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Development of Dry Season Supplements for Ruminants and Their Degradation Characteristics in the Semi Arid of Nigeria

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ABSTRACT

This experiment was conducted to develop dry season supplement for ruminants and their degradation characteristics. Ten (10) different rations were formulated, F1, F2, F3, F4, F5, F6, F7, F8, F9, and F10 using a mixture of different locally available feed ingredients with different inclusion levels which includes sorghum husk, maize bran, wheat offal, millet bran, rice bran, bran (dusa), cowpea husk (as energy source), cotton seed cake, groundnut haulms and poultry litter (as protein source). Rumen degradation of the formulations revealed that at 6, 12 and 18 hours, F9 and F10 recorded significantly higher degradability with no statistical difference in degradability amongst F1 through to F8. At 48 hours of incubation period The % DM degradation for all the formulations is not significantly different which ranged from 76.50% - 79.84% DM while at 72hours it ranges between 78.84% - 83.67% DM degradability. The cost of production from this analysis showed that highest production cost was (₦6100) equivalent to $39.35 while least production cost was (₦2710) equivalent to $17.48. 20% inclusion level of poultry litter in ruminant ration will result in a significant increase in rumen DM degradation by stimulating activities of rumen microbes' thereby increasing digestibility of crop-residues which are mostly fibrous in nature.

Keywords: Degradation Characteristics, Dry Season, Ruminants, Supplements, Semi Arid.

INTRODUCTION

Nutrition plays a major role in the productive performance of ruminants. This is important among animals managed on ranges, since quantity and quality of herbage in the tropics is determined by the seasonal pattern of rainfall (Fialho *et al.*, 1995). The forages available are seasonal in supply, available during the rainy season which last between June to September. Animals that depend on natural vegetation for their nutrition suffer heavy losses during the dry season which coincides with the productive performance (Deaville *et al.*, 1994). Most of the crop residue used for grazing during the dry season is low in digestibility and nitrogen content for maintenance and growth (Miller *et al.*, 1984) and these feed resources are characterized by low digestibility, energy, crude protein and poor availability of minerals and vitamins (Prasad *et al.*, 2001; Nagpal and Arora, 2002). Animal performance with such feedstuffs can be poor due to low voluntary intake and digestibility, which result from low protein concentrations and high levels of indigestible or slowly degradable fiber (Prasad *et al.*, 1998). The problem of dry season livestock feeding in particular has directed research efforts towards harnessing and enhancing the utilization of abundant arable by-products and crop residues. The abundance of crop residue makes them cheap sources of nutrients for ruminants. Although they are generally low in nutrients (Nicholson, 1984) various strategies have been adopted in improving their nutrients and utilization in ruminant rations, though judicious supplementation to supply the most limiting nutrients (Preston, 1987; Alhassan 1988). Balancing the nutrient that provides the major building blocks for tissue synthesis and milk production should be the primary concern of the nutritionist. This can be achieved by blending of crops residues to meet the nutrient requirement of the ruminant (Leng, 1990).

The advances made in the last century in understanding the principles of ruminant nutrition have led to the production of feeding systems and models describing the nutrient need of different classes of ruminants, cattle, sheep and goat, and theses systems have direct application with animals maintained in barns and feedlots. In these situations, it is possible to compute production responses to be expected from the supply of a given amount of feed of known quality and hence to formulate least cost rations to achieve an optimum production target (Bheekhee *et. al.*, 2002). In Nigeria, the smallholder farmers have limited resources available for feeding to their ruminant livestock. They are unable to select the basal diet according to the requirement whatever is available at no or low cost. Therefore, the strategy for improving production should be to optimise the efficiency of utilization of the available feed resources and thereby attempt to maximise annual production (Jackson, 1980). During the rainy season in the tropics, the crude product content of grasses is about 7%, however the grasses rapidly become matured and the crude protein content drops drastically to about 4.6% after 3-5 months. The crude protein drops below 4% and in late part of the dry season, values of 1-2% has been reported (Soca *et al.*, 1991). Most tropical grasses during the dry season are characterized by low intake and digestibility and their growth and development pattern include rapid rise in lignin content as they grow and a decline in digestibility as maturity approaches, making it difficult to supply consistently high quality feeds needed by ruminant animals for optimum growth, production, reproduction and maintenance (Shelton, 2004). The low nitrogen and mineral contents of the crop residues as well as their high lignin and silica contents are considered the major reason for their low digestibility and consequently low productivity of the animals (Van Soest, 1992; Sundsol *et al.*, 1999; Smith *et al.*, 2005). Therefore, the objective of this study is formulating least cost rations using locally available feed ingredients that contain necessary nutrient required by ruminants.

