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EFFECT OF FERMENTATION WITH RUMEN LIQUOR ON THE NUTRITIVE VALUE AND RUMEN DEGRADATION CHARACTERISTICS OF SOME FIBROUS FEEDS FOR RUMINANTS IN SEMI-ARID NIGERIA

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ABSTRACT

This study determines the effect of fermentation with rumen liquor on the nutritive value and rumen degradation characteristics of some locally available fibrous feeds. Nine (9) different rations were formulated based on the 60:40 ratio of energy to protein. The result of the proximate analysis showed that rations fermented with rumen liquor recorded an increase in crude protein content which ranged from 8.87 to 15.78 % when compared to the control which varied from 6.51 to 10.89 %. The ash content of the control ranged from 6.50 – 11.00 % and increased when fermented with rumen liquor with a range of 6.71 – 11.51%. The nitrogen free extract ranged from 43.33 – 53.17 % for control and increased when the rations were fermented with rumen liquor 48.70 – 56.36 %. A decrease in crude fibre content from (29.07 – 37.16 %) to (21.80 – 29.77 %) was observed. Ether extract, acid detergent fibre and neutral detergent fibre contents followed the same trend as that of crude fibre. The rate of dry matter disappearance of the control and the rations fermented increased with incubation time. Rations fermented with rumen liquor had the highest dry matter disappearance at 96 hrs. The dry matter degradation after 48 hours was above 60% in formulations fermented with rumen liquor. In conclusion fermentation with rumen liquor had increased the crude protein content and degradability of these feedstuffs and could therefore improve intake and utilization by ruminant livestock.

Key words: degradation characteristics, fermentation, fibrous feeds, nutritive value, rumen liquor, semi-arid.

INTRODUCTION

Ruminant diets in most developing countries are based on forages and crop residues. In the dry season and post-harvest periods, characteristics of tropical environments, these feeds resources become the main sources of energy for use by ruminants. The digestibility of agricultural by-products is very low because of the inherent lignin in the cellulose and hemicelluloses matrix (Akinfemi *et al.,* 2009. The development of an environmentally friendly recycling methodology will help to convert the vast mass of crop residues produced annually into value added ruminant feed. Fermentation is an alternative method to enhance the nutrient content of feed through the biosynthesis of vitamins, essential amino acids and protein, by improving protein quality and fibre digestibility (Oboh, 2006). Rumen content of ruminant animals is an abundant abattoir waste that contains millions and billions of microbes that can be used to ferment lingo-cellulosic agricultural by-products to produce a more digestible feed for ruminant livestock.

The nylon bag technique offers a relatively cheap and rapid method of assessing the potential feeding value of feedstuff. The technique can also test the effectiveness of any

physical, biological or chemical processing which might improve the value of the product. The objective of the study is to determine the effect of rumen liquor fermentation on the nutrient composition and degradability of some locally available fibrous feeds.

MATERIALS AND METHODS

Location of Experimental Site

The study was conducted at the Teaching and Research farm, University of Maiduguri. Maiduguri is situated on latitude 10˚ N and 14 ^{o} N and longitude 11.3^{o} E and 14.45˚ E (BOSHIC, 2007). It falls within the Sahelian Region (semi-arid zone) of West Africa. It is characterized by short rainy season (3 – 4 months) and very long dry season (8 – 9 months). The mean ambient temperature could be as low as 23^{o}C during the dry season and gets as high as 40 ^{o}C or more during the hot season. Relative humidity is about 45 % in August which usually drops to about 5 % in the months of December and January and has evaporation of 203 mm/year. Day length varies from 11-12 hours (BOSHIC, 2007).

Sources of Feed and Preparation of Feed

The local feedstuffs used for the study were purchased at the Maiduguri Cattle market. The feeds were sorghum husk, groundnut haulms, cowpea husk and *Faidherbia albida* pods. Poultry litter from deep litter broiler production was sourced from the University Farm.

