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RUMEN DEGRADABILITY AND KINETIC PROPERTIES OF SOME FEEDSTUFF UTILISED BY CAMELS IN A SEMI ARID ENVIRONMENT OF NIGERIA

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ABSTRACT

The knowledge of the nutritive value of camel feedstuffs is important to the understanding of camel-forage relationship and development of sound husbandry decision. This study evaluated the rumen degradability and kinetics of some feedstuffs relish by camels. The crude protein (CP) of the feedstuffs ranged from 4.29% for *Guirea senegalensis* and *Diospyros mespiliformis* to 11.65% for *Centaurea perrottetii*. However, crude fibre (CF) content followed the reverse order. The solubility (a), the amount degraded with time (b) and the degradation rate (c) of the various feedstuffs were significantly ($P<0.001$) different. The feedstuffs differed significantly ($P<0.001$) in potential degradability (a + b) of the dry matter in the following order: *Leptadenia pyrotechnica* (leaves)>*Centaurea perrottetii, Anogeissus leiocarpus*>*Acacia steberiana, Annona senegalensis*>*Ziziphus mauritiana*>*Acacia albida, Diospyros mespiliformis*>*Guirea senegalensis and Acacia nilotica*>*Leptadenia pyrotechnica* (twig)>*Balanites aegyptica,* respectively. Correlation between proximate composition (CP and CF) and the rumen degradability rate constant (c) of the feedstuffs was significantly ($P<0.05$) negatively related ($r = -0.696$) between CF and CP. In conclusion, the result indicates an inverse relationship between CP and CF, and the dependence of effective degradability (P) on outflow rate (k).

Key words: Camel, feedstuff, kinetics, outflow rate, rumen degradability

Camel is likely to produce animal protein at a comparatively low cost in the arid zones based on feeds and fodder that are generally not utilised by other domestic species due to either their size or food habits (Tendon *et al,* 1988).

The deteriorating conditions of soils in Northern Nigeria has made the area unproductive for agriculture thus causing food scarcity. Rapid desertification in the region requires an alternative means of supplying protein especially from animal source. The role of the camel as a meat and milk producer is becoming more important in Nigeria due to the versatile role it plays rather than as a symbol of social prestige, which was the role it used to play, but which has since greatly diminished (Dawood and Alkanhal, 1995; Kalla *et al,* 2008).The knowledge of the quality of the feeds selected by the camel and feeds preferences is important to the understanding of the forage camel relationship.

Formulations of camel's nutritional requirements remain largely empirical and often inferred from those of cattle. This study was therefore aimed at determining the chemical composition, degradability and rumen kinetics of some feedstuffs consumed by camels.

Materials and Methods

Location

The samples of the experimental feedstuffs were collected from Hadeja-Jamaare river basin rangeland (Azare town and environs), in Bauchi State, located on latitude 11040l North of the equator and longitude 10011l East of the Greenwich Meridian. The area has an altitude of 436 metres above sea level and mean annual rainfall of 700-900mm (IAR/BSADP, 1996). The vegetation zone is the Sahel type of savannah which is also known as the semi arid vegetation.

Soil Sample Analysis

Soil samples were randomly collected from the study area at depths of 0-30, 30-60, 60-90 and 90-120cm using a soil auger for laboratory analysis. Particle size distribution, soil pH, organic carbon, available phosphorus, total nitrogen, exchangeable bases and micro nutrients (copper, iron, zinc and manganese) were determined using standard laboratory procedures as described by Agbenin

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(1995). Table 1 shows the soil properties of the study area.

Feedstuff Sampling and Preparation

The plant parts selected by the animals were hand plucked or clipped during each observation time. Samples were collected from different plants of the same species in the area to make the samples more representative. The plant materials were weighed, chopped, mixed, sampled and taken to the laboratory where these were dried at 55°C in a forced drought oven for 24 h and equilibrated at room temperature for 2 h. The dried samples were weighed and ground on a Wiley mill to pass a 2.5mm screen, sub-sampled and stored in plastic bags until analysed.

Animals and their Management

Two bulls were fitted with permanent ruminal cannulae 40mm in diameter at the Abubakar Tafawa Balewa University Teaching and Research Farm. The animals were *ad libitum* provided with feed, water and salt lick in an individual pens.