MATERIALS AND METHODS

This experiment was carried out at the Livestock unit of the University of Maiduguri Teaching Research Farm, Maiduguri, Borno State. The area falls within the Sahel (semi-arid) region of West Africa, which is noted for its great climate and seasonal variation. It has very short period (3-4 months) of rainfall giving 645.9mm/annum with a long dry period/season of about 8-9 months. Relative humidity is 45% in August which usually lowers to about 5% in April and May.

Samples used include sorghum husk, Maize bran, Wheat offal, Millet bran, Rice bran, Bran (Dusa), Groundnut haulms, cowpea husk, Cotton seed cake and poultry litter, which were all purchased from the Maiduguri cattle market except poultry litter which was obtained from the poultry production unit of the University of Maiduguri Teaching and Research Farm. All the other ingredients were crushed using pistle and mortar for uniform and proper mixing during formulation. Ten Rations were formulated using the principal guide 60/40 energy to protein ratio as suggested by Mohammed *et. al.,* (2007) The poultry litter is properly stored after sun drying in order to destroy some pathogenic microorganisms like E. coli and salmonella as suggested by (Mohammed *et al.,* 2007).

Rumen Degradation Study

The rumen degradation was conducted at the University of Maiduguri Livestock Teaching and Research Farm on a healthy bull fitted with permanent rumen cannula of 40mm diameter. The bull was fed cowpea husk continuously as basal diet supplemented with 500g/day of mixture of maize bran, cotton seed cake using ration 60:40 of energy to protein. The materials used during the experiment (cannulation) are nylon bags (labelled with permanent marker for identification) 80mm×20mm and pore size 0.052mm, forceps, cotton wool, Dettol and thread (string). 3g of each formulation was put into the nylon bags, incubated in duplicate in the rumen of the bull for 6,12,18,24,36,48 and 72 hours. Bags were withdrawn by method of sequential addition Osuji *et al.,* (2000). The bags containing undigested residues were removed from the rumen after each incubation period and washed thoroughly in running tap water until the washing water is clear. The bags with the contents were dried in an oven at 60 °C for 48 hours to constant weight to determine the amount of dry matter loss degraded in the rumen. Similarly, the difference in organic matter weight before and after incubation was equivalent to dry matter degraded in the rumen (Orskov *et al.,* 1980; McDonald, 1981).

Washing Loss

Soluble portion of the feed was determined by weighing 5 g of the feed samples into nylon bags in replicates. It was soaked in warm water at 40 °C for one hour, removed and washed under a running tap for 15 minutes in two circles till clear water was obtained. The bags were oven dried at 60 °C for 48 hours to constant weight (Orskov *et al.,* 1980).

Statistical Analysis

Data collected were subjected to analysis of variance (Steel and Torrie, 1980). Significant differences between means were tested using LSD.

Chemical Analysis

All the ingredients and the ten formulated experimental diet were analysed for dry matter, crude protein, crude fibre, ether extracts, ash and nitrogen free extracts using the methods of the Association of Official Analytical Chemists (AOAC, 2000).

Cost Analysis of Formulated Rations

The cost of producing all the ten (10) formulated rations was determined based on the current market prices of the ingredients used in the formulation at the time of production, and when a USD $1 is equivalent to N155 Nigerian Naira.

RESULTS AND DISCUSSION

Ten (10) rations were formulated using locally available ingredients. Each formulation contains an energy and protein sources combined in ratio of 60:40 respectively.

