize offal, cowpea husk (energy source), groundnut haulms and poultry litter (protein source). The formulation was based on the ratio 60:40 of energy to protein sources. Ten formulations F_1–F_{10} were developed. The dry matter (DM) content of the formulation was within the range of (89.60–99.8%), crude protein (4.37–15.80%), crude fibre (25.5.00-46.00%), and gross energy (12.13-13.18 GE MJ/Kg DM). Three grams of the samples were weighed into the nylon bags and incubated for 6, 12, 18, 24, 36, 48 and 72 hours respectively. There were significant differences in the DM disappearance of the formulations. All the formulations used in this study recorded above 50% dry matter degradability at 48 hours period of incubation. This implies that the formulations were highly degradable in the rumen and warrant them to be used as rations for ruminants. In conclusion, when local feed ingredients are mixed in the right proportion, it can contribute significantly to the nutritional requirement of ruminants.

Key words: Maize offal, cowpea husk, poultry litter, groundnut haulms, DM disappearance.

Description of Problem

Poor nutritional status, especially in terms of quality of the feed resources available to ruminants is mostly adducible to the low plane of nutrition (1) and hence, the low productivity of these animals (2). In Nigeria, the scarcity and fluctuation in quantity and quality of feed supply all year round is a major constraint to livestock production (3; 4). Livestock subsist on natural range lands for about six month and depend mainly on crop residues for the rest of the year (5). The future hope for feeding the rapidly growing human population in the Sub-Saharan Africa and in Nigeria in particular will depend on the enhanced and efficient utilization of non-conventional resources that cannot be used as food for humans or feed for livestock (3; 4).

An important class of non-conventional feed is by-product feedstuff or crop residues, which are obtained during harvest or processing of a commodity in which human food or fibre is obtained (6). Large quantity of crop residues (sorghum husk, millet husk, cowpea husk, maize bran, wheat bran, millet bran, groundnut haulms, maize cobs, maize straw etc.), produced on private and government farms in Nigeria are wasted yearly. Some are left to rot in the field, which may improve soil fertility but most of them are burnt (5).

As reported by (7), native pastures and crop residues are the most widely available low-cost feeds for ruminants in the tropics. Occasionally however, supplementary feeding is provided by way of food processing by-products such as cassava peels and cereals milling by-products (8). In the dry season and post-harvest periods, these feed resources become the main sources of energy for use by ruminants when poor quality forages prevail (9). This is important in view of the fact that rural dwellers in the tropics, who mostly rear one type of ruminant or the other (10), as an adjunct to arable crop production (11) hardly have the means to purchase completely mixed diets for their animals (12) nor can they afford to invest in the establishment of improved pastures and feed concentrates supplements supplies (13).

Despite the abundance of a variety of these large quantities of post-harvest crop residues, less information is available on the usefulness of most of these materials as feed for ruminants, particularly in terms of their degradability in the rumen (14). To predict which feedstuff can support productive functions in the animal, their degradability must be ascertained, since most of these by-products and crop residues contain a large portion of lingo-cellulose and usually poor in protein, energy, minerals and vitamins (15).

The use of simple but robust techniques for evaluation of the nutritional quality of these feed resources will contribute to their efficient utilization. The most widely used method in Nigeria is the *in situ* incubation of samples in nylon bags in the rumen (16). It provides the estimates to rate of disappearance of feeds constituents; potential ruminal degradability of feedstuffs and feed constituents while incorporating effects of particulate passage from the rumen (17). Therefore, this study intends to investigate the nutritive value of feeds formulated using some local feedstuffs and there rumen degradation.

Materials and Method

Location of experimental site

The study was conducted at the University of Maiduguri Livestock Teaching and Research Farm along Bama road, Maiduguri. The study area is located on latitude 11°15′N, longitude 30°05′E at an altitude of 354 m above mean sea level. It falls within the Sahelian region (semi-arid zone) of West Africa; which is characterised by hot dry season, short duration of rainfall of about 4-5months. Rainfall varies from 300-500mm while ambient temperatures range from 34-40°C; relative humidity ranges from 45-50% between Aprils and May. The hottest months are between March and May, with temperature of about 42°C or more, while the coolest season is from June to September with high relative humidity; 45% (18).