All the feed ingredients were ground using pestle and mortar before compounding the ration in order to reduce the particle size. Nine (9) rations were formulated containing different proportions of sorghum husk, cowpea husk, groundnut haulms, poultry litter and *Faidherbia albida* pods based on the energy to protein ratio of 60:40 as suggested by Mohammed *et al.* (2007).

Rumen Liquor Preparation

The rumen content of slaughtered ruminant animals was collected at the Maiduguri abattoir in the morning after slaughtering and evisceration. The rumen content was sieved in order to obtain the liquor while the solid material was discarded. The liquor after collection was stored in an air tight plastic bucket and taken to the laboratory.

Fermentation procedure

Two hundred gram (200 g) from each of the nine (9) formulations was placed in a plastic container; 500 ml of rumen liquor was added to it and mixed very well, made airtight and fermented for a period of 96 hours. The treatments were sun-dried for three (3) days and ground to pass through 1mm sieve for chemical analysis and 2.5 mm for rumen degradability studies.

Rumen Degradability Studies

A healthy bull fitted with a rumen cannula of 90 mm size (internal diameter) was used for the rumen degradability studies. The bull was confined in a pen and fed 3.0 kg of maize bran mixed with cowpea husk once, and a basal diet of native grass hay was fed *ad-libitum* at 8:00am and 4:00pm. Mineral salt lick and water were provided *ad-libitum* throughout the study period.

The nylon bags containing the samples were tied, attached to un-degradable string and tightened to avoid falling off during turning and removal from the rumen. The bags containing the samples were incubated in duplicate in the rumen of the cannulated bulls for 0, 6, 12, 18, 24, 36, 48, 72 and 96 hrs. The 0 hour time point represents the bags, which were not incubated in the rumen of the animals, but was treated in the same manner as other bags that were incubated upon removal from the rumen (washing loss). All bags were placed in the rumen at the same time and removed at the required time (Ørskov *et al.*, 1980).

The whole component of the string and the nylon bags was taken to the laboratory and

washed under a running tap till water running through them is clear. The bags with the contents were air-dried, after which the sample was oven-dried at 105°C for 24 hours for determination of the amount of dry matter loss.

Chemical Analysis

Samples of the formulated rations were analysed before and after fermentation for Dry matter (DM), Crude protein (CP), Crude fibre (CF), Ether extract (EE), Ash, Nitrogen free extract (NFE) using the methods of AOAC (1990), while acid detergent fibre (ADF) and Neutral detergent fibre (NDF) were calculated according to the formula of Pogano Tuscano *et al*. (1986).

Statistical Analysis

The results from the proximate analysis of the fermented and unfermented rations were subjected to analysis of variance (ANOVA) using the Statistical Package for the Social Sciences (SPSS, 2006 version 8.0). Significant differences between means were separated using Least Significant Difference (LSD). The results of the dry matter degradation were fitted into the exponential equation, $p = a + b (1 – e^{-ct})$ (Ørskov and McDonald (1979) and Ørskov *et al.*, 1980).

RESULTS AND DISCUSSION

Proximate composition of the formulated rations

The proximate composition of the formulated rations (F1 to F9) is shown in Table 1. F3 had the highest DM content (98.60 %), while F5 had the least DM content (97.00 %). F6 had the highest CP value (10.89 %) while F2 had the least value (6.51 %). However F2 had the highest CF content (37.16 %) and F3 had the least value (29.07 %). F4 had the highest EE value (2.50 %), and the least value was obtained in F3 (1.00 %). The highest value of ash was obtained in F2 (11.00 %), while the least and similar values of 6.50 % were obtained in F4 and F9. NFE value was highest in F9 (53.17 %), and the least value was recorded in F2 (43.33 %). ADF and NDF values were highest in F2 (43.32 % & 53.34 %) and the least values were recorded in F3 (35.94 % and 48.02 %) respectively.