Wheat offal is the major feed ingredient used in the most of the formulations as an energy source having a total of about 148kg out of the 1000kg of all the ten formulations F10 (60%), making it the only energy source in F10 followed by F9 (30%), F6 and F4 (24%) and F3(10%). Sorghum husk was next to wheat offal, having a total of about 110kg out of the 1000kg of all the ten formulations F2 (40%), followed by F1 and F5 (30%) then formulation F3 (10%). Rice bran has a total of about 106kg making it next to sorghum husk with highest level of inclusion in formulation F4 (36%) followed by F1 and F8 (30%), then formulation f3 (10%).

Cotton seed cake is the major protein source together with poultry litter followed by groundnut haulms. Cotton seed cake was included in all the ten formations except formulation F9, while poultry litter is excluded in just one formation, formulation F8. Groundnut haulms were only included in formulations F1, F2, F5, and F9. Poultry litter has a total of about 128kg of the 1000kg of all the ten formulations F7, F9 and F10 (20%), followed by formulation F2 and F6 (16%), F1, F3 and F5 (10%) then F4 (6%). Cotton seed cake had a total of about 186kg out of the 1000kg of all the formulations, with highest level of inclusion in formulation F8 (40%) followed by formulation F4 (34%), F2 and F6 (24%), F10 (20%), F1 and F5 (10%), then formulation F3 (4%). Groundnut haulms had 86kg out of the 1000kg while poultry litter had 126kg with highest level of inclusion recorded in the formulation F6, F9 and F10 (20%); this was slightly higher than what was reported by Nadeem *et al.*, (1993) who recorded 25 to 30% inclusion level of poultry litter, in diet of ruminants.

Table 1: Proximate Composition of ingredients used in the Formulations

Proximate Composition (%)	Feed Ingredients									
	MB	MLB	RB	SH	WO	BD	CH	CSC	GH	PL
%DM	97.80	97.57	87.90	98.20	96.20	94.40	80.70	94.50	95.03	95.50
%CP	1.30	4.28	8.50	1.36	13.20	4.70	6.90	38.80	15.00	14.00
%CF	13.00	18.70	11.94	13.50	23.35	18.00	9.40	10.00	11.35	20.00
%EE	1.50	1.20	2.60	1.48	5.00	5.50	1.40	6.00	4.12	5.00
%Ash	4.50	8.30	11.33	19.14	3.00	1.00	9.80	5.00	4.65	6.00
%NFE	77.50	77.49	53.53	62.72	52.00	68.17	53.20	34.70	59.91	50.50

MB: Maize bran; MLB: Millet bran; RB: Rice bran; SH: Sorghum husk; WO: Wheat offal; BD: Bran (Dusa); CH: Cowpea husk; CSC: Cotton seed cake; GH: Groundnut haulms; PL: Poultry litter

The proximate composition of the feed ingredients used in the formulations is shown on table 1. The dry matter content of the ingredients ranges from 80.70% - 98.20% DM. SH recorded highest (97.80% DM). CH recorded lowest percent dry matter (80.70% DM). The DM recorded for MB, MLB, SH, WO, BD, GH, and PL are slightly higher than the 90.16% DM reported by Shahid *et al.* (2008) while CH and RB are within the range of 85 to 93% DM reported by (Park *et al.*, 1995). % CP content of the ingredients ranges from 1.30 - 38.80% CP. Cotton seed cake recorded highest crude protein content (38.80%CP) which is similar to 38% CP for a cotton seed cake reported by (Imade, 2004), while the crude protein for Poultry litter is similar to (15 – 52% CF) reported by (Abdulrazak and Fijihara, 1990) but in contrast to 26.51% CP obtained by Asrat *et al., (*2008). The Crude protein (<8.4%) of some of the ingredients indicates that it cannot supply the minimum ammonia levels required for microbial activity in the reticulo-rumen if fed solely (Norton, 1994).