Nylon bags of (33mm x 160mm, pore size 50 x 27 microns) were used according to the procedures of rumen degradation described by Ani (1992). The washing loss was determined by weighing 5g of the milled samples (two bags per treatment) and washing after soaking for an hour in water at 39°C.

Data Collection and Analysis

Dry matter (DM) was determined by drying the samples in an oven at 55°C for 48 hours in an oven. Ash was determined by igniting feed samples (1g each) for 3 h in a muffle furnace preheated to 550°C (Abdulrazak and Fujihara, 1999). Organic matter was calculated as the difference between DM and ash. Crude protein (g N/kg DM x 6.25) was determined, using the Kjeldahl method (AOAC, 1990). Crude fibre (CF) and Ether extract (EE) was determined according to AOAC (1990).

DM disappearances from the nylon bags with time were modelled using the equation suggested by Orskov and McDonald (1979):

$P = a + b\,(1 - e^{-ct})$……………………equation 1.

Where, P = is the disappearance at time t, a = the rapidly disappearing fraction (zero time intercept), b = proportion of the feed which is slowly degraded with time, c = the rate constant for the degradation of 'b'.

The data was subjected to analysis of variance (ANOVA) by using the General Linear Model (GLM) with incubation time and feedstuffs as fixed factors in SPSS for windows (1996). Significant difference between means was detected by Duncan Multiple Range Test (DMRT).

The effective degradability of the various feedstuffs based on different ruminal outflow rates was calculated using the equation:

$P = a + bc/c + k$……..…..…………equation 2.

Where, *P* is the per cent disappearance from the nylon bag at time 't'; a, b and c being constants from Equation 1 describing the degradation and, 'k' is the fractional outflow rate. The 'k' value for each feedstuff was calculated (Orskov, 1992).

Results

The chemical composition (%) of the various feedstuffs before incubation is presented in Table 2. The proportion of each nutrient; dry matter (DM), crude protein (CP), crude fibre (CF) as well as ether extract (EE) varied in the different feedstuffs. The CP of the feedstuffs ranged from the highest 11.65% for *Centaurea perrottetii* to 4.29% for *Guirea senegalensis* and *Diospyros mespiliformis*. However, CF content followed the reverse order.

The dry matter losses from the nylon bag after incubation of the various feedstuffs with the constants of the fitted exponential equations are shown in table 3. The solubility 'a' of dry matter ranged from 19.68% for *Guirea senegalensis* to 38.20% for *Leptadenia pyrotechnica* (leaves). The 'a' values are significantly (P<0.001) different across the treatments. The amount of dry matter degraded in the rumen with time 'b' is significantly (P<0.001) higher for *Anogeissus leiocarpus* (47.73%) and lower for *Balanites aegyptica*-thorns (23.33%). The degradation rate 'c' of the dry matter of the feedstuffs ranged from 0.0032 for *Diosyros mespiliformis* to 0.0409 fractions per hour for *Leptadenia pyrotechnica* (leaves) and the values were highly significantly (P<0.001) different from each other. The feedstuffs differed significantly (P<0.001) in potential degradability (a + b) of dry matter in the following order: *Leptadenia pyrotechnica* (leaves)>*Centaurea perrottetii, Anogeissus leiocarpus*>*Acacia steberiana, Annona senegalensis*>*Ziziphus mauritiana*>*Acacia albida, Diospyros mespiliformis*>*Guirea senegalensis and Acacia nilotica*>*Leptadenia pyrotechnica* (twig)>*Balanites aegyptica-thorns,* respectively.

Comparative degradation constant 'c' at 48 hours and the outflow rate 'k' also at 48 hours is shown on Table 4. The feedstuffs had a 'k' value ranging from 0.51%/hour for *Balanites aegyptica*

Table 1. Some properties of soil at Azare.