Table 1: Proximate Composition of Formulated Rations (%)

Formulations	DM	CP	CF	EE	ASH	NFE	ADF	NDF
F1	98.00	9.43	35.12	2.00	10.00	45.45	41.46	52.00
F2	97.90	6.51	37.16	2.00	11.00	43.33	43.32	53.34
F3	98.60	7.29	29.07	1.00	10.00	52.64	35.94	48.02
F4	97.60	10.49	30.12	2.50	6.50	50.39	36.90	48.71
F5	97.00	10.45	33.18	2.00	7.00	47.37	39.69	50.72
F6	97.20	10.89	31.21	2.10	6.90	48.09	37.90	49.43
F7	97.10	9.18	32.11	2.00	6.79	49.92	38.72	50.02
F8	98.00	8.48	35.10	2.00	7.00	47.42	41.44	51.96
F9	97.30	8.26	30.07	2.00	6.50	53.17	36.86	48.68

Key: F1 – F9 = formulations, DM= Dry matter, CP= Crude protein, CF= Crude fibre, EE= Ether extract, NFE= Nitrogen free extract. ADF= Acid detergent fiber NDF=Neutral detergent fiber. ADF and NDF were calculated according to the formula of Pogano Tuscano *et al*. (1986). ADF= 9.432 + 0.912(% CF) and NDF= 28.924 + 0.657(% CF) while NFE was calculated according to the formula NFE= 100-(% CP + % CF + % EE + % Ash).

The CP values ranged from 6.51 % to 10.89 %. The higher CP value of F4, F5 and F6 was due to high proportion of cowpea husk used in the formulation which had a higher CP value than sorghum husk. This is in agreement with the results obtained by Addass *et al.* (2011), who reported that, the combination of the different feed ingredients, have helped to raise the CP contents of some cereals by-products. The low CP values obtained for F1, F2 and F3 could be due to the high proportion of sorghum husk which had a very low CP content.

The crude fibre content ranged from 29.07 % to 37.16 %. Baber *et al.* (1988) reported that during the dry season, a decrease of digestibility of grasses occur with increase in lignin and fibre content. The value obtained for F2 (37.16 %) is similar to the value 38.00 % obtained by Addass *et al.* (2011) for a diet formulated with sorghum husk and *Faidherbia albida* pods. The low CF content recorded in F3 might be due to the low CF content of the protein feed ingredients used in the formulation.

For the values of ash obtained in this study, F2 has the highest ash content and might be attributed to the high ash contents in sorghum husk and poultry litter that was used in formulating the ration. The values obtained for the different formulations were similar to the values reported by Chumpawadee *et al.* (2006) for some crop residues and selected roughages.

ADF and NDF values ranged from 35.94 % to 43.32 % and 48.02 % to 53.34 % respectively. There are many factors that may affect fibrous fraction (ADF and NDF) such as stage of growth (Promkot and Wanapat, 2004), maturity, specie or variety, drying method, growth environment and soil types.

In formulations fermented with rumen liquor (Table 2), the highest DM value was obtained in F1 (95.50 %), and the least value is obtained in F7 (93.90 %). F4 recorded the highest (15.78 %) CP value, while the least value (8.87 %) was recorded in F2. F2 has the highest CF value (29.77 %), and the least value (21.80 %) was obtained in F7. Higher ether extract value of 1.95 % was recorded in F9, while F4 had the least value (1.09 %). For ash values, F2 had the highest content (11.51 %), and the least value was obtained in F4 (6.71 %). The NFE value in F7 (56.36 %) was recorded as the highest value, and the value in F2 (48.70 %) was recorded as the least value. Highest ADF and NDF values (36.58 % and 48.48 %) were obtained in F2 and the least values (29.31 % and 43.25 %) respectively were obtained in F8.

