Nigerian J. Anim, Sci. 2024, 26 (1): 67-74

Nutritive value and in-situ rumen degradation of selected livestock feeds

[1]*Chana Z. M., [2]Abubakar, M., [1]Kolo U. M., [3]Yakubu A. K. and [1]Abubakar. A.D.

[1]Department of Animal Science, Faculty of Agriculture, University of Maiduguri, P.M.B 1069, Maiduguri, Borno State, Nigeria.
[2]Department of Animal Production, Faculty of Agriculture and Agricultural Technology, Abubakar Tafawa Balewa University, P.M.B. 0248, Bauchi State, Nigeria
[3]Department of Animal Science, Faculty of Agriculture, Modibbo Adama University, P.M.B. 2076, Yola, Adamawa State, Nigeria

Correspondence author: *zuwairachana@gmail.com, 07037298119*

Target audience: *Livestock farmers, Ruminant nutritionists and Extension agent*

Abstract

A study was conducted to evaluate the nutritive value and in situ ruminal degradation of maize bran (MB), cotton seed cake (CSC), sorghum pinnacle (SP) and poultry litter (PL) using three pistulated rams. The rumen degradability of these feedstuffs were studied at 0, 3, 6, 12, 24, 48, 72 and 96 hours incubation periods using the equation Y = a + b (1 – e-ct). The results of the chemical composition of these feedstuffs were at a higher nutrient profile especially CSC and PL. The dry matter losses from the nylon bags of the various feedstuffs were significantly (P<0.05) different across them and major losses occurred between 12 to 72 hours incubation time. There was a significant (P<0.05) difference in degradability characteristics across the various feedstuffs. Solubility (a) of the dry matter ranged from 28.02% for SP to 42.05% for PL. The amount of dry matter degraded in the rumen with time (b) is highest for PL (55.67%) and lowest in SP (25.07%). While the degradation rate (c) ranged from 0.003/h for SP to 0.021/h for PL and potential degradability was 85.78, 97.98, 53.09 and 97.72% for MB, CSC, SP and PL respectively and was the reflection of their nutritive value. The effective rumen degradability of these various feedstuffs were significantly (P<0.05) different between the treatment groups and at each outflow rate. An increase in the outflow rate from 0.02 to 0.08/h led to corresponding decrease in the degradability of the various feedstuffs. It was concluded that effective degradability of poultry litter, cotton seed cake and maize bran were exceptional at all the four outflow rates used, hence confirms the superiority of these feeds over sorghum pinnacle.

Key words: Nutritive value, in situ rumen degradation and some animal feedstuffs.

Description of Problem

Conventional animal feedstuffs like cotton seed cake (CSC) are known to supply both rumen degradable protein (RDP) and undegradable protein (UDP) with values of 27.4% and 18.3% respectively as well as 45.7% crude protein (Chesworth, 1992). However, most available concentrates are not economical for feeding ruminants in the tropics due to high cost occasioned by competitive uses from man and monogastric animals (Abubakar et al., 2010). Although, attention has turned to using less expensive crop residues and agro-industrial by-products as ruminant animals have the potential to use them. Consequently, research efforts in recent times have been geared towards the identification and determination of the nutritive value of crop residues and agricultural by-products, with the hope of expanding the scope of available feed resources in this regard for ruminants. Those studied include maize stover (Adebowale, 1985), brewers dried grains (Ibeawuchi and Akinsoyinu, 1989), cocoa dust (Aregheore, 1995), rice straw (Adegbola, 2002) and by-products of palm fruits (Musibau, et al., 2008) among others. Agricultural by-products such as maize offal, groundnut haulms, poultry house wastes, sorghum and millet pinnacles are commonly used in ruminant feeding systems to supply both protein and energy to the animals. They are increasingly important as they are available at competitive prices relative to other commodities (Grassers et al., 1995).

Ruminal degradability is an important measurement to consider when determining the nutritive value of any feed (Kendall et al., 1991). For many by-product feeds, there is insufficient information available regarding the effect of sample of feed used on rumen degradability values and little research has characterized individual by-product feed (De Peters et al., 1997). Furthermore, utilization of different feedstuffs by ruminants is largely dependent upon microbial degradation within the rumen. Therefore, the degradation characteristics would provide a useful guide for ranking on the basis of nutritive value. The current study was aimed to determine the nutrient composition and in situ (nylon bag) rumen degradation of some animal feed commonly used for ruminant animals.