Soil depth (cm)	Particle size distribution (%)			$pH(H_2O)$	O.C	TN	Av.P	Zn	Fe	Cu	Mn	Ca	Mg	K	Na
	Sand	Silt	Clay		g/Kg		mg/Kg					(mo/(+)/Kg			
0-30	76.5	10.98	12.92	7.09	1.35	0.14	11.4	0.43	0.34	0.02	0.28	1.81	0.89	0.05	0.07
30-60	75.8	8.28	15.92	6.38	1.07	0.11	15.2	0.22	0.15	0.02	0.21	1.28	0.79	0.50	0.04
60-90	76.8	5.28	17.92	6.27	0.94	0.11	16.8	0.24	0.00	0.02	0.37	1.52	0.70	0.82	0.02
90-120	68.8	9.28	21.92	6.90	0.92	0.10	6.7	0.17	0.70	0.02	0.38	4.50	0.68	0.81	0.02

O.C = Organic carbon TN = Total Nitrogen Av. P = Available Phosphorus

Table 2. Chemical composition of the various feedstuffs before incubation (%).

Feedstuffs	Nutrients				
	DM	OM	CP	EE	CF
Centaurea perrottetii	91.61	94.49	11.65	2.63	29.43
Leptadenia pyrotechnica (twig)	90.83	96.12	5.89	1.20	31.73
Balanites aegyptica (thorns)	89.69	95.39	5.81	2.41	31.50
Leptadenia pyrotechnica (leaves)	89.89	95.37	5.23	1.11	32.61
Guirea senegalensis	87.73	95.74	4.29	1.39	38.23
Acacia nilotica	94.20	96.72	4.62	2.10	35.24
Diospyros mespiliformis	90.23	96.77	4.29	2.41	39.43
Anogeissus leiocarpus	90.23	94.87	6.39	1.29	33.23
Ziziphus mauritiana	89.26	94.27	8.43	2.31	32.29
Acacia albida	94.23	94.80	6.28	2.13	31.29
Annona senegalensis	89.81	95.40	5.63	1.23	35.24
Acacia steberiana	88.93	96.02	5.49	1.19	32.61

DM = Dry matter OM = Organic matter CP = Crude protein EE = Ether extract CF = Crude fibre

to 2.58%/hour for *Centaurea perrottetii* with their corresponding 'c' values of 0.0357 and 0.0332 fractions per hour, respectively.

The effect of outflow rate on effective rumen degradability of the experimental feeds is presented in Table 5. There was a similarity in the effective degradability *'P'* as the outflow rate 'k' increases from 0.02 to 0.10%/hour.

The relationship between chemical composition and rumen degradability rate constant 'c' of the feedstuffs are presented in Table 6. The correlation coefficients between crude fibre (CF) and degradability rate constant 'c' and crude protein (CP) and 'c' showed a non significant negative (r = -0.384) and positive (r = 0.228) relationship, respectively. However, correlation between crude fibre (CF) and crude protein (CP) was significantly ($P<0.05$) negatively related (r = -0.696). This indicates an inverse relationship between CF and CP indicating that the higher CF content triggered a low CP value of the various feedstuffs.

Discussion

The variation in the nutrient content considered in each feedstuff could be an indication of relative bioavailability in the feedstuffs (Aina *et al,* 2006). This variation reflects the presence of plant species of different quality and the range varies depending upon maturity of the plant and condition of growth (Van Soest, 1982).

There were differences in the dry matter degradability of the feedstuffs for the four incubation periods (24, 48, 72 and 96 hours). The fineness and the high content of water soluble materials in these feedstuffs could have made this possible. Orskov (1988) made similar observations. The crude fibre (CF) and N (or protein) concentration may be attributed to the differences between feedstuffs in dry matter solubility 'a' and in potential dry matter degradability (a + b). Therefore, the observation that feedstuffs with low CF content were degraded faster, confirmed the already established fact that digestibility decreases with increasing fibre

Table 3. Dry matter disappearance and rumen degradation characteristics of the various feedstuffs.