The data in Table 2 indicated that all the formulations fermented with rumen liquor had lower dry matter content ranging from 93.90 % to 95.50 % when compared to the control (Table 1). Dry matter content is reduced with fermentation, because of the associated increased in moisture content with advanced fermentation duration (Songsak and Sirilak, 2009; Adeyemi *et al.*, 2007). This findings are similar to those reported by other researchers (Adeyemi and Familade, 2003 & Adejinme *et al*., 2007). Songsak and Sirilak (2009) reported similar trend of reduced DM content when cassava starch industry by-products were fermented using rumen microorganisms. A decrease in DM content (96.86 % to 95.44 %) was recorded when cassava peel was fermented with rumen micro-organisms. This is comparable to that reported by Adeyemi *et al*. (2007) for unfermented (38.42 %) and fermented whole cassava root meal (32.33 %) and Adejinme *et al.* (2007) for fermented and unfermented cocoa pod husk respectively. Adeyemi *et al.* (2010) recorded an increase in DM content from 85.90 % for unfermented to 86.72 % for fermented pineapple peel which is used for feeding rabbit. The result of the study is also comparable with those reported by Abd El-Galil and Ebtehag (2011) which showed that untreated bean straw had DM content of 91.68 % and the content was reduced when it was treated with *Bacillus* (90.12 %) and *Ruminococcus albus* (89.40 %).

Table 2: Proximate Composition of Formulated Rations Fermented With Rumen Liquor (%)

Formulations	DM	CP	CF	EE	ASH	NFE	ADF	NDF
F1	95.50	10.05	27.96	1.69	10.12	50.18	34.93	47.29
F2	95.35	8.87	29.77	1.15	11.51	48.70	36.58	48.48
F3	95.15	9.40	24.36	1.23	11.37	53.64	31.65	44.93
F4	94.46	15.78	26.52	1.09	6.71	49.90	33.62	46.35
F5	94.35	15.24	25.79	1.55	7.56	49.86	32.96	45.87
F6	94.25	14.90	24.94	1.62	7.12	51.42	32.18	45.31
F7	93.90	12.06	21.80	1.84	7.94	56.36	29.31	43.25
F8	94.95	13.33	27.40	1.12	7.63	50.52	34.42	46.93
F9	94.10	13.19	23.33	1.95	7.87	53.66	30.71	44.25

KEY: F1– F9 = Formulations fermented with rumen liquor, DM = Dry matter, CP = Crude protein, CF = Crude fibre, EE = Ether extract, NFE = Nitrogen free extract, ADF = Acid detergent fiber and NDF = Neutral detergent fiber. ADF and NDF were calculated according to the formula of Pogano Tuscano *et al*. (1986). ADF= 9.432 + 0.912(% CF) and NDF= 28.924 + 0.657(% CF) while NFE was calculated according to the formula NFE= 100-(% CP + % CF + % EE + % Ash). SH= Sorghum Husk, CH= Cowpea Husk, GH= Groundnut Haulms, PL= Poultry Litter, FAP= *Faidherbia albida pods.*

The results showed that the formulations fermented with rumen liquor had higher CP content with values ranging from 8.87 % to 15.78 % (Table 2) compared to the control (Table 1). From the results obtained the CP content of the formulations fermented with rumen liquor were higher than the formulations that were not fermented. Fermentation is reported to enhance the nutritional value of feedstuffs, especially the protein content (Eka, 1979). It was also reported by Oboh (2006) that the apparent increase in CP values was due to the proliferation of microorganisms in form of single cell protein. This is similar to the reports of Songsak and Sirilak (2009) who recorded CP values of 2.52 % and 17.58 % and, 2.49 % and 19.24 % for unfermented and microorganism fermented cassava pulp and peels, respectively. Similarly, Ezeronye (2004) reported increased in CP content from 5.6 % to 18.20 % when pulped cassava and rice husks were fermented using rumen digesta as inoculum. Adeyemi *et al.* (2007) also fermented whole cassava root meal with rumen filtrate and recorded an increase in CP content from 3.31 % to 9.28 %. In a study by Adeyemi *et al.* (2010) a similar trend of increase in CP from 5.11 % to 7.28 % was reported for fermented pineapple peel meal which was fed to growing rabbits. The results were in agreement with Oboh (2006) in a study with *Saccharomyces cerevesae* and *Lactobacillus* spp using solid state fermentation techniques.