Sample collection and preparation

Feed ingredients used included Maize offal, Cowpea husk, Poultry litter and Groundnut haulms. These crop residues were purchased at the Maiduguri livestock market (Kasuwan Shanu). The poultry litter was collected from the dropping pit of battery cages at the University of Maiduguri Poultry Farm Unit 1. The poultry litter was sundried for two weeks (19) and underwent particle size reduction using pestle and mortar while all fibrous materials like feathers were removed with a sieve. The groundnut haulms were also ground into small particles (50 mm) using grinding machine to facilitate easy mixing with other ingredients.

Experimental feed formulation

Ten experimental diets (F_1–F_{10}) were formulated in a 100 kg mixture. The feed ingredients were Maize offal and Cowpea husk (energy sources) and Poultry litter and Groundnut haulms (protein sources) as shown in Table 1. The experimental diets were formulated by varying the level of each ingredient in a particular formulation.

Table 1: Feed Formulation based on (100Kg)/ Formulation (Kg)

Feed stuff	F_1	F_2	F_3	F_4	F_5	F_6	F_7	F_8	F_9	F_{10}
Maize bran	30	40	30	20	40	10	50	20	30	20
Cowpea husk	30	20	30	40	20	50	10	40	30	40
Poultry litter	30	20	10	20	10	30	10	10	20	30
Groundnut haulms	10	20	30	20	30	10	30	30	20	10
Total	100	100	100	100	100	100	100	100	100	100

The ingredients were arranged as energy sources (maize bran and cowpea husk) and protein sources (poultry litter and groundnut haulms); by using the principle guide of 60:40 ratio of energy to protein (20; 21). This is to allow for balance in energy content of the diets, as ruminants generally eat to satisfy their energy needs (22). Mixing of the feed ingredients was done manually with a shovel on a clean cement floor. The ingredients were thoroughly mixed to obtain a homogenous mixture. The formulated diets were then bagged and subsamples were collected for laboratory analysis and rumen degradation.

Housing, feeding and *in situ* DM determination

Three healthy rumen cannulated Wadara bull at the University of Maiduguri Teaching and Research Farm were used. The bulls were fitted with a permanent rumen cannula of 40 mm in diameter and was housed in a pen for easy sampling. The bulls were offered diets containing cowpea husk, maize bran and groundnut haulms in the mornings and evenings; water was given *ad libitum* throughout the experimental period. The items used for the *in situ* degradation were: nylon bags made from polyester filter cloth with an approximate size of 80×20mm, with a mesh of about 20-40µ; nylon string or twine; forceps for withdrawal of the nylon bag from the rumen; Dettol antiseptic and cotton wool for cleaning the cannula area after withdrawal. The incubation procedure is as follows:

- The feed samples were ground through a 3 mm screen (mesh) using a Laboratory hammer mill.
- The samples were oven dried at 105 ℃ overnight to determine the dry matter (DM).
- The nylon bags were oven dried at 65℃ for 30 minutes, allowed to cool and weighed.
- Three grams of the sample (feed) was placed in the nylon bag, tied tightly using the nylon string which is resistant to the rumen microbes, at about 25cm to the cannula top. The nylon bag containing the sample was suspended in the rumen.

Samples were incubated at 0 hour (h), 6 h, 12 h, 18 h, 24 h, 36 h, 48 h and 72 h. Sequential removal approach (23) was used to withdraw the sample from the rumen. After removal, the bags were washed thoroughly, under running water until the effluent is clear. The washed bags and samples residues were dried in an oven at 65℃ for 48 hours. The bags was allowed to cool in a desiccator and reweighed. The DM (dry matter) disappearance (23) was calculated using the formula:

$$\text{DM disappearance (\%)} = \frac{a-b}{a} \times 100$$

Where: a = weight of sample before incubation
b = weight of sample after incubation

The rate of degradation of DM was calculated with the formula as proposed by (24).

$$Y = a + b\,(1 - e^{-ct})$$

Where: Y = degradability at time, t
a = intercept (washing losses)
b = potentially degradable fractions
c = rate of degradation of b
t = time

Proximate analysis

The proximate analyses of the formulated diets were carried out in triplicates according to the descriptions of (25) procedure. A bomb calorimeter was used to determine the energy value of the formulations.

