Rumen Degradation Characteristics of Multinutrient Blocks in Semi-Arid Region of Nigeria

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Abstract. An investigation was carried out on eleven different multinutrient blocks in the semi-arid region of Nigeria. Three crossbred steers fitted with permanent rumen cannula were used to evaluate the nutritional value of multinutrient blocks using the nylon bag techniques. A randomized design was employed to determine the ruminal degradability of multinutrients and their effect on rumen ecology. Approximately 5 g of the feed sample were weighed into duplicated nylon bags (45 µ pore size) and incubated ruminally at 0, 6, 12, 24, 48, and 72 h-post feeding. The results showed that the mean values of the ruminal temperature (38.7^{o}C) and pH (6.6) were not different among different incubation. All the multinutrient blocks recorded above 59% DM degradability at 48h period of incubation. The mean values for the potential degradation of the multinutrients were generally high and ranged from 83.2 to 95.8%. It was concluded that inclusion of multinutrients in the diet of ruminants result in a significant improvement in DM degradation in the rumen.

Key words: digestibility, in vivo technique, multinutrient, ruminants

Abstrak. Penelitian dilakukan terhadap sebelas blok multinutrisi berbeda di wilayah semi-gurun di Nigeria. Tiga sapi peranakan yang diberi pakan dengan “canula” rumen permanen digunakan untuk mengkaji nilai nutrisi dari blok multinutrien menggunakan teknik kantung nilon. Rancangan acak digunakan untuk menentukan kecernaan ruminal multinutrisi dan pengaruhnya pada ekologi rumen. Kurang lebih 5 g sampel pakan ditimbang pada kantong nilon duplikasi (ukuran pori-pori 45 µ) dan diinkubasi ruminal pada 0, 6, 12, 24, 48 dan 72 jam setelah pemberian pakan. Hasil menunjukkan bahwa rataan nilai suhu rumen (38,7^{o}C) dan pH (6.6) tidak berbeda di semua inkubasi. Semua blok multinutrisi tercatat di atas 59% kecernaan BK pada 48 jam inkubasi. Nilai rataan degradasi potensial blok multinutrisi umumnya tinggi dan berkisar antara 83,2 sampai 95,8%. Disimpulkan bahwa penggunaan multinutrisi pada pakan ruminasia menghasilkan peningkatan signifikan pada kecernaan bahan kering di rumen.

Kata kunci: kecernaan, teknik in vivo, multinutrisi, ruminan

Introduction

Ruminant diets in most developing countries are based on fibrous feeds and crop residues. These feeds are not balanced and are particularly deficient in protein, minerals, and vitamins. Efficient supplementation with mixture of local feeds that contain protein has been demonstrated to improve rumen ecology, dry matter intake and subsequently meat and milk production (Wanapat, 1999). Multinutrient blocks are supplements commonly used for ruminants which contain energy, urea, essential minerals and vitamins. It is a very interesting solution to the problem of nutritional deficiencies that animals are facing for a large part of the year, especially during the dry season. The blocks are solidified mixture of agro-industrial byproducts used for supplementing poor quality roughages and native rangelands. They are considered as a catalyst supplement, allowing a fractionated, synchrinised and balanced supply of the main nutrients (IFAD, 2000).

Limited information is available on characteristics of multinutrients degradation in the rumen of feed blocks locally used for livestock in semi-arid region of Nigeria e.g. multinutrient blocks with molasses, without molasses, with cement, Kuka or other binders. These ingredients contain high proteins and used as alternative dietary strategic supplements to improve rumen ecology. Therefore the objective of this study was to determine the degradability of multinutrient blocks locally produced in this region using the nylon bag technique.

Materials and Methods

Experimental site. The study was conducted at the University of Maiduguri Teaching and Research farm, situated on latitude 11^{o}51^l North, longitude 30^{o}5^l East and at altitude of 354 m above sea level. Rainfall varies from 300 to 500 mm and the ambient temperature is highest by April and May within the range of 35-40^{o}C, while relative humidity ranges from 45-50%.