Incubation Time (hrs)	Feedstuffs													
	CTF	LLT	BAT	LLL	GSS	ANC	DMS	ALP	ZMA	AAA	ASL	ASA	LS	RSD
24	60.03^{b}	44.18^{c}	29.33^{h}	64.32^{a}	31.50^{g}	38.80^{e}	30.74^{gh}	25.00i	35.05f	39.28^{e}	36.68^{f}	41.64^{d}	***	1.72
48	61.50^{b}	48.20^{c}	32.51^{h}	78.71^{a}	42.14^{e}	44.24^{d}	32.93^{h}	36.09^{g}	37.82^{fg}	43.62^{de}	38.35^{f}	43.04^{de}	***	1.67
72	66.13^{b}	49.63^{e}	48.04^{ef}	84.82^{a}	53.98^{d}	54.63^{d}	44.33^{g}	47.91^{ef}	57.47^{c}	47.44^{f}	43.08^{g}	48.36^{ef}	***	1.74
96	68.85^{b}	51.89^{g}	49.82^{h}	85.34^{a}	55.83^{f}	55.97^{f}	58.37^{e}	70.39^{b}	61.70^{d}	58.74^{e}	63.90^{c}	64.90^{c}	***	1.68
Constants from fitted equations:														
a	32.70^{b}	22.27^{g}	26.31^{d}	38.20a	19.68^{h}	24.44^{def}	28.79^{c}	22.66^{fg}	25.84^{d}	23.05^{efg}	24.74^{de}	26.45^{d}	***	1.03
b	36.15^{e}	29.62^{j}	23.33^{k}	47.15^{b}	36.01^{f}	31.53^{i}	29.58^{j}	47.73a	35.86^{g}	35.69^{h}	39.16^{c}	38.45^{d}	***	0.92
c	0.0332^{b}	0.0357^{ab}	0.0064^{ef}	0.0409^{a}	0.0204^{c}	0.0206^{c}	0.0032^{f}	0.0069^{ef}	0.0085^{ef}	0.0179^{cd}	0.0089^{ef}	0.0118^{de}	***	0.01
a + b	68.85^{b}	51.89^{g}	49.82^{h}	85.34^{a}	55.83^{f}	55.97^{f}	58.37^{e}	70.39^{b}	61.70^{d}	58.74^{e}	63.90^{c}	64.90^{c}	***	1.68

means in the same row with different superscripts are significantly different (***P<0.001) LS = Level of significance
a = Rapidly disappearing fraction (i.e. zero time intercept). b = Proportion of the feed which is slowly degraded with time.
c = Rate constant for degradation of 'b a + b = Potential extend of degradation. RSD = Residual standard deviation
CTF = *Centaurea perrottetii* LLT = *Leptadenia pyrotechnica* (twig) BAT = *Balanites aegyptica* (thorns) ANC = *Acacia nilotica*
LLL = *Leptadenia pyrotechnica* (leave) GSS = *Guirea senegalensis* DMS = *Diospyros mespiliformis* ALP = *Anogeissus leiocarpus*
ZMA = *Ziziphus mauritiana* AAA = *Acacia albida* ASL = *Annona senegalensis* ASA = *Acacia steberiana*

content (Bogoro *et al,* 1994). This clearly confirms the observation that the higher the acid detergent fibre (ADF) content (a component of CF) the lower the rumen degradability rates and *vice versa* (Pearce, 1983). The knowledge of this relationship would be useful in compounding ruminants diets (Bogoro *et al,* 2006).

The comparative degradability rate 'c' and outflow rate 'k' at 48 hours of the various feedstuffs showed a close relationship with each other. Similar observations have been made (Orskov, 1992; Bogoro *et al,* 1999) for feedstuffs. The 'k' and 'c' values are used in comparing digestion kinetics with those of kinetics related to particulate outflow from the rumen to the lower gut in the ruminant animal (Bogoro *et al,* 1999). Some of the feedstuffs recorded low 'c' values in this study. This is indicative of the fibrous nature of those feedstuffs (Abubakar, 2008), hence, low rumen degradability. This implies a long rumen residence time for those feedstuffs to be broken down to fine particles enough before leaving the rumen (Abubakar, 2008).

Increasing the outflow rate 'k' from 0.02 to 0.10 results in a corresponding decrease in effective degradability of the various feedstuffs. The rapidly soluble fraction 'a' and the rate constant 'c' for the degradation of the feed 'b' could have influenced the effective degradability (Abubakar, 2008). The effective degradability 'P' dependence on outflow rate is illustrated in Table 5. These observations agree

Table 4. Comparative degradability rate (c) and outflow rate (k) of the various feedstuffs.