Statistical analysis

The data obtained were analysed using the Generalised Linear Models Procedure (PROC GLM) (26) in a one-way analysis of variance. The treatment effect were tested and significant differences between treatments means was established by Duncan's Multiple Range Test. The rate of DM disappearance was analysed using the NEWAY programme developed by the Rowett Research Institute.

Result and Discussions

The proximate composition of the formulated diets (F_1-F_{10}) is shown in Table 2. There were significant differences (P<0.05) in the dry matter content of the formulated diets.

Table 2: Proximate composition of the diets (%)

P (%)	F_1	F_2	F_3	F_4	F_5	F_6	F_7	F_8	F_9	F_{10}	SEM
DM	99.68^{a}	97.40^{c}	99.70^{a}	94.90^{d}	99.80^{a}	97.70^{c}	89.60^{e}	94.60^{d}	99.64^{a}	98.90^{b}	0.24
CP	13.13^{bc}	12.69^{c}	8.31^{f}	4.37^{g}	13.48^{b}	15.80^{a}	8.45^{f}	10.59^{d}	9.45^{e}	7.96^{f}	0.23
CF	33.50^{e}	46.00^{a}	28.20^{g}	32.50^{f}	26.50^{h}	44.00^{b}	40.50^{c}	37.00^{d}	25.50^{i}	26.00^{hi}	0.28
EE	6.00^{c}	5.00^{d}	3.00^{f}	3.00^{f}	5.00^{d}	3.00^{f}	4.00^{e}	7.00^{b}	6.00^{c}	8.00^{a}	0.28
Ash	3.00^{e}	3.50^{e}	3.00^{e}	9.50^{c}	13.50^{b}	2.00^{f}	15.00^{a}	3.00^{e}	3.00^{e}	8.00^{d}	0.25
GE	12.13^{b}	12.42^{b}	12.47^{b}	12.55^{b}	12.88^{ab}	12.97^{ab}	13.01^{ab}	13.01^{ab}	13.01^{ab}	13.18^{a}	0.28

^{abc}: Means with different superscripts within a row are significantly different (P<0.05), P=Parameter, DM=Dry matter, CP=Crude protein, EE=Ether extract, CF=Crude fibre, GE= Gross energy (MJ/kg DM).

Dry matter content ranged from 89.60% to 99.80%. Highest dry matter content was observed in F_5 (99.80%) and the lowest in F_7 (89.60%). The dry matter values, obtained in this study was in line to what was reported by (27, 28 and 29) for dry matter content of crop residues as it is said to increase with maturity of the plants.

On the basis of crude protein content; there were significant difference (P<0.05) among formulated diets. Diet F_6 had the highest crude protein content (15.80%), while diet F_4 had the least protein content (4.37%). The increase in crude protein (above 7%) in the diets implied that the combination of the different feed ingredients have helped to raise the crude protein contents of some other feed ingredient of lower crude protein value. This result may increase feed intake. This was in consistence with what was reported by (30), who obtained a raise in crude protein values when groundnut shell was supplemented with agro-industrial by-products.

There were significant difference (P<0.05) between the crude fibre contents of the formulations. Crude fibre contents was highest in F_2 (46.00%), while the lowest crude fibre contents was recorded in F_9 (25.50%).

The Crude fibre content in this study was in consistence with the work of (32) who recorded a crude fibre range of 30-45% and (29) who recorded a range of 23-38%.