Feed samples. The feed samples used in formulating the blocks included wheat offal, millet bran, rice bran, maize bran, sorghum bran, browse pods, food waste, cotton seed cake, poultry litter, molasses, blood meal, bone meal, urea, salt, cement.

Production of the blocks. Using ingredients purchased from local market, formulations were developed. The mixing was done as described by Mohammed et al. (2007). Each mixture was placed in a wooden container moulds lined with a polythene sheet. Each compartment measuring 15x15x10 cm (Allen, 1992). Removal of the blocks was carried out immediately after the block material settled by knocking the sides of the moulds gently. After removal of the moulds, blocks were arranged in a drying area, and then sun dried. Water spillage or rain drops was carefully avoided so as to keep the blocks in good condition. Proximate and cost analysis was also determined. The blocks were randomly assigned to treatments.

Experimental animal management. Three crossbred steers weighing 250 kg and about 2½ years each were fitted with a rumen cannula. The animals were housed in a pen and fed 1.5 kg mixture of maize bran and cowpea husk once daily and a basal ration of high quality grass hay. It was offered twice daily at 8:00 am and 4:00 pm. Mineral salt lick and water were available at all times. Two-week adaptation period was observed prior to suspension of the bags.

Rumen degradation study. Feed samples from each block were collected, oven dried and ground to pass through 2.5 mm screen. The nylon bags with mesh size of 45 µ and 140x90 mm were used to contain five grams (5 g) of feed samples, then tied to the neck, attached to undegradable string and tightened to avoid falling during turning and removal from the rumen. The incubation periods chosen were 0, 3, 6, 12, 24,48 and 96 hours. Samples of the rumen fluid were taken through the cannula during removal; temperature and pH were immediately measured using temperature and pH meter. The whole component of the string from the rumen were taken to laboratory and washed thoroughly in two circles for 15 minutes under running tap water. The bags were then oven-dried at 60^{o}C for 48 hours to constant weight to determine the total dry matter loss (McDonald, 1981; Orskov et al., 1980).

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^oC for one hour, removed and washed thoroughly under a running tap for 15 minutes in two circles. The bags were oven dried at 60^oC for 48 hours to constant weight (Orskov et al., 1980).

Chemical analysis. Feed samples were analyzed for dry matter (DM), crude protein (CP), crude fiber (CF) and Ash using the methods of AOAC (1999).

Statistical analysis. Data collected were subject to analysis of variance (Steel and Torrie, 1980). Significant differences between means were tested using LSD. The results of the DM degradation were also fitted into the equation $P=a+b\ (i-e^{-ct})$ where P=amount degraded at time (t), a=rapidly soluble fraction, b= amount which in time will degrade, c=fractional rate constant at which the fraction 'b' will be degraded, e=natural logarithm and t= time.

Results and Discussion

The chemical compositions of the formulations are shown in Table 1. The DM content ranged from 92.60% to 98.7%. The highest DM content of 98.7% was recorded in F18 and the lowest in F13. The reason may be due to the high level of dried food waste and the different bran used in the formulations. This is similar to Onwuka (1999) that the bran contained 96% DM.

The lowest DM content may be due to high content of wheat offal recorded in F15 (55%), lower dried food waste and high water content (22.0 litres). This was in line with Evans (2005) and Ibrahim (2006) reporting 58.1% and a low DM content of 54.4%. The CP content of all the formulations was moderate and ranged from 9.3 to 21.4%. This was slightly different from result by Onwuka (1999) namely between 10.9 and 14.8% CP. The difference in CP content may be due to the type and quality of feed ingredients used; such as CSC and poultry litter included in the feed mixture as sources of protein. Urea which contains non-protein nitrogen might also add to the differences observed in CP content.