The crude fibre ranged from 9.40 - 23.35%CF. This is within the range of 22.6% CF reported by Hadjipanayiotou *et al.*, (1993) except for wheat offal that record 23.35% in concord to the findings of Mlay *et al*, (2005), who found the fibre content in maize bran to be 31.9% which is found to be very effective in decreasing faecal transit time. The ether extract vary from 1.20-6.00% EE. Cotton seed cake record highest (6.00%). Thus, Highest dry matter content, crude protein, crude fiber, ether extract, ash and nitrogen free extract were recorded in SH, CSC, WO, CSC, SH, and MB as (98.20%DM), (38.80%CP), (23.35%CF), (6.00%), (19.14%), (77.50%NFE) respectively. This could be attributed to the type and quality of feed ingredient used. Since it was a dry ruminant feed formulation and water free, ingredients used like poultry litter was well sun dried for about four (4) days and stored in a moisture free environment to reduce its moisture content and pathogens. The nutritive value of crop residues varies according to species, varieties, stage of maturity, methods of harvest, storage, environmental conditions, and feeding among others factors (Sabanda and Said, 1993).

From Table 2, the dry matter content of the formulations ranges from 98.3% - 99.9%. This dry matter content indicates all constituents excluding water of the ingredients used in the formulation. Highest % DM was recorded in F1, F7, and F9 as (99.90%). The %DM in this study is slightly above (95.4%DM) reported by Mubi *et. al.*, (2013) but similar to the range of

93.80%-98.70% DM reported by (Zarah *et al.*, 2014). The crude protein content of all the formulations ranged from 2.0% - 6.12% and this range is slightly lower than what was reported by Ibrahim (2010) who reported in a similar experiment 6.65% - 9.10% CP range. Formulation F1 recorded least %CP (2.00%) while F9 recorded highest (6.12%).

Table 2: Proximate Composition of Formulations

Proximate Composition (%)	Formulations									
	F_1	F_2	F_3	F_4	F_5	F_6	F_7	F_8	F_9	F_{10}
%DM	99.90	98.60	99.80	99.00	98.40	98.30	99.90	99.80	99.90	99.70
%CP	2.0	4.20	3.58	4.20	3.76	4.46	4.72	5.60	6.12	5.86
%CF	33.0	18.0	11.0	45.0	38.0	27.0	22.0	31.0	34.0	27.0
%EE	5.0	2.0	2.0	5.0	6.0	2.0	3.0	2.0	6.0	2.0
%Ash	9.0	5.0	4.0	9.0	3.0	5.0	3.0	11.0	3.0	4.0
%NFE	50.9	69.40	79.22	35.80	47.64	59.84	67.18	50.20	50.78	60.84
ME (MJ/Kg DM)	3.61	3.64	3.66	3.68	3.71	3.74	3.82	3.85	3.91	3.94

The crude protein content of all the formulations is sufficient for ruminants which will provide ammonia required by rumen microorganism to support optimum microbial activity (Norton 2003). This differences and variation in crude protein percentage among formulations may be due to the type of protein source and its level of inclusions in the rations. This is completely different from what was reported by Onwuka, (1999) and Mohammed *et al.*, (2007) who reported 10.9% to 14.8% CP and 11.0% - 13% CP respectively. The differences observed could also be associated with soil nitrogen condition, level of maturity of the crop residue and varietal differences (Huiling *et al*., 2009). Crude fibre ranged from 11.0%-45.0% CF which agrees the range of 10.5-41.0% CF and also in line with (11 – 13%) CF reported by Zarah *et al.*, (2014) Mohammad and Baulube (2004) respectively. Formulation F4 recorded highest crude fibre level (45.0% CF), while F3 recoreded least (11.0%). Such high crude fibre content of the F4 could be due to the quality and fibrous nature of ingredients used which reduces digestibility rate of the diet as well. Ether extract ranged from 2.0% - 6.0% EE similar to the work of Kinfemi *et al.*, (2009) with 6.13% EE. The mean ash content of all the formulations is (5.60%) which is a little lower than the value of (7.83%) reported by Dibal (1991) for semiarid browse plants. The ME content in MJ/kg DM ranged between 3.61–3.94 MJ/kg DM. However, the observed differences in mineral composition in these products may be due to genetic factor and environmental factors like irrigation frequency, soil composition and fertilizer used (Ikram *et al*., 2010).