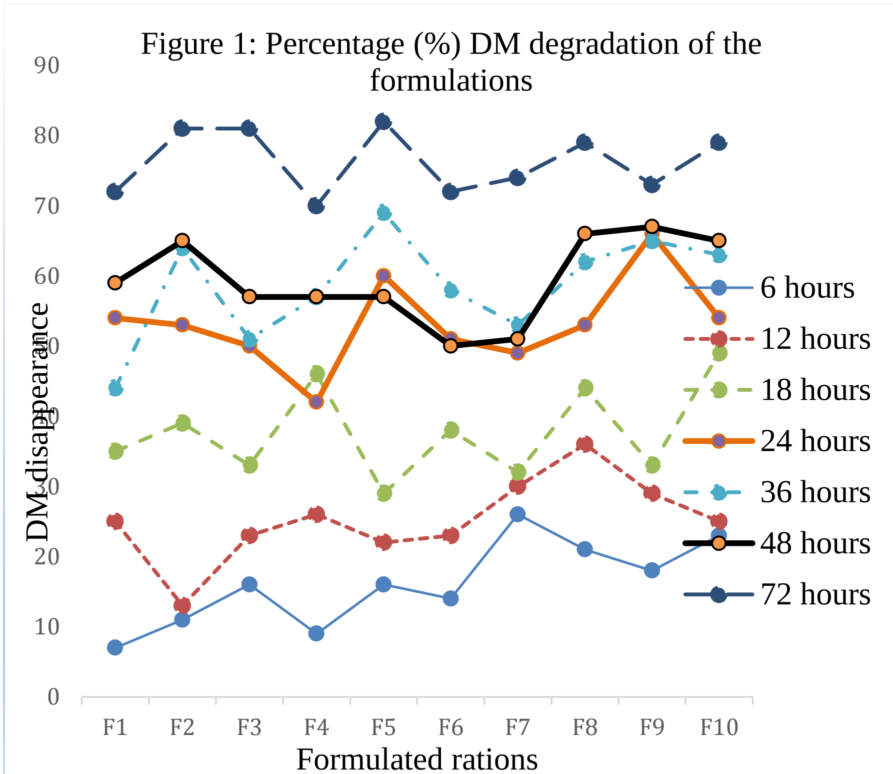
There were significant difference ($P<0.05$) in the Ether extract between the formulations. Highest ether extract values was recorded in first F_{10} (8.0%), while the lowest value was recorded in diets F3, F4 and F6 (3.0%) respectively. This result was in consistence to the work of (31) who recorded ether extract values in the range of 3.0-6.0%. On the other hand, it is in conflict with the work of (29) who reported ether extract values to range between 1.90-2.60% when crop residues were mixed to form a ration.

Ash content showed significant difference ($P<0.05$) between the formulations. Ash content was highest in diet F_7 (15%) which was little above what was reported by (29). The lowest values were recorded in diets F_6 (2.0%); the result was way below what was obtained by (29) who reported ash content ranges between 6.00%-11%.

There were significant difference ($P<0.05$) between the energy content of the various formulations. Highest energy content were recorded in F_{10} (13.18 MJ/Kg DM). This was in conflict with the findings of (29) who used similar ingredients but was in consistence with the reports of (33) and (32), who reported on the general low energy values for crop residues.

In situ dry matter (DM) degradation of formulations

Figure 1 gives the DM degradation in percentage of the formulated diets at different hours of incubation in the rumen.



After 6 hours of incubation, highest degradation percentage was recorded in F_7 (26%). The general low DM disappearance after 6hours of incubation is a confirmation of the generally how quality ascribed to crop residues (34). The highest degradation percentage recorded in F_7 may be attributed to the high content of maize offal in the diet which is highly degradable and in turn increased the diet degradation in the rumen, it served as a good source of high rumen degradable feedstuff (35). It may also be attributed to the diet fed to the bulls. The basal diet might have encouraged the growth of rumen microbes which were already in large numbers to colonise the feed in the nylon bags (3). The lowest degradability recorded in F_1 (7%) may have resulted from high cell wall contents (36) as a result of the high levels of Cowpea husks and Groundnut haulms which will require a longer time for degradation.

At 12 hours of incubation, the highest degradation percentages were obtained in F_8 (36%), while the lowest were recorded in F_2 (13%), still confirming the generally low quality of crop residues which have been reported to be of low feeding value (34; 37).

After 18 hours of incubation, the highest degradation percentages were obtained in F_{10} (49%). The relatively high DM disappearance value in this diets may be attributed to the presence of poultry litter which provided a good source of rumen degradable protein required by the microbes for protein synthesis (35).

After 24 hours of incubation, all the diets had DM disappearance values above 50%, except F_4 (42%) and F_7 (49%). These increase may be attributed to large particle loss from the nylon bags with high levels of Poultry litter and Maize bran than for those with high levels of Cowpea husks and Groundnut haulms. The Poultry litter and maize bran were highly soluble and therefore, may have yielded a relatively higher chances of degradation in the rumen (14). Also, degradation increases with longer resident time in the rumen for feed stuffs such as poultry litter and maize offal.