Moreover, the CP content in this study was similar to 11-13% CP by Mohammed et al. (2007) because both studies used CSC and poultry litter as the main protein sources. The CF content of the formulations ranged from 10.5-41.0%. The highest CF was recorded in F6 and the lowest in F4 and F10. The high level might be due to the fibrous feeds used in the formulation. Similar results were reported by Hadjipanayiotou et al. (1993) who obtained 22.6% CF in rice bran only. The ash content ranged from 7.0-23.0%. The highest value was recorded in F10 and the lowest in F15. This might be associated to the level of bone meal in the formulation. Rice bran may also contribute to the ash content. The lowest ash content was recorded in F5 because of the low level of bone meal or rice bran used in the formulation. These values were much higher than 7-8% reported by Mohammed et al. (2007). However, the blocks made here have shown an improvement over the range of 3.21-4.32% ash proposed by Sansoucy (1986).

The ruminal environment indicated that the ruminal pH and temperature were not different across the time of incubation as depicted in Table 2. The mean ruminal pH and temperature of 6.6 and 38.8 were within the optimal range for microbial digestion of fiber and protein (Wanapat, 1990). Similarly, the value of pH and temperature range of 6.5-7.0, and 39-41^0C was reported by Promkot and Wanapat (2003).

Table 1. Chemical composition of the formulation (%)

Formulation	DM	CP	EE	CF	ASH
F1	97.0	15.6	4.0	10.5	8.0
F2	97.5	13.1	3.0	12.5	7.0
F3	96.4	13.7	2.5	41.0	12.5
F4	94.7	13.7	2.5	13.5	15.5
F5	93.8	13.8	5.0	10.5	23.0
F6	97.0	20.7	1.5	12.5	13.0
F7	97.1	21.4	2.0	30.5	17.5
F8	98.2	19.3	3.0	24.0	13.5
F9	98.7	16.1	2.5	20.5	11.5
F10	97.4	16.9	2.0	15.0	15.5
F11	97.1	13.5	1.5	24.0	15.0

DM: dry matter, CP: crude protein,CF: crude fiber

Table 2. Ruminal pH and temperature of steers during nylon bag studies

h-post suspension	pH	Temperature (^{o}C)
0	6.7	38.4
3	6.6	38.8
6	6.6	38.4
12	6.6	38.9
24	6.6	39.0
48	6.6	39.5
72	6.8	38.5
Mean±SD	6.6±0.1	38.8±0.3

Table 3 shows the pattern of dry matter disappearance of the multinutrients in the rumen. All the treatments except T1 (60.0%) had high washing loss at zero hour (0h) (P<0.05) due to the solubility of the nutrients in water. All the multinutrients used in this study was recorded above 50% dry matter degradability at 48 hours period of incubation. This implied that the multinutrients in the blocks were highly degradable in the rumen. Although it can be inferred that the multinutrient blocks had good levels of dry matter degradability, there were significant differences (P<0.05) in the incubation values from 0-76 h. T7 had the highest degradability values of 92.0% and this high value was also obtained by Oni et al. (2008) in a study of the dry matter degradation characteristics of some agro-industrial byproducts. However, T1,T3, T4, T6, T7 and T9 maintained above 40% dry matter degradability even at 24 h period of incubation. Most of the nutrients available in the feed ingredients will be released in the rumen since they make up the dry matter content (McDonald et al.,1988). Lower values of dry matter degradability ranged from 35-11.8% were recorded at 0- 6 h of incubation. This clearly indicated that the blocks had a reasonable resident time in the animal rumen which also allowed proper mixture with other feed materials consumed by the animals. Multinutrient blocks with non significantly difference degradability (P<0.05) were in this order T4>T5>T6>T7>T8.