The CF content of the rations had decreased in the formulations fermented with rumen liquor (Table 2) ranging from 21.80 % to 29.77 %, compared with unfermented formulations (Table 1). This showed that nutrients locked up in the fibre matrix may become accessible and utilizable by animals for improved performance (Dairo and Egbeyemi, 2012). Crude fibre fermentability has been identified as one of the limiting factors in the utilization of high fibre content feeds. The significant decrease in CF content of rumen liquor fermented formulations could be attributed to the possible rumen microbe secretion of some extra cellular enzymes such as cellulase into the formulations

and degraded the fibre (Songsak and Sirilak, 2009). The reduction might be attributed to the ability of fermenting microflora to hydrolyse and metabolise carbohydrates as carbon sources in order to synthesis cell biomass (Madigan *et al*., 2002). This is in agreement with the result obtained by Abd El-galil and Ebtehag (2011) for bean straw treated with *Bacillus* species. Abd El-galil (2008) found that using bacterial treatment (*Ruminococcus albus* and *Clostridium cellulovorans*) caused a decrease in crude fibre content from 44.08 % to 28.44 % in rice straw. This trend is also comparable to that reported by Adeyemi *et al.* (2010) for unfermented and fermented pineapple peel with a CF value of 27.95 % and 23.36 % respectively. The result of this study is also in agreement with the findings of Adeyemi *et al*. (2007) in a study with whole cassava root meal, and Noomhorm *et al*. (1992) with cassava, and reported that CF content of the tested feed decreased with fermentation.

The ether extract (EE) values of formulations fermented with rumen liquor are slightly lower ranging from 1.95 % to 1.09 % as compared with the formulations that are unfermented (Table 1). The result of the study is in agreement with the report of Dairo and Egbeyemi (2012), which recorded a decrease in EE values of fermented cassava peel and dried caged layer's manure (from 3.27 % to 3.21 %) with increase in fermentation duration. Similar decrease in EE values were obtained by Adeyemi *et al*. (2010) in their studies with fermented (1.55 %) and unfermented (1.79 %) pineapple peel meal. This is also in disagreement with Adeyemi *et al.* (2007) who reported an increase in EE values with increase in fermentation duration. Songsak and Sirilak (2009) recorded a slight increase in EE values (0.51 % and 0.74 %) for unfermented and rumen microorganism fermented cassava pulp and (0.66 % and 0.72 %) for unfermented and rumen microorganism fermented cassava peel.

The ash values of the rations fermented with rumen liquor were higher ranging from 6.71 % to 11.51 %. There was a decrease in the ash content of some of the rations after fermentation. Eka (1979) observed that during fermentation of feedstuffs, there may be an enrichment of the products as fermented products tend to exhibit a relative increase in protein, lipid and ash contents even though the products may have decreased carbohydrates content. This disagrees with the result obtained by Adeyemi *et al*. (2010) for fermented and unfermented pineapple peel (9.84 % and 11.80 %) respectively. Abd El-Galil and Ebteheg (2011) recorded an increase in ash content for bean straw treated with *Bacillus* and *Ruminococcus albus* with values of 9.72 %, 11.09 % and 12.45 % untreated, *Bacillus* and *Ruminococcus albus* treated bean straw respectively.

Table 2 shows an increase in NFE values of rations after undergoing fermentation with rumen liquor. Abd El-Galil and Ebtehag (2011) recorded an increase in NFE content when he treated bean straw with *Bacillus* and *Ruminococcus albus*. This trend is comparable to that reported by Adeyemi *et al.* (2010), Adeyemi *et al*. (2007) and Adejinme *et al.* (2007) for unfermented and fermented pineapple peel meal, whole cassava root meal and cocoa pod husk respectively. While Songsak and Sirilak (2009) recorded a decrease in NFE values with fermentation of cassava pulp and cassava peel. The result of the study showed that fermentation of the formulations resulted in a decrease in ADF and NDF contents when compared with the control (Table 1). This decrease could be as a result of the activities of cellulolytic bacteria. During fungal growth, part of the cell wall is converted into soluble sugars to provide energy, a phenomenon that could be responsible for the decrease in major fibre component (Karunnanada and Varga, 1996). It is also comparable with the result of Akinfemi *et al.* (2010) who recorded a decrease in ADF and NDF contents for biologically treated millet stover. Mahrous *et al.* (2011) recorded similar values for ADF and NDF for fungus treated sugarcane bagasse and showed that these enzymes hydrolyze the biopolymer in cell wall

structure to fermentable sugars, which was used as carbon source for fungal growth to produce biomass that enrich the treated crop residues. Similar results were reported by Abd El-Galil and Ebtehag (2011), Kholif *et al*. (2001) and Mahrous *et al.* (2011).