At 36 hours of incubation, the highest DM disappearance percentages were obtained in F_5 (69%). The low degradability ascribe to husks, hays, and haulms is in consistence with values demonstrated by F_1 (38; 39). It was reported that harvesting at different stages of growth of crop residues (40) differ in solubility and degradability and also (41) demonstrated that the degree of lignification has a negative effect on cell digestion in forages. Any of this mentioned factors above would have been responsible for the results obtained after 36hours of incubation.

The disappearance of the DM contents in the diets by the end of 48 hours of incubation is generally considered to be equivalent to digestibility (42) and being the mean retention time of fibrous feed in ruminant (37). The result revealed that F_6 had 80% dry matter disappearance. The findings of this study showed DM disappearance values for all diets after 48 hours of incubation is said to be satisfactory since they were above the prescribed 40-50% (43) to warrant further consideration as ruminant feed resources. This information provides an insight into the level of rumen undegradable DM post incubation for 48 hours.

In a larger sense, the relatively high dry matter disappearance values in these diets especially F_5, and F_9 reveals the potential of the diets being good source of nutrients for microbial growth (44).

Conclusion and Applications

From the study, it was found that

1. F_5 increased DM by 10.2%; F_6 increased CP by 11.43% and F_{10} increased GE by 1.05%. All the formulation had a DM disappearance that is above 50% at 48 hours of incubation, which warrant them to be considered as feeds for ruminants.

2. This shows that combination of two or more different feeds of protein and energy sources can yield a better result than using a single feed ingredient to feed ruminant animals.

References

1. Doma, U.D., Mohammed, L.K. and Umeh, A.P. (1999). Observation on the characteristics of small holder sheep and goat management practice in old Bauchi State. *Tropical Journal of Animal Science*, 2, 125-130.
2. Otchere, E.O., Ahmed, H.U., Adenowo, T.K., Kallah, M.S., Bawa, E.K., Olorunju, S.A.S. and Voh, A.A. (1987). Sheep and goat production in the Fulani agropastorial sector of Northern Nigeria, *World Animal Review*, 64, 50-55.
3. Ørskov, E. R. (1998): Feed Evaluation with emphasis on fibrous roughages and fluctuating supply of nutrients. A review. *Small Ruminant Research*, 28, 1-8.
4. Ørskov, E. R. (1999). How can agricultural scientist contribute to rural poverty alleviation? In: *Promoting Sustainable small scale livestock production towards reduction of malnutrition and poverty in rural and sub urban families in Nigeria*. Ørskov, E.R., Adegbola, T.A., Bogoro, S. and Butswat, I.S.R. (Eds.). Nigeria: FacE–Pam/ATBU Publications. pp 13–23.
5. Williams, T.O., Rivera, F. and Kelly, T.G. (1997). The influence of socio-economic factors on the availability and utilization of crop residues as animal feeds. In Renard, C. (Ed.). *Crop Residues in sustainable mixed crop/livestock farming system*. Wallingford: CAB international. pp 25–39.
6. Makkar, H.P.S. (2005). Application of the *in vitro* Gas method in the evaluation of feed Resources and Enhancement of Nutrition value of Tannin-Rich Tree/Browse leaves and Agro-industrial by–products. Animal production and Health section, International Atomic Energy Agency, Vienna.
7. Tchinda, B., Wegad, D. and Njwe, R.M. (1993). Rumen degradation of elephant grass supplemented with graded levels of perennial peanut by West African Dwarf sheep. In: Lebbie S.H.B., Rey, B. and Irungu, E.K. (Eds). Small ruminant's research and development in Africa. *Proceedings of the second biennial conference of the Africa small ruminant research network AICC Amsha, Tanzania*, 7-11th December, 1992. ILCA, Addis Abba, Ethiopia, PP: 187-190.
8. Okojie, J.A. (1999). The role of government and universities of Agriculture in improving animal production and consumption, in Nigeria. *Tropical Journal of Animal Science*, 2, 1-7.
9. Kibon, A. and Ørskor, E.R. (1993). The use of degradation characteristics of browse plant to predict intake and digestibility of goats. *Journal of Animal production*, 57, 247-251.
10. ILCA (International Livestock Centre for Africa), (1979). *Small ruminant production in the humid tropics, Systems study 3*, ILCA, Addis Ababa, Ethiopia. pp 35.
11. Upton, M. (1988). Goat production in the humid tropics, actual and potential contribution to agricultural development. In: Goat production in the humid tropics. Smith, O.B. and Bosman, H.G. (Eds.). *Proceedings of a workshop at the University of Ife, Ile-Ife, Nigeria,* 20-24 July 1987. pp 11-20.
12. Tuah, A.K., Ørskov, E.R., Obese, F.T., Okai, D.B. and Greenhalgh, J.F.D. (1993). The Effect of supplementation of cassava peal (CP) diets with grade levels

