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Effect of Fermentation on the Nutritive Value and Rumen Degradation Characteristics of Some Locally Available Fibrous Feeds

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Abstract **– The study was conducted to determine the effect of fermentation with water 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 water recorded an increase in crude protein content which ranged from 7.12 to 13.60 % when compared to the control which varied from 6.51 to 10.89 %. Also the ash content increased when fermented with water (6.69 – 9.95 %), compared with the control of the rations (6.50 – 11.00 %). The nitrogen free extract values (43.33 – 53.17 %) increased when the rations were fermented with water (49.01 – 55.93 %). A decrease in crude fibre content (29.07 – 37.16 %) was observed when the rations were fermented (24.85 – 33.38 %). 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 water had higher dry matter disappearance values at 96 hrs (59.45% - 75.68%), while the control recorded the least values (55.16 - 70.95 %). The dry matter degradation after 48 hours was above 50% in the fermented formulations (50.49 – 66.17 %). The soluble dry matter fraction 'a' was highest in the fermented formulations (18.82 – 28.35 %) and lowest in the control (16.67 – 25.53 %). The insoluble but rumen degradable fraction "b" was highest in fermented formulations (31.10 – 55.54 %) and lowest in the control (30.94 – 52.59 %). The rate of degradation 'c' was recorded highest in fermented formulations (0.023/h – 0.037/h), and lowest in the control (0.011/h – 0.031/h), while the potential degradability (a+b) was highest in fermented rations (59.45 – 75.68) and lowest in the control (55.16 – 70.95). In conclusion, the result of the study showed that fermentation with water had increased the crude protein content and degradability of the feedstuffs and would therefore improve intake and utilization by ruminant livestock.**

Keywords **– Degradability, Fermentation, Locally Available Fibrous Feeds, Water.**

I. Introduction

Ruminant diets in most developing countries are based on forages and crop residues. These feeds are imbalanced in nutrients and are particularly deficient in protein, minerals, and vitamins and are highly lignified. 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, when poor quality forages prevail in the tropical environment (Kibon and Ørskov, 1993). The high cost of concentrate feeds for ruminants in the tropics, especially during the dry season necessitates continuous search for less expensive and highly nutritive feedstuffs. Moreover, the digestibility of agricultural by-products is very low because of the inherent lignin in the cellulose and hemicelluloses matrix (Akinfemi*et al.,* 2009). In view of this, it is therefore necessary, especially in developing countries, to develop an environmentally friendly recycling methodology that will convert the vast mass of crop residues produced annually into value added ruminant feed (Akinfemi*et al.,* 2010).

Various methods of pre-treatment aimed at delignification have been studied; these include biological, chemical and physical treatments. Numerous researchers have conducted studies on chemical and physical treatments, but in the developing countries such as Nigeria there is limited information on biological treatment of agricultural by- products (Akinfemi*et al.,* 2010). 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). Ruminal degradability is an important measurement to consider when determining the nutritive value of any feed. The study was undertaken to determine the nutrient composition, the effect of fermentation with water on the rumen and degradability of some locally available fibrous feeds.

II. Materials and Methods

Experimental Site

The study was conducted at the Teaching and Research farm, University of Maiduguri. Maiduguri is situated on latitude 10° N and 14° N and longitude 11.3° Eand 14.45° E (BOSHIC, 2007). It falls within the 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°C during the cold dry season and gets as high as 40°C or more during the hot dry 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 feedstuffs used for the study were purchased at the Maiduguri Cattle market (popularly known as *KasuwanShanu*). The feeds were sorghum husk, groundnut haulms, cowpea husk and *Faidherbiaalbida* pods (*Toltola* in Kanuri and *'Ya'yangawo* in Hausa). 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. The feed was formulated based on the energy to protein ratio of 60:40. Nine (9) rations were formulated, Sorghum husk, cowpea husk and groundnut haulms which served as energy source were included at 60 % of the ration, while poultry litter and *Faidherbiaalbida* pods which served as protein sources were included at levels ranging from 20 % to 40 % of the ration as shown in Table 2.