Table 3: Means of Dry Matter Disappearances and Degradation Characteristics of formulated rations (%)

Incubation Time (hrs)	Formulations									
	F1	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**	**F8**	**F9**	**SEM**
6	23.10^{b}	26.25^{b}	25.58^{b}	35.44^{a}	28.84^{ab}	21.89^{b}	24.21^{b}	29.69^{ab}	29.82^{ab}	2.85*
12	25.38^{c}	29.87^{abc}	27.04^{abc}	37.76^{a}	31.22^{abc}	26.13^{bc}	28.95^{abc}	39.69^{ab}	32.22^{abc}	3.50*
18	29.95^{b}	32.51^{ab}	31.93^{ab}	37.92^{ab}	34.39^{ab}	29.78^{b}	32.63^{ab}	41.64^{a}	42.01^{a}	3.24*
24	30.96^{d}	34.78^{bcd}	38.68^{b}	47.20^{a}	39.42^{b}	31.18^{cd}	37.21^{bc}	45.96^{a}	48.91^{a}	1.89*
36	49.75^{a}	34.99^{b}	47.41^{a}	54.08^{a}	49.74^{a}	48.04^{a}	48.95^{a}	49.66^{a}	51.26^{a}	3.33*
48	49.91^{c}	45.17^{d}	51.04^{c}	56.91^{a}	54.77^{ab}	52.25^{bc}	50.79^{c}	55.06^{ab}	57.21^{a}	1.06*
72	56.65^{ab}	48.12^{b}	51.56^{b}	63.53^{a}	61.38^{a}	62.36^{a}	63.41^{a}	65.63^{a}	63.92^{a}	2.82*
96	61.35^{c}	55.16^{d}	56.11^{d}	68.82^{a}	66.14^{b}	70.95^{a}	70.89^{a}	70.68^{a}	70.38^{a}	0.68*
Degradation characteristics										
A	18.04^{bc}	16.67^{c}	25.17^{a}	25.53^{a}	23.16^{a}	19.66^{b}	19.22^{bc}	18.09^{bc}	19.07^{bc}	0.98*
B	42.32^{b}	38.49^{c}	30.94^{d}	43.29^{b}	42.98^{b}	51.29^{a}	51.67^{a}	52.59^{a}	52.31^{a}	1.12*
a+b	61.35^{c}	55.16^{d}	56.11^{d}	68.82^{ab}	66.14^{b}	70.95^{a}	70.89^{a}	70.68^{a}	70.38^{a}	1.06*
C	0.025^{c}	0.011^{g}	0.027^{b}	0.025^{bc}	0.019^{f}	0.022^{de}	0.024^{cd}	0.021^{ef}	0.031^{a}	0.000*

Key: SEM = standard error of means, $^{a, b, c, d}$…. means in the same row bearing different superscripts are significantly different ($p<0.05$), * = Significant ($p<0.05$), a = soluble fraction, b = insoluble but degradable fraction, c = rate of degradation of b, a+b = potential degradability.

Rumen Degradation Studies

The DM disappearance and degradability characteristics of the formulations are shown in Table 3. Ruminal DM disappearance increased with incubation time. The highest DM disappearance at 96 hrs was recorded in F6 (70.95 %), while the least value was recorded in F2 (55.16 %). Soluble DM fraction 'a' was highest in F4 (25.53 %) and the lowest value was obtained in F2 (16.67 %). The amount of DM degraded in the rumen with time 'b' was highest in F8 (52.59 %) and lowest in F3 (30.94 %). The degradation rate 'c' of dry matter of the rations formulated with time ranged from 0.011/h to 0.031/h.