Feedstuffs	48 hour 'k' value	'c' value
Centaurea perrottetii	2.58	0.0332
Leptadenia pyrotechnica (twig)	0.51	0.0357
Balanites aegyptica (thorns)	1.53	0.0064
Leptadenia pyrotechnica (leaves)	0.67	0.0409
Guirea senegalensis	1.23	0.0204
Acacia nilotica	1.84	0.0206
Diospyros mespiliformis	1.83	0.0032
Anogeissus leiocarpus	1.76	0.0069
Ziziphus mauritiana	1.70	0.0085
Acacia albida	1.32	0.0179
Annona senegalensis	1.67	0.0089
Acacia steberiana	1.56	0.0118

with earlier report (Orskov, 1985) that effective rate of degradation depends on solubility 'a', the rate at which the 'b' fraction is degraded 'c' and the outflow rate of small particles 'k'.

The correlation between chemical components (crude protein and crude fibre) and degradability rate constant 'c' demonstrate the extent to which chemical composition (which is a good indicator of nutritive value of feedstuffs, especially those without anti-nutritional components) could be related with rates of rumen degradability and by implication, the nutritive value of ruminant feedstuffs. The result is

Table 5. Effective degradability (P) of the feedstuffs at different outflow rates (K).

Feedstuffs	Outflow Rates (K)				
	0.02	0.04	0.06	0.08	0.10
Centaurea perrottetii	55.26	49.10	45.58	43.30	41.71
Leptadenia pyrotechnica (twig)	41.06	36.07	33.19	31.32	29.99
Balanites aegyptica (thorns)	31.97	29.53	28.56	28.04	27.71
Leptadenia pyrotechnica (leaves)	69.85	62.02	57.29	54.03	51.87
Guirea senegalensis	37.86	31.84	28.82	27.00	25.78
Acacia nilotica	40.44	35.16	32.50	30.90	29.83
Diospyros mespiliformis	32.86	30.98	30.29	29.93	29.71
Anogeissus leiocarpus	34.90	29.68	27.56	26.45	25.74
Ziziphus mauritiana	36.54	32.12	30.29	29.22	28.65
Acacia albida	39.91	34.08	31.25	29.12	28.20
Annona senegalensis	36.34	31.59	29.60	28.51	27.82
Acacia steberiana	40.72	35.21	32.77	31.39	30.51

therefore similar with earlier reports (Preston, 1986; Orskov, 1992).

Conclusion

The study indicated that dry matter degradability of the various feedstuffs is influence by the crude protein and crude fibre content of the feedstuffs. High crude protein content with consequent low crude fibre content elicits dry matter degradability value of the feedstuffs and *vice versa*.

It also reveals that an increment in the out flow rate (k) from 0.02 to 0.10 affected the effective degradability of the feedstuffs. This indicates the dependence of effective degradability (P) on outflow rate which is influenced by the rapidly disappearing fraction (a) i.e. zero time intercept, proportion of the feed which is slowly degraded with time (b) and (c) rate constant for degradation of 'b'.

Table 6. Relationship between chemical composition and degradability rate constant 'C' of the different feedstuffs.

Feedstuffs	Crude fibre (CF)	Crude protein (CP)	'C' Value
Centaurea perrottetii	29.43	11.65	0.0332
Leptadenia pyrotechnica (twig)	31.73	5.89	0.0357
Balanites aegyptica (thorns)	31.50	5.81	0.0064
Leptadenia pyrotechnica (leaves)	32.61	5.23	0.0409
Guirea senegalensis	38.23	4.29	0.0204
Acacia nilotica	35.24	4.62	0.0206
Diospyros mespiliformis	39.43	4.29	0.0032
Anogeissus leiocarpus	33.23	6.39	0.0069
Ziziphus mauritiana	32.29	8.43	0.0085
Acacia albida	31.29	6.28	0.0179
Annona senegalensis	35.24	5.63	0.0089
Acacia steberiana	32.61	5.49	0.0118

r (CF:CP)=-0.696*; r (CP:C)=0.228^{NS}; r (CF:C)=-0.384^{NS}; NS=Not-Significant *=P<0.05

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