Table 3: Percentage dry matter degradability

Time (Hours)	Formulations										
	F_1	F_2	F_3	F_4	F_5	F_6	F_7	F_8	F_9	F_{10}	SEM
6	30.33^{b}	24.84^{b}	22.00^{b}	22.00^{b}	24.34^{b}	31.34^{b}	30.34^{b}	22.17^{b}	48.17^{a}	45.50^{a}	3.53*
12	34.84^{b}	33.34^{b}	31.67^{b}	29.84^{b}	29.84^{b}	34.17^{b}	34.17^{b}	26.67^{b}	50.50^{a}	48.84^{a}	3.15*
18	37.34^{b}	41.17^{b}	34.00^{b}	32.00^{b}	35.67^{b}	37.67^{b}	37.67^{b}	36.84^{b}	57.34^{a}	60.17^{a}	3.10*
24	44.50^{cd}	50.00^{bc}	40.00^{cd}	38.34^{d}	43.50^{cd}	44.50^{cd}	44.50^{cd}	44.34^{cd}	59.17^{ab}	66.67^{a}	2.94*
36	67.17^{c}	69.67^{bc}	69.50^{bc}	70.83^{bc}	75.67^{b}	82.34^{bc}	82.34^{a}	70.84^{bc}	69.17^{c}	70.50^{bc}	1.57*
48	76.50	76.50	77.84	76.67	78.50	79.84	79.34	79.84	78.17	78.17	2.12^{NS}
72	78.84^{d}	79.00^{cd}	79.34^{cd}	81.00^{abcd}	83.34^{ab}	82.83^{bcd}	82.83^{abc}	82.83^{abc}	83.67^{a}	82.67^{abcd}	0.98*

Note: ^{a,b,c,}... Means in the same row bearing different superscript are significantly different (P<0.05).
NS = Not Significant (P>0.05), * = Significant (P< 0.05), SEM = Standard error of the mean.
F_1-F_{10} = Formulations.

The result of rumen degradability is of the formulated rations is presented in Table 3. At 6, 12, and 18 hours, formulations F9 and F10 recorded significantly (P<0.05) higher percent degradability. There was no statistical difference (P>0.05) in degradability amongst F1 through to F8. The highest (P<0.05) value of degradability at 24 hours was recorded on formulation F10 and the lowest on F4. However, there was no statistical difference (P>0.05) in degradability between formulations, F10 and F9, F9 and F2 as well as amongst F1, F2, F3, F5, F6, F7 and F8. Similarly, degradability was not different (p>0.05) amongst F1, F3, F4, F5, F6, F7, and F8. At 36hours of incubation, there was no statistical difference (P>0.05) in degradability between F1 and F2, F3, F4, F5, F6, F8, F9 and F10 as well as amongst F1, F2, F3, F4, F5, F6, F8, F9 and F10 except F7 with highest (P<0.05) value of degradability. There was no effect of formulation on degradability (P>0.05) at 48 hours. All the formulation may be considered acceptable for ruminant feeding in accordance with the 40 – 50% degradability range recommended by FAO (1986) at 48 hours. However, the mean degradability values observed for at 48 hour of incubation period are higher than the minimum of 60% recommended (Smith *et al.,* 1988).