The dry matter degradation characteristics of the multinutrients in the blocks are shown in Table 4. The 48 h incubation values and the water soluble fraction, ‘a’, for all the multinutrients except in T2 were significantly similar for T1, T7 and T10, T4,T9 and T11, T3,T5,T6 and T8, the range is 82.2 to 87.8 to 10.0 respectively. The mean values for the potential degradation of the multinutrients were generally high and ranged from 83.2% in T3 to 95.8% in T5. This may have been due to the insoluble but degradable fraction (Oni et al., 2008). The values obtained in this research were higher than what was obtained by

Table 3. DM disappearances of multinutrients incubated in the rumen (%)

H	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11
72	84.0^{b}	56.6^{k}	70.8^{g}	82.0^{e}	71.2^{c}	68.0^{a}	92.0^{j}	60.0^{ab}	75.0^{h}	86.2^{f}	75.4^{d}
48	82.2^{a}	56.2^{a}	66.6^{a}	72.6^{a}	66.2^{a}	68.0^{a}	87.8^{e}	60.0^{b}	70.0^{f}	86.2^{d}	71.6^{e}
24	76.4^{c}	36.6^{c}	66.6^{c}	50.0^{c}	66.2^{c}	42.0^{cd}	74.0^{b}	60.0^{a}	62.0^{e}	66.0^{f}	45.8^{g}
12	46.0^{b}	28.8^{b}	48.8^{b}	40.0^{b}	56.2^{b}	28.0^{a}	74.0^{i}	47.2^{e}	62.0^{d}	57.0^{g}	30.0^{f}
6	40.0^{d}	20.2^{d}	20.8^{d}	40.0^{d}	44.4^{cd}	19.8^{c}	74.0^{ab}	38.4^{f}	21.8^{h}	30.0^{i}	25.0^{g}
3	27.8^{e}	12.5^{e}	15.0^{c}	19.3^{e}	44.4^{e}	14.4^{c}	40.0^{e}	20.0^{ab}	11.8^{d}	13.0^{f}	15.2^{i}

Values bearing different superscript at the same row shows significant (P<0.05). H is hours of incubation.

Table 4. Dry matter degradation characteristics of the multinutrients (%)

D	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	SEM
48hr	82.2	56.2	66.6	72.6	66.2	68.0	87.8	60.0	70.0	86.2	71.6	3.90
A	6.0	23.4	23.2	10.0	23.8	20.0	20.0	20.0	20.0	10.0	14.0	1.90
B	84.0	70.0	60.0	75.0	72.0	64.0	94.0	71.0	69.0	82.0	77.0	3.70
a+b	90.0	93.4	83.2	85.0	95.8	84.0	96.0	91.0	89.0	92.0	91.0	2.90
C	0.08	0.06	0.06	0.07	0.07	0.07	0.08	0.08	0.08	0.08	0.08	0.003

D: degradation characteristics, A: soluble fraction, B: insoluble but degradable fraction, a+b: potential degradability, C: rate of degradation of b

Larbi et al. (1996). This may be as a result of the high degradability of the multinutrients in the block. The multinutrients varied in DM degradation characteristics and these differences were reflected in Table 4. Comparison of the potential degradability (a+b) with 72 h DM degradability shows that degradation was almost complete by this hour for T2, T3, T6, T8, T9 and T10. Kibon and Orskov (1993) reported that degradation of some browse species were almost complete by 96 h while comparing their potential degradability. All the multinutrients had lower proportion escaping ruminal degradation with a ‘c’ value of 6- 8%. The result obtained in this study was not in agreement with that by Asaolu and Odeyinka (2005), assumedly due to the non-ligniferous contents of the multinutrients in the blocks.

Conclusion

Multinutrient blocks could serve as alternative supplements to crop residues, hay and other low quality roughages for ruminants in the semi-arid region of Nigeria. The extents of degradation of the multinutrients in the blocks were relatively high for inclusion in practical production diets for ruminants. The predicted rates of degradation indicated a possible synchronization of release of nutrients from each block if they are fed as supplements. Furthermore, inclusion of multinutrient blocks in the diet of ruminants resulted in significant improvement in DM degradation in the rumen and therefore improvement in livestock production.

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