Materials and Method

Study Area

The experiment was conducted at the Livestock Teaching and Research Farm University of Maiduguri. Maiduguri is situated at latitude 110 51lN and longitude 130 09lE at an altitude of 354 m above sea level (Encarta, 2007), which falls within the semi-arid zone of West Africa. The area is characterized by short period of rainy season (3-4 months) from June to September with annual rainfall ranging from 500 to 600 mm and a long period of dry season usually 8 to 9 months (October to May). Ambient temperatures are high (38-440C) in the months of March to May whereas low temperatures are recorded in December and January ranging from 15-190C (Weather and climate, 2016). Relative humidity is low in the month of March (30%) and high in the month of August (80%).

Experimental Materials

The experimental feedstuffs were maize bran, cotton seed cake, sorghum pinnacle and poultry litter.

Nylon Bag Procedure

Three (3) ruminally pistulated Balami rams weighing averagely 39kg were used for the in situ in sacco rumen degradation studies. They were cannulated at the University of Maiduguri Veterinary Teaching Hospital under the care and supervision of Veterinarians. The cannulated rams were fully healed and recovered 4 weeks after the operation. They were carried to the research area (University of Maiduguri Livestock Teaching and Research Farm) and allowed 14 days adjustment period prior to the commencement of the research. The rams were housed in a well-ventilated pens, pegged separately with a considerable distance on the flour. This is to avoid clash and rubbing their sides on the wall to prevent rupture of the stitched area. The cannulated areas were disinfected daily to prevent infection. Multi-action skin spray (Charmil) was always sprayed to repel houseflies and heal the wound. Each cannulated ram serves as replicate and were all fed with similar concentrate diet to have similar rumen condition so as to avoid bias. They also had access to clean drinking water and mineral supplement block.

Nylon bags with approximately 5cm by 10cm and 41µm pore size (ANKOM Technology) were used. They were oven dried at 650C for 30 minutes, allowed to cool and weighed. The selected feed materials (maize bran, cotton seed cake, sorghum pinnacle and poultry litter) were dried at 650C for 24 hours and milled. Three (3) grams of the dried feed samples were placed in each of the nylon bags, tied using a nylon string and incubated in triplicate. The nylon bags containing the sample were anchored into the rumens of the cannulated rams immediately after morning feeding. Samples were incubated at 0, 3, 6, 12, 24, 48, 72 and 96 hours. However, all bags were placed at the same time and removed as required. The 0 hour time represented the bags which were not incubated in the rumen of the animals, but were treated in the same manner as other bags that were incubated. Sequential removal was used to withdraw the sample bags from the rumen after incubation. Bags were washed thoroughly under running tap water until all effluent were cleared and sample residues were dried at 650C for 48 hours to constant weight to determine the undegraded dry matter content of the incubated samples and were allowed to cool in a desiccator and reweighed.

Determination of particle loss from nylon bags

Particle loss from the nylon bags were measured according to Orskov and McDonald (1979). The differences between the amount of DM in the original sample and that remaining on the filter after the test was expressed as a percentage of the initial sample as a measure of fraction of DM that was truly water soluble. According to Woods et al. (2002) particle loss was calculated as the difference between the fraction of feed lost through pores during washing and the truly water soluble fraction.

DM Disappearance (%) = a-b/a×100

Where:

a = weight of sample before incubation (zero time intercept)

b = weight of sample after incubation

The rate of DM degradation was calculated by fitting values to the exponential equation of Orskov and McDonald, (1979).

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

Where:

Y = degradability at time t

a = intercept (washing losses at zero time intercept)
b = potentially degradable fraction with time t
c = constant rate for degradation of b
t = time (0, 3, 6, 12, 24, 48, 72 and 96 hours)

The effective DM degradability of the feedstuffs based on the different ruminal outflow rates was calculated (Orskov, 1992) using the equation:

$ED = a + bc/c + k$

With an assume outflow rates of (k) at 0.02, 0.04, 0.06, 0.08/h.

Where:

ED = Effective degradability

a, b and c being constants from the equation above

k = fractional outflow rate

Chemical analysis

The Dry Matter (DM) content of the samples (before and after incubation) was determined by oven-drying for 48 hours. Ash was measured by igniting the samples in a muffle furnace at 5000C for 4 hours. Nitrogen (N x 6.25, or crude protein) content was determined by the automated Kjeldahl method AOAC (2000). The neutral detergent fibre (NDF) and acid detergent fibre (ADF) were determined by the method described by Van Soest (1991). Ether extract was determined using the soxhlet extraction technique.