At 48 hours. F6, F8 recorded highest percent degradability despite the high concentration of rice bran followed by F7 with formulations F1 and F2 recording lowest. The high degradation of formulations F6 (79.84%) and F8 (79.84%) could be as a result of longer incubation period within the rumen which allows the feed to absorb enough moisture and gives the rumen microbes enough time to act on the diets despite their fibrous nature. In addition, the variation in degradability of the formulations could be due to their fibre content as a result of high concentration of fibrous ingredients used in the formulations (MacDonald *et al.,* 1995). The rumen microbial activity increases with energy content of a feed, the high degradability of formulations F6 and F8 could be due to their relatively higher Metabolizable Energy content, 3.74 MJ.ME/kg DM and 3.85 MJ.ME/kg DM as compared to formulations F1, F2, F3, F4 and F5 (3.61, 3.64, 3.66, 3.68 and 3.71 MJ.ME/kg MD) respectively. At 72 hours, there is significantly (P<0.05) higher percent degradability in all the formulations with highest recorded in F9 and least on F1. There was significant difference (P>0.05) in degradability between formulations F5, F7 and F10 and amongst F1, F2, F3, F4, F5, F6, F7, F8 and F10. Despite the higher crude fibre content in formulations F9 and F10 compared to F1, F2, F3, F6 and F7, the highest degradability at 6, 12 and 18 hours was obtained in F9 followed by F10. The reason for this degradability pattern was probably due to higher concentration of wheat bran in the formulations (F9 and F10). As shown by previous studies, crude protein content of diets at different energy levels increased dry matter intake (Lu, and Patchoiba, 1990) and digestibility (Blaxter *et al.,* 1961). This could also attribute to the high degradability of formulations F9 and F10 who recorded highest crude protein content of 6.12% and 5.86% respectively. Energy content of a feed increases activities of rumen microbes and the high energy content of F9 and F10 (3.91 and 3.94 MJ.ME/kg.DM) could be another reason for this high degradability of F9 and F10 at 6, 12 and 18 hours. Effective degradation (degradation in the rumen) depends on how long the food remains in the rumen which is also a function of the quantity of the feed fed to the animal (Reddy, 2001).

The level of dry matter disappearance in this work is lower than what was reported by Zarah *et al.,* (2014) who recorded 92.00% DM at 72 hours but similar to 82.00% recorded by Mbaya *et al.,* (2012). In addition longer incubation period, the reason for this degradability pattern could be as a result of inclusion level of feed ingredients used in the formulations. High degradability of F9 at 6, 12, 18 and 72 hours could be due to inclusion level of poultry litter which is capable of stimulating ruminant microbial digestion by increasing the ammonia pool in the rumen of the animal there by increasing the rate of feed degradability within the rumen (McDonald *et al.,* 1995) with energy content of (3.91 MJ.ME/kg DM) a less concentrations of fibrous feed ingredients used in its formulation could be reason for its high degradability. As a result of good degradability of formulations, F5 and F9, ruminant animals fed this ration will have better performance.

Table 4: Cost of production of the different formulations

COST	Formulations									
	F_1	F_2	F_3	F_4	F_5	F_6	F_7	F_8	F_9	F_{10}
Cost (₦/kg)	41.15	36.55	28.60	70.30	27.10	53.60	53.60	76.00	46.50	61.00
Total cost(₦/100kg)	4115	3655	2860	7030	2710	5360	5360	7600	4650	6100

NB: $1 is equivalent to ₦155

Table 4 gives the cost of producing formulations F1-F10 in naira per gram and Naira per 100Kg. The cost of producing a kilo gram (1kg) of each formulation ranged from ₦27 – ₦76/kg ($0.17 - $0.49 respectively) as at the time of the experiment when $1 is equivalent to ₦155. The highest cost of production ₦7600/100kg ($49.0) was recorded in formulating F8 and the least ₦2710 ($17.48) in F5. This is slightly higher than what was reported by Ibrahim *et al.,* (2011) who recorded high cost of production of 100kg of a ration at ₦2835($18.29) and lowest at ₦2522 ($16.27). The major reason this production cost in this research work is attributed to high market prices of the ingredients used coupled with seasonality and availability of the ingredients.

CONCLUSION

This study have shown that utilization of crop by-products and crop residues to formulate rations for ruminants can meet both their metabolizable energy, protein and mineral requirements for both maintenance, production and reproduction at a very lower cost especially during periods of feed shortage (dry season). Furthermore, blending crop residues with at least 20% level of inclusion of poultry litter in a 100kg ration in dry season supplements for ruminants will result in a significant improvement in DM degradation in the rumen by stimulating activities of rumen microbes' thereby increasing digestibility of crop-residues which are mostly fibrous thus increasing their intake, digestibility and utilization by ruminant animals.

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