of Palm Kernel Cake (PKC) on the performance of growing Djallonke sheep. In: Small ruminant's research and development in Africa. In: Lebbie S. H. B., Rey, B. and Irungu, E.K. (Eds.). *Proceedings of the second biennial conference of the Africa small ruminant research network AICC, Amsha, Tanzania,* 7-11 December, 1992 ILCA, Addis Abba, Ethiopia. pp 163-167.

13. Smith, O.B., Idowu, O.A., Asaolu, V.O. and Odunlami, O. (1991). Comparative rumen degradability of forages, browse, crop residues and agricultural by–products. *Livestock Research for Rural Development*, 3(2), 1-5.
14. Ikhimioya, O.A. Isah, U.J. and Bamikole, M.A. (2005). Rumen Degradability of Dry Matter and Crude Protein in Tree Leaves and Crop Residues of Humid Nigeria. *Pakistan Journal of Nutrition,* 4(5), 313-320.
15. Bogoro, S.E.B. (1997). *Effect of protein energy supplementation on rumen kinetics, metabolite profile and growth performance of rams fed high fibre diets*. Ph. D. Thesis Abubakar Tafawa Balewa University, Bauchi, Nigeria.
16. Umunna, N.N., Nsahlai, I.V. and Osuji, P.O. (1995). Degradability of forage protein supplement and their effect on the kinetics of digestion and passage. *Small Ruminant Research,* 17, 145–152.
17. Orden, E.A., Yamaki, K., Ichinohe, T., and Fujihara, T. (2000). Feeding Value of Ammoniated Rice Straw Suplimented with Rice Bran in Sheep: II. In Situ Rumen Degradation of Untreated and Ammonia Treated Rice Straw. *Asian-Australasian Journal of Animal Sciences*, *13*(7), 906–912.
18. Metrological Station (2017). *Annual Weather Report for Maiduguri Climate*. Department of Geography, University of Maiduguri, Nigeria.
19. Kellou, K.M. (2005). *Developments of Multinutrient Blocks for dry season supplementary feeding of sheep in a semi-arid Environment.* M. Sc Thesis, University of Maiduguri, Nigeria. pp 23-38.
20. Mohammed, I.D. (2006). *ANS 304: Animal Feeds and Feeding*. Lecture notes. Department of Animal Science, University of Maiduguri, Nigeria.
21. Chestworth, J. (1992). *The Tropical Agriculturist: Ruminant Nutrition*. Coste, R. (ed) (page 103-104). London: CTA/Macmillan.
22. Ago, Y.A. (2013). The Problem of Livestock Production Is Feeding. *AGRONIGERIA*, *Daily Trust*, p. 2. Abuja. Retrieved from http://agronigeria.com.ng/2013/09/12/the-problem-of-livestock-production-is-feeding/
23. Osuji, P.O., Nsahlai, I.V, and Khalili, H. (1993). *Feed Evaluation* (ILCA manual). Addis Ababa, Ethiopia: ILCA (International Livestock Centre for Africa).
24. Ørskov, E.R. and McDonald, I. (1979). The estimation of protein degradability in the rumen from incubation measurement weighted according to rate of passage. *Journal of Agriculture Science Cambridge*, 92, 499-503.
25. AOAC, (Association Of Analytical Chemist). (2005). *Official Method of Analysis* (17th ed.). Maryland, USA: AOAC International.
26. SAS, (Statistical Analysis Systems). (2002). *Software package*. North Carolina, USA: Statistical Analysis Systems Institute, Cary.
27. Ehoche, O.W., Theresa, Y.M., Bavanendra, V. and Adu I.T. (1983). The nutritive value of farm treated cotton seed cake for growing lambs.

Journal of Animal Production Resource 3(1), 15–25.