Data Analysis

The data were subjected to analysis of variance (statitixs 10) in a randomized complete block design. The rate of Dry Matter disappearance were analyzed using Neway programme developed by the Rowett Research Institute (Orskov and McDonald, 1979). Potential and effective degradation were computed using non-linear regression analysis SPSS (version 23) package and means were separated using Least Significant Difference (LSD).

Results and Discussion

The chemical composition (%) of the feed materials (maize bran, cotton seed cake, sorghum pinacle and poultry litter) before incubation is presented in Table 1. They were at higher nutrient profile especially organic matter and crude protein. The values of CP observed in this study for CSC (35%) was higher as compared to (30.93%) reported by Abubakar et al. (2010) but they recorded higher CP (22.26%) in poultry litters as equated with the current work. Maize bran CP was in agreement with the report by Abubakar et al. (2010) but higher than 7.60% for guinea corn reported by Malau-Aduli et al. (2003). It was generally observed that the chemical composition of most of the feedstuffs were higher than the conventional feeds like groundnut shells (CP 5.90%; CF 31,80%; ASH 8.50%) cowpea (CP 7.10%; CF 33.40%; Ash 7.15%) and guinea corn bran (CP 7.60%; CF 24.80%; Ash 6.95%) as reported by Malau-Aduli et al. (2003). The NDF contents of MB (40.51%), CSC (34.52%), SP (48.88%), and PL (44.57%) in this work were below the reported value of 55 to 60% that can limit feed intake (Meissner et al., 1991).

Table 1: Chemical composition (%) of various feedstuffs before incubation

Parameters	DM	OM	CP	ASH	EE	NDF	ADF	NFE
MB	91.76	90.34	09.14	01.42	03.06	40.51	25.51	64.51
CSC	94.24	88.75	35.24	05.49	10.39	34.52	17.20	34.60
SP	92.68	85.41	05.39	07.27	04.01	48.88	37.14	45.63
PL	93.16	79.71	17.61	13.45	10.56	44.57	31.16	27.71

DM = Dry Matter, OM = Organic Matter, CP = Crude Protein, EE = Ether Extract, ADF = Acid Detergent Fibre, NDF = Neutral Detergent Fibre, NFE = Nitrogen Free Extract, MB = Maize Bran, CSC = Cotton Seed Cake, SP = Sorghum Pinnacle, PL = Poultry Litter.

The mean DM disappearance was presented in Table 2. Significant ($P<0.05$) difference was observed among the different feedstuffs. However, degradability percentage of more than 40% was recorded at 12 hours in all the feedstuffs except sorghum pinnacle. The dry matter losses from the nylon bag after incubation of the various feedstuffs with the constants of the fitted exponential equations occurred between 12 to 76 hours with a variation among the different feed ingredients. It was so because the ingredients were of different particle size, texture and solubility. The various feedstuffs were ranked in decreasing order as: PL> CSC >MB >SP which was a reflection of their nutritive value. The extend of degradation after 48 hours of incubation was good for three (maize bran, cotton seed cake and poultry litter) of the feedstuffs as it was above 50%, this implies good digestibility potential for these feedstuffs when harnessed as feed resources for ruminant livestock as 48 hours degradability is often considered to be equivalent to digestibility (Bhargava and Orskov, 1987). Although, sorghum pinnacle was less than 50%, this was probably as a result of high cell wall content (Bogoro et al., 2006).

Table 2: DM Disappearance (%) of Various Feedstuffs

Incubation Periods (hrs)	**Maize Bran**	**Cottons Seed Cake**	**Sorghum Pinnacle**	**Poultry litters**	**SEM**	**LS**
0	32.00^{a}	35.67^{a}	14.78^{b}	33.45^{a}	3.86	*
3	36.00^{a}	39.78^{a}	28.67^{b}	40.76^{a}	2.43	*
6	38.22^{b}	41.89^{ab}	33.11^{c}	45.23^{a}	1.83	*
12	46.78^{a}	44.44^{a}	38.00^{b}	50.15^{a}	1.96	*
24	47.89^{ab}	48.11^{ab}	42.67^{b}	57.46^{a}	2.70	*
48	60.33^{ab}	53.11^{ab}	45.11^{b}	66.14^{a}	3.98	*
72	65.56^{a}	56.00^{b}	50.89^{b}	71.04^{a}	2.47	*
96	73.11^{a}	63.89^{b}	53.22^{c}	78.75^{a}	3.62	*

SEM = Standard Error of Mean, LS = Level of Significance, * = Significant ($P<0.05$), a,b,c,d = Means in the same row with different superscripts are significantly different, hrs= Hours.