The potentially degradable DM fraction 'a+b' was highest in F6 (70.95 %) and lowest in F2 (55.16 %). The control (Table 3) had the least DM disappearance when compared with the formulations that were fermented (Tables 4). The low rate of disappearance of DM could be attributed to the fact that crop residues have high fibre and lignin contents thus prevents invasion

by rumen micro-organisms. For the values of the soluble fraction 'a', the control recorded the least when compared with the formulations that were fermented. The low 'a' fraction in the control could be due to high level of lignification of the feeds, but as the feeds were fermented, the 'a' values increased. According to Adogla- Bessa and Owen (1995), high level of lignifications resulted from the accumulation of soluble carbohydrates due to later stage of maturity. Also the values obtained for the insoluble but degradable fraction 'b', rate of degradation with time 'c' and the potential degradation (a+b) for the control followed the same trend as that of DM disappearance and soluble fraction 'a'. Low values recorded in the control are due to the presence of lignin which protects carbohydrates from attack by rumen microbes (Sallam *et al*., 2007). Similar values of 'c' were obtained for corn stover (0.022/h), cassava hay (0.020/h), rice straw (0.018/h) and sugar cane top (0.018/h) by Chumpawadee *et al*., (2006). The DM disappearance and degradability characteristics of the formulations fermented with rumen liquor (RL) are presented in Table 4. Ruminal DM disappearance increased with rumen incubation time for all the formulations. The highest DM disappearance value at 96hr of incubation was recorded in F1 (79.07 %) and the lowest value was recorded in F2 (75.38 %). The soluble DM fraction 'a' was highest in F3 (31.63 %) and lowest in F7 (21.24 %). For the insoluble but degradable fraction 'b', the highest value was obtained in F1 (56.23 %) and the least in F3 (44.93 %). The rate of degradation with time 'c' for the formulations fermented with rumen liquor was highest for F8 (0.048/h) and lowest in F2 (0.027/h). Potentially degradable DM fraction 'a+b' was observed to be highest in F1 (79.07 %) while the least value was recorded in F2 (75.38 %).

Formulations fermented with RL had the highest DM disappearance values when compared to the unfermented formulations (control) (Tables 3). The DM degradation after 48 hr of incubation was very good in formulations fermented with RL, as it was above 60 % when compared to the control. According to Ehargavi and Ørskov (1987) high values after 48 hrs of incubation imply high degradability, since degradability values at this time are regarded as being equivalent to digestibility. The high percentage recorded at 48 hrs in formulations fermented with RL could be due to the presence of microbes in the rumen liquor which helped in breaking down the lignin of the plant cell walls. This implies good digestibility potential of these formulations when harnessed as feed resources for ruminant livestock.

DM degradation characteristics for rations fermented with RL is presented in Table 4. Differences were observed between the formulations fermented with RL and the control. The soluble DM fraction 'a' was highest in formulations fermented with RL (Table 4) and least in the control (Table 3.). The highest 'a' value obtained in these formulations was as a result of fermenting the formulations with RL. This is possibly a reflection of the depletion of lignin contents of the formulations (Chumpawadee, Chantiratikul and Chantiratikul, 2007). The DM fraction 'a' obtained in this study was similar to those reported by Chumpawadee *et al*. (2006) for some crop residues and selected roughages. The values of F3, F4 and F5 were similar to the values recorded by Chumpawadee *et al*. (2005) for ground corn (29.01 %). Abubakar *et al*. (2010) recorded 29.64 % for sundried broiler litter similar to the 'a' values of F4 and F5.