Feed Fermentation

Two hundred gram (200 g) each of the nine (9) formulations was placed in a plastic container; 500 ml of water was added 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 breed of bull (Wadara X Friesian) weighing 250 Kg aged 3 years 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 as a supplement, 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.

Feed samples from each treatment were collected and ground to pass through 2.5 mm sieve. Three grams (3 g) of each of the samples was weighed in duplicate into the nylon bags. The nylon bags containing the samples were tied, attached to undegradable 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 bull, but were 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 water 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 PoganoToscano*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), where:

p = the potential disappearance at time t (%),
a = fraction of material that is soluble (%),
b = fraction that is potentially degradable in the rumen (%)
c = constant rate of degradation of fraction b (h^{-1})
e = natural logarithm
t= time (h).

III. Results and Discussion

The proximate composition of the formulated rations (F1 to F9) is shown in Table 3. F3 had the highest DM content (98.60 %). F6 had the highest CP value (10.89 %) while F2 had the lowest CP value (6.51 %) and the highest CF content (37.16 %). F4 had the highest EE value (2.50 %), and the lowest value was obtained in F3 (1.00 %). The highest value of ash was obtained in F2 (11.00 %), while the lowest and similar values of 6.50 % were obtained in F4 and F9. NFE value was highest in F9 (53.17 %), and the lowest value was recorded in F2 (43.33 %). ADF and NDF values were highest in F2 (43.32 % and 53.34 %) and the lowest values were recorded in F3 (35.94 % and 48.02 %) respectively.

The CP values ranged from 6.51 % to 10.89 %. The higher CP values of F4, F5 and F6 could be due to the 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, had helped to raise the CP contents of some cereals by-products. The low CP values recorded for F1, F2 and F3 could be due to the high proportion of sorghum husk which had a very low CP 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 *Faidherbiaalbida* 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 (Table 1). 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.

The 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.

The proximate composition of formulated rations fermented with water is shown in Table 4. In the rations fermented with water, the highest DM content was recorded in F3 (96.25%), while the lowest value was recorded in F6 (94.35%). Highest CP content of 13.6% was obtained in F6, and the lowest value was obtained in F2 (7.12%). Highest CF content was recorded in F2 (33.38%), while the lowest value was in F9 (24.85%). Ether Extract values were similar was in F3 and F7 values of 2.0%. Ash value was highest in F1 (9.95%) while 6.69% was recorded as the least value in F6. In all the formulations it was observed that F9 had the highest (55.93%) NFE content, while the least value (49.01%) was obtained in F2. The highest ADF and NDF values (39.88% and 50.86%) were obtained in F2, while the least (32.10% and 45.25%) respectively were obtained in F9.

The data in Table 4 indicated that all the formulations fermented with water had lower DM content ranging from 94.35% (F6) to 96.25% (F3) when compared to the control (Table 3). Songsak and Sirilak (2009) reported a decrease DM content when cassava starch industry by-products were fermented naturally with water, the values were 96.04% and 87.61% for unfermented and naturally fermented cassava pulp respectively. Also a decrease was recorded when they fermented cassava peel (95.44% to 92.41%). The result was comparable to that reported by Adeyemi*et al.* (2007) for unfermented (38.42%) and fermented whole cassava root meal (32.33%). Adejinme*et al.* (2007) also reported a decrease when he fermented cocoa pod husk. Similarly Adeyemi*et al.* (2010) recorded a decrease in DM content from 85.90% to 86.72% when pineapple peel was fermented with water.

The results showed that the fermented formulations had higher CP content, with values ranging from 7.12% (F2) to 13.78% (F6), compared to the control. Fermentation is reported to enhance the nutritional value of feedstuff, 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. Also in a study by Adeyemi*et al.* (2010) a similar trend was reported for fermented pineapple peels.