The DM characteristic of each of the various ingredient with the constants of the fitted exponential equations are shown in Table 3. There was significant (P<0.05) difference in potential degradability across the feedstuffs. Solubility (a) of the dry matter ranged from 28.02% for SP to 42.05% for PL. The amount of dry matter degraded in the rumen with time (b) is highest for PL (55.67%) and lowest in SP (25.07%). While the degradation rate (c) ranged from 0.003/h for SP to 0.021/h for PL.

Table 3: DM Degradation Characteristics (%) of the Feed Ingredients

Parameter	Maize Bran	Cotton Seed Cake	Sorghum Pinnacle	Poultry litter	SEM	LS
A	35.68[b]	40.14[a]	28.02[c]	42.05[a]	1.10	*
B	50.10[b]	57.84[a]	25.07[c]	55.67[a]	1.87	*
C	00.01[b]	00.01[b]	00.003[c]	0.021[a]	2.94	*
PD (a+b)	85.78[b]	97.98[a]	53.09[c]	97.72[a]	2.97	*

a = Washing Loss, b = Rumen Degradable Fraction, c = Degradable Constant Rate, a+b = Potential Degradability, K= Fractional Outflow Rate from the Rumen at Retention Time of 0.02, 0.03, 0.06 and 0.08/h, SEM= Standard Error of Mean, LS= Level of Significance, *= (P<0.05), a,b,c,d = Means in the same row with different superscript are significantly different.

The effects of outflow rate on effective rumen degradability of the various feedstuffs is presented in Table 4. The feedstuffs were significantly (P<0.05) varied between the treatment groups and higher at 0.02/h with poultry litter having the highest value and sorghum pinnacle the least. An increase in the outflow rate from 0.02 to 0.08/h led to corresponding decrease in the degradability of the various feedstuffs. The (a) fraction and constant rate for the degradation of (b) in the current study has influenced on the effective degradability. This observation agrees with the report of Orskov (1985) that effective rate of degradation depends on solubility, rate at which feed fraction is degraded and outflow rate of small particles. The effective degradability of poultry litters, cotton seed cake and maize bran were exceptional at all the four outflow rates used, hence confirms the superiority of these feeds over sorghum pinnacle. Adjorlolo et al. (2001) reported that effective degradability is a better index of feed quality. Therefore, all the feed ingredients of the current study can be judged to have good potential as feed resources for ruminant animals and could be used directly in ruminant feeding as protein and energy sources.

Table 4: Effective DM Degradation (%) of Various Feed Ingredients

Parameter	Maize Bran	Cotton Seed Cake	Sorghum Pinnacle	Poultry litter	SEM	LS
K(0.02)	51.69[b]	56.26[b]	43.51[b]	67.54[a]	6.14	*
K(0.04)	51.58[b]	48.40[b]	41.04[b]	65.65[a]	6.35	*
K(0.06)	46.61[b]	45.41[b]	37.89[b]	61.43[a]	6.22	*
K(0.08)	43.12[b]	43.55[b]	35.27[b]	58.24[a]	5.73	*

MB = Maize Bran, CSC = Cotton Seed Cake, SP= Sorghum Pinnacle, SUPP = Supplement, a = Washing Loss, [b] = Rumen Degradable Fraction, [c] = Degradable Constant Rate, [a+b] = Potential Degradability, K= Fractional Outflow Rate from the Rumen at Retention Time of 0.02, 0.04, 0.06 and 0.08/h, SEM= Standard Error of Mean, LS= Level of Significance, *= ($P<0.05$), a,b,c,d = Means in the same row with different superscript are significantly different.

Conclusion

The results of the present study showed that the nutrient content and rumen degradation of the feedstuffs used have the capacity to support ruminant animal production. However, the high rate of effective degradability observed for poultry litter and cotton seed cake indicate that they should not be used solely to ruminants but as supplement to improved productivity.

References

Abubakar, M., Adegbola, T.A., Abubakar M.M., Shehu Y., Ngele M.B. and Kalla D.J.U. (2010). Nutritional evaluation of different sources of nitrogen on digestible nutrient intake, nitrogen balance and production of rumen metabolites in growing Yankasa sheep. Emirate Journal of Food and Agriculture. 22(4):298-307.