28. Dibal, D.B., (1991). *Chemical Composition and feeding values of some browse plants in the semi-arid region of North–Eastern Nigeria.* M.Sc. thesis, Department of Animal Science, University of Maiduguri, Nigeria.
29. Addass, P.A., Nyako, H.D., Agga, D.P., Mohammed, I.D., Midau, A., Fintan, J.S. and Ja'afar-Furo M.R., (2011). Nutrients evaluation of some common feed resources for cost effective feeding of ruminants in Mubi, Nigeria. *Agricultural and Biology Journal of Northern America.*
30. Millam, J.J., Abdu, S.B., Bube, M.M., Bello, S.S. Samuel, I. John, P.A. and Yakubu, L.R. (2017). Evaluation of urea and lime treated groundnut shells in mixed rations on intake and digestibility of *Yankasa* rams. *Journal of Animal Production Research,* 29(2), 119-128.
31. Mohammed, I.D., Baulube, M. and Adeyinka, I.A. (2001). Multi–nutrient Block 1: Formulation and production under a semi–arid Environment of north East Nigeria. *Journal of Biological Science*, 7(2), 389–392.
32. Millam, J.J. (2016). *Effects of Urea and Lime Treated Groundnut Shell in Mixed Diets on Nutrient Intake and In Situ Degradation in Yankasa Rams*. M. Sc Disseration. Department of Animal Science, Ahmadu Bello University.
33. Akinfemi, A., Adua, M.M., and Adu, O.A. (2012). Evaluation of nutritive values of tropical feed sources and by-products using in vitro gas production technique in ruminant animals. *Emirate Journal of Food and Agriculture, 24*(4), 348–353.
34. Preston, T.R., and Leng, R.A. (1987). *Matching Ruminant production system with Available Resources in the tropics and subtropics*. Arnidale NSW, Australia: Penambul Books Ltd.
35. Madsen J. and Hvelplund T. (1988).The influence of different protein supply and feeding level on pH, ammonia concentration and microbial protein synthesis in the rumen. *Acta Agricultural Scandinavica,* 38, 115-125.
36. Van Soest, P.J. (1988). Effect of Environment and quality of fibre on the nutritive value of crop residues. In: Plant Breeding and the nutritive value of crop residues. In: Reed, J.D., Capper, B.S., and Neate, P.J.H. (Eds.). *Proceedings of a workshop held at international Livestock Centre for Africa, Addis Ababa, Ethiopia* 7th – 10th December, 1987. pp 71–96.
37. Kimambo, A.E., Weisbjerg, M.R., Hvelplund, T. and Madsen, J. (1994). Feeding value of some tropical feeds evaluated by nylon bag technique. In: *Proceedings of a Workshop on Integrated Livestock/Crop Production Systems in Small Scale and Communal Farming Systems in Zimbabwe.* UZ/RVAU/NIAS Publication. pp 58-68.
38. Kamande G.M. (1988). *Forage and concentrate protein utilization by dairy cattle.* M. Sc Thesis. University of British Columbia, Vancouver, BC, Canada. pp 113.
39. Rutagwenda, T. (1989). *Adaptation of sheep and goats to seasonal changes of forage on a semi-arid thornbush savannah pasture in northern Kenya.* Ph D. Thesis. Tierärztliche Hochschukle, Hanover, FR Germany. 131 pp.
40. Abate, A. and Kiflewahid, B. (1999): Use of the nylon-bag technique in determining the complementarity of feedstuffs for dairy cattle rations. *East African Agricultural and Forestry Journal,* 45, 255-260.

41. Van Soest P.J. (1982). *Nutritional ecology of the ruminant.* Oregon, USA: O & B Books. pp 374.
42. Ehargava, P.K. and Ørskov, E.R. (1987). *Manual for the use of nylon bag technique in the evaluation of feedstuff: Feed Evaluation and Experimentation Development Services.* The Rowett Research Institute, Bucksburn, Aberdeen, Scotland.
43. Preston, T.R., (1986). *Better utilization of crop residues and by-products in animal feeding: Research Guideline 2. A practical manual for research workers.* Addis Ababa, Ethiopia: ILCA, Pp 44.
44. Djouvinov, D.S. and Todorov, N.A. (1994). Influence of dry matter intake and passage rate on microbial protein synthesis in the rumen of sheep and its estimation by Cannulation and a non-invasive method. *Animal Feed Science and Technology*, 48, 289-304.