The CF content of the fermented formulations decreased with values ranging from 24.85% to 33.38%, compared with the control (29.07% to 37.16%). Also 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 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 is identified as one of the limiting factors in utilization of high fibre content feeds.
This result was also comparable to that reported by Adeyemi*et al.* (2010) for unfermented and fermented pineapple peels with CF values of 27.95% and 23.36% respectively.

The ether extract (EE) values of rations fermented with water were slightly lower with values ranging from 1.95% to 1.09% compared with the control. Also Songsak and Sirilak (2009) recorded a slight increase in EE values (0.51% and 0.64%) for unfermented and naturally fermented cassava pulp and (0.66% and 0.76%) for unfermented and naturally fermented cassava peel. 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. Similar decrease in EE values was reported by Adeyemi*et al.* (2010) for fermented (1.55%) and unfermented (1.79%) pineapple peel meal.

The ash values of the rations fermented with water were lower with values ranging from 6.69% to 9.95% (Table 4) compared to the control (Table 3). 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 is not in conformity with the result reported by Adeyemi*et al.* (2010) for fermented and unfermented pineapple peel (9.84% and 11.80%) respectively.

The values in Tables 3 showed an increase in NFE values of rations after undergoing fermentation. This trend is comparable to that reported by Adeyemi*et al.* (2010) and Adejinme*et al.* (2007) for unfermented and fermented pineapple peel meal and cocoa pod husk respectively. However the results obtained by Songsak and Sirilak (2009) were not in agreement, as they recorded a decrease in NFE values with fermentation of cassava pulp and cassava peel.

The result of the study showed that fermentation of the rations resulted in a decrease in ADF and NDF contents when compared with the control (Table 3). Rations fermented with water had lower ADF and NDF contents when compared to the control. 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).

Rumen Degradation Studies

The DM disappearance and degradability characteristics of the formulations are shown in Table 5. Ruminal DM disappearance increased with incubation time. The highest DM disappearance at 96 hrs was recorded in F6 (70.95 %), while the lowest 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 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 unfermented formulations (Table 5) had the lowest DM disappearance when compared with the fermented formulations. The low rate of disappearance of DM could be attributed to the higher fibre and lignin contents in crop residues which prevents invasion by rumen microorganisms. For the values of the soluble fraction 'a', the control recorded the lowest values when compared with the fermented formulations. 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- Bassa 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'.

The low values recorded in the control were probably due to the presence of lignin which protects carbohydrates from attack by rumen microbes (Sallam*et al.*, 2007). 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).

DM disappearance and degradability characteristics of formulations fermented with water are shown in Table 6. The result showed an increase in DM disappearance with increased in incubation time. The highest DM disappearance at 96hours of incubation was recorded in F9 (75.68), while the lowest value was recorded in F3 (59.45). Soluble DM fraction 'a' was highest in F3 (28.35) and lowest in F1 (19.84). The amount of DM degraded in the rumen with time 'b' was highest in F6 (55.54) and lowest in F3 (31.10). The degradation rate 'c' of DM of the formulations fermented ranged from 0.038/h (F9) to 0.023/h (F2). For the values of potentially degradable DM fraction (a+b), F9 recorded the highest value (75.68) while the lowest value was recorded in F3 (59.45).

Formulations fermented with water had DM disappearance values that were higher than the control. The DM disappearance values recorded at 48 hours for all the formulations are above 50%. The results of DM degradation characteristics showed that the parameters 'a, b, c and a+b' were higher than the control.

This is an indication that fermentation increased the nutritive value of feedstuffs by depleting the lignin contents of the formulations (Chumpawadee*et al*., 2007). The value of DM fraction 'a' obtained in the formulations fermented with water were Similar to the values of Corn stover (30.94), Cassava hay (20.65) and Sugarcane top (18.00) reported by Chumpawadee*et al*., (2006).