Adebowale, E.A. (1985).The response of sheep and goats fed maize straw treated with local alkali. Nigerian Journal of Animal Production. 12:137-140.

Adegbola, T.A. (2002). Nutrient intake digestibility and rumen metabolites in bulls fed rice straw with or without supplements. Nigerian Journal of Animal Production. 29(2):40-46.

Adjorlolo, L.K., Amaning-Kwarteng, K., and Fianu, F.K. (2001). In vivo digestibility and effect of supplemental mucuna forage on treated rice straw degradation. Small Ruminant Research, 41: 239-245.

AOAC, (2000). Official Methods of analysis. 17th edition. Association of official Analytical Chemists, Washington. DC. USA.

Aregheore, E.M. (1995). Effect of sex on growth rate, voluntary feed intake and nutrient digestibility of West African Dwarf sheep fed crop residues rations. Small Ruminant Research. 15:217-221.

Bhargava, P.K. and Orskov, 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. 1-20.

Bogoro, S., Manchop, C. and Kalla, D.J.U. (2006). Effects of quality of diets on the in sacco, in vivo rumen degradability of cotton seed cake and soyabean stover. Journal of Arid Agriculture. 16: 121-128.

Chesworth, J. (1992). Ruminant

Nutrition. Macmillan Press, China. 170.

De Peters, E.J., Fadel, J.G. and Arosemena, A. (1997). Digestion kinetics of neutral detergent fibre and chemical composition within some selected by-products feedstuffs. Animal Feed Science and Technology, 67: 127-140.

Encarta, (2007). National Geospatial-Intelligence Agency, Bethesda, MD, USA.

Grasser, L.A., Fadel, J.G., Garnett,I. and De Peters, E.J. (1995). Quantity and economic importance of nine selected by-products used in California dairy rations. Journal of Dairy Science. 78: 962-971.

Ibeawuchi, J.A. and Akinsoyinu, A.O. (1989). Influence of brewers dried grains on the ruminal volatile fatty acids (VFA) production and milk constituents in Zebu cows. Nigerian Journal of Animal Production, 16: 1-7.

Kendall, E.M., Ingalls, J.R. and Boila, R.J (1991). Variability in the rumen degradability and post-ruminal digestion of dry matter, nitrogen and amino acids of canola meal. Can. Journal of Animal Science, 71: 739-754.

Malau-Aduli, B.S., Eduvie, L.O., Lakpini, C.A.M. and Malau-Aduli, A.E.O. (2003). Variations in livestock gains, milk yield and composition of red Sokoto goats fed crop-residue-based supplement in the sub humid zone of Nigeria. Livestock Production Science, 83: 63-71.

Meissner, H.H., Koster, H.H., Nieuwoudi, S.H. and Coertze, R.J. (1991). Effect of energy supplementation on the intake and digestion of early and mid-season ryegrass and Panicum/Smuts finger hay and on in sacco disappearance of various forage species. South African Journal of Animal Science. 21:33-42.

Musibau, A.B. and Olaniyi, J.B. (2008). Chemical composition and in sacco dry matter degradability of residue and by-products of palm fruit processing in the rumen of steers. Animal Science Journal, 79: 314-321.

Orskov, E.R. (1985). Supplementation of low quality roughage diet for optimal microbial and host animal nutrition. In: El-shazly, K. (Edition). Use of Agricultural by-products in developing countries. University of Alexandria, Egypt. 128.

Orskov, E.R. (1992). Protein Nutrition in Ruminants. Academic press Ltd, London. 2nd edition. United Kingdom. 31-85.

Orskov, E.R. and MacDonald, I. (1979). The estimation of protein degradability in the rumen from incubated measurements weighted according to the rate of passage. Journal of Agriculture Science Cambridge, 92(2): 499-503.

Van Soest, P.J. Robertson, J.B. and Lewis, B.A. (1991). Methods for dietary fiber, neutral detergent fiber and non-starch polysaccharides in relation to animal nutrition. Journal of Dairy Science. 74: 3583-3597.

Weather and climate (2016). www.weatherandclimate.com. Accessed 6/06/2018.

Woods, V.B., O'Mara, F.P., Moloney, A.P. (2002). The in situ ruminal degradability of concentrate feedstuffs in steers as affected by level of feed consumption and ratio of grass silage to concentrate. Animal Feed Science and Technology, 100: 15-30.