Table 4: Dry Matter Disappearances and Degradation Characteristics of formulated rations fermented with rumen liquor (%)

	Formulations									
Incubation Time (hrs)	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**	**F8**	**F9**	**SEM**
6	32.45^{ab}	29.24^{ab}	32.52^{ab}	31.39^{ab}	32.36^{ab}	33.85^{ab}	26.08^{b}	36.32^{a}	34.52^{ab}	2.83*
12	41.50^{ab}	33.08^{d}	32.90^{d}	40.96^{ab}	34.80^{cd}	43.30^{a}	32.53^{d}	36.99^{bcd}	38.35^{abc}	1.61*
18	45.22^{a}	36.35^{d}	37.42^{cd}	44.95^{a}	35.79^{d}	44.69^{ab}	46.51^{a}	38.83^{bcd}	42.86^{abc}	1.86*
24	47.45^{ab}	48.81^{ab}	43.88^{ab}	47.31^{ab}	44.35^{ab}	52.58^{a}	49.09^{ab}	39.63^{b}	56.60^{a}	4.05*
36	52.83^{de}	55.51^{cde}	54.38^{cde}	50.14^{e}	58.74^{bcd}	62.36^{abc}	64.41^{ab}	56.89^{bcde}	67.35^{a}	2.63*
48	63.97^{bcd}	61.14^{d}	65.14^{abcd}	61.97^{d}	69.18^{ab}	63.06^{cd}	69.66^{ab}	70.82^{a}	68.85^{abc}	1.87*
72	69.09^{ab}	67.92^{b}	73.13^{a}	70.75^{ab}	73.29^{a}	67.87^{b}	72.04^{ab}	73.21^{a}	73.11^{a}	1.49*
96	79.07^{a}	75.38^{a}	76.02^{a}	77.31^{a}	77.74^{a}	78.01^{a}	77.12^{a}	76.28^{a}	78.63^{a}	1.39^{NS}
Degradation characteristics										
A	22.84^{de}	25.60^{c}	31.63^{a}	28.18^{b}	29.04^{b}	21.80^{ef}	21.24^{f}	23.71^{d}	22.87^{de}	0.52*
B	56.23^{a}	49.78^{c}	44.93^{d}	49.13^{c}	48.70^{c}	56.21^{a}	55.88^{a}	53.57^{b}	55.76^{a}	0.69*
a+b	79.07^{a}	75.38^{e}	76.02^{de}	77.31^{bcd}	77.74^{bc}	78.01^{abc}	77.12^{cd}	77.28^{cd}	78.63^{ab}	0.05*
C	0.034^{ab}	0.027^{b}	0.046^{a}	0.035^{ab}	0.034^{ab}	0.046^{a}	0.040^{ab}	0.048^{a}	0.039^{ab}	0.005*

Key: - SEM = standard error of means, $^{a, b, c, d}$…. means in the same row bearing different superscripts are significantly different ($p<0.05$), * = Significant ($p<0.05$) a = soluble fraction, b = insoluble but degradable fraction, c = rate of degradation of b, a+b = potential degradability.

The values obtained for the insoluble but rumen degradable fraction 'b' in RL treated formulation were higher when compared with the control (Tables 3) and is possibly influenced by the soluble carbohydrate fraction readily available to the microbial population in the formulation (Chumpawadee, Chantiratikul and Chantiratikul, 2007). Abubakar *et al*. (2010) recorded similar result to the 'b' values of F7, F8 and F9 for sundried broiler litter (54.94 %) and Cotton seed cake (54.68 %).

High rate of 'c' observed in the formulations treated with RL might be due to fermenting of the rations with RL which helped in decreasing cell wall constituents of the formulations. Similar 'c' values to F3, F6, F7 and F8 was recorded for Groundnut haulms (0.044/h) by Abubakar *et al*. (2010). For the potential degradation ``a+b' values, formulations fermented with RL were higher than the control (Table 3). The values obtained for formulations fermented with RL were similar to the values recorded for rice straw and sugar cane top by Chumpawadee *et al*. (2005). Suchitra and Wanapat (2008) also recorded similar value of 'a+b' (79.5%) for Cassava hay.

CONCLUSION

The result of this study has shown that fermentation of the formulations with rumen

liquor has improved the nutritive value of the formulations by increasing the crude protein content and reducing the crude fibre content. The dry matter disappearance of the rumen liquor fermented formulations after 48 hrs of incubation was above 50 % which implies high digestibility when fed to ruminant animals. Rumen liquor could therefore be used as a source of inoculants in fermenting the fibrous feed resources that are found in abundance during the dry season, so that they can be better utilized by ruminant livestock.

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