IV. Conclusion

In conclusion fermentation had increased the crude protein content and degradability of the feedstuffs and would therefore improve intake and utilization by ruminant livestock.

Table 1: Proximate composition of feed ingredients (%)

Ingredients	**DM**	**CP**	**CF**	**EE**	**ASH**	**NFE**	**ADF**	**NDF**
SH	91.70	6.90	26.00	1.00	15.00	51.10	33.14	46.01
CH	97.80	8.22	31.00	1.00	6.00	53.78	37.70	49.29
GH	96.40	7.41	29.00	2.00	6.00	55.59	35.88	48.00
PL	96.50	8.47	28.00	2.00	8.00	53.53	34.97	47.32
FAP	96.60	10.11	23.00	2.00	4.00	60.89	30.41	44.04

Key: - SH= Sorghum husk, CH= Cowpea husk, GH= Groundnut haulms, PL= Poultry litter, FAP= *Faidherbiaalbida pods,* DM= Dry matter, CP= Crude protein, CF= Crude fibre, EE= Ether extract, NFE= Nitrogen free extract, ADF = Acid detergent fibre and NDF = Neutral detergent fibre.
ADF and NDF were calculated according to the formula of PoganoToscano*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).

Table 2: Percentage of Feed Ingredients Used in Formulating the Ration

Formulations	**SH**	**CH**	**GH**	**PL**	**FAP**
F1(60 % SH:40 % PL)	60	-	-	40	-
F2(60 % SH:40 % FAP)	60	-	-	-	40
F3(60 % SH:20 % PL & 20 % FAP)	60	-	-	20	20
F4(60 % CH:40 % PL)	-	60	-	40	-
F5(60 % CH:40 % FAP)	-	60	-	-	40
F6(60 % CH:20 % PL & 20 % FAP)	-	60	-	20	20
F7(60 % GH:40 % PL)	-	-	60	40	-
F8(60 % GH:40 % FAP)	-	-	60	-	40
F9(60 %:20 % PL & 20 % FAP)	-	-	60	20	20

Key: - SH= Sorghum husk, CH= Cowpea husk, GH= Groundnut haulms, PL= Poultry litter, FAP= *Faidherbiaalbida* pods.

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Table 3: Proximate Composition of Formulated Rations (%)

Formulations	DM	CP	CF	EE	ASH	NFE	ADF	NDF
F1(60% SH:40% PL)	98.00	9.43	35.12	2.00	10.00	45.45	41.46	52.00
F2(60% SH:40% FAP)	97.90	6.51	37.16	2.00	11.00	43.33	43.32	53.34
F3(60% SH:20%PL & 20%FAP)	98.60	7.29	29.07	1.00	10.00	52.64	35.94	48.02
F4(60%CH:40%PL)	97.60	10.49	30.12	2.50	6.50	50.39	36.90	48.71
F5(60%CH:40%FAP)	97.00	10.45	33.18	2.00	7.00	47.37	39.69	50.72
F6(60%CH:20%PL & 20%FAP)	97.20	10.89	31.21	2.10	6.90	48.09	37.90	49.43
F7(60%GH:40%PL)	97.10	9.18	32.11	2.00	6.79	49.92	38.72	50.02
F8(60%GH:40%FAP)	98.00	8.48	35.10	2.00	7.00	47.42	41.44	51.96
F9(60%:20%PL & 20%FAP)	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 PoganoToscano*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).

Table 4: Proximate Composition of Formulated Ration Fermented with Water (%)

Formulations	DM	CP	CF	EE	ASH	NFE	ADF	NDF
F1(60% SH:40% PL)	95.95	7.65	31.58	1.50	9.95	49.32	38.23	49.67
F2(60% SH:40% FAP)	95.85	7.12	33.38	1.00	9.49	49.01	39.88	50.86
F3(60% SH:20%PL & 20%FAP)	96.25	8.19	26.38	2.00	9.44	53.99	33.49	46.26
F4(60%CH:40%PL)	94.60	12.89	27.71	1.00	6.78	51.62	34.70	47.13
F5(60%CH:40%FAP)	95.25	12.46	29.69	1.50	6.79	49.56	36.77	48.43
F6(60%CH:20%PL & 20%FAD)	94.35	13.60	27.10	1.50	6.69	51.11	34.15	46.73
F7(60%GH:40%PL)	95.25	11.37	26.60	2.00	6.98	53.05	33.69	46.40
F8(60%GH:40%FAD)	95.15	10.36	29.30	1.00	7.12	52.22	36.15	48.17
F9(60%:20%PL & 20%FAD)	94.75	10.66	24.85	1.50	7.06	55.93	32.10	45.25

Key: F1 – F9 = Formulations fermented with water, 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 PoganoToscano*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).

Table 5: Means of Dry Matter Disappearances and Degradation Characteristics of formulated rations (%)

Incubation	**Formulations**									
Time (hrs)	**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.

Table 6: Means of Dry Matter Disappearances and Degradation Characteristics of formulated ration fermented with water (%)

Incubation Time (hrs)	Formulations									SEM
	F1	F2	F3	F4	F5	F6	F7	F8	F9	
6	28.59^{b}	26.61^{b}	28.35^{b}	34.59^{a}	28.84^{b}	33.94^{a}	27.36^{b}	25.36^{b}	30.02^{ab}	1.60*
12	29.43^{ab}	30.21^{ab}	32.22^{ab}	38.51^{a}	33.16^{ab}	38.34^{a}	38.98^{a}	25.88^{b}	31.83^{ab}	3.24*
18	33.11^{cd}	36.00^{bc}	37.37^{bc}	42.74^{ab}	36.05^{bc}	39.88^{abc}	44.34^{a}	27.17^{d}	37.60^{abc}	2.13*
24	42.59^{abc}	40.85^{abc}	39.81^{bc}	53.08^{a}	39.79^{bc}	41.68^{abc}	49.15^{ab}	33.23^{c}	42.15^{abc}	4.06*
36	48.95^{cd}	47.95^{d}	47.17^{de}	60.17^{a}	46.06^{de}	44.05^{e}	52.08^{bc}	47.68^{d}	53.40^{b}	1.10*
48	51.27^{e}	52.82^{de}	50.49^{e}	66.73^{a}	56.84^{e}	52.59^{de}	55.38^{cd}	50.49^{e}	60.74^{b}	1.22*
72	56.03^{de}	57.18^{de}	53.09^{e}	70.95^{ab}	66.32^{bc}	61.66^{cd}	69.14^{ab}	70.06^{ab}	72.64^{a}	1.82*
96	64.92^{b}	61.00^{c}	59.45^{c}	73.31^{a}	73.58^{a}	75.50^{a}	74.62^{a}	74.90^{a}	75.68^{a}	0.83*
Degradation characteristics										
A	19.84^{d}	18.82^{d}	28.35^{a}	26.53^{abc}	28.04^{ab}	19.96^{d}	19.89^{d}	23.23^{bcd}	20.84^{cd}	1.99*
B	45.08^{bc}	42.18^{c}	31.10^{d}	46.78^{b}	45.54^{b}	55.54^{a}	54.73^{a}	52.90^{a}	54.84^{a}	0.98*
a+b	0.030^{ab}	0.023^{b}	0.036^{ab}	0.029^{ab}	0.027^{ab}	0.035^{ab}	0.036^{ab}	0.032^{ab}	0.038^{a}	0.000*
C	64.92^{b}	61.00^{b}	59.45^{b}	73.31^{a}	73.58^{a}	75.50^{a}	74.62^{a}	74.90^{a}	75.68^{a}	2.17*

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.

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