Comparison of water melon (*Citrullus vulgaris*)-seed meal, *Acacia tortilis* pods and sunflower-seed cake supplements in central Tanzania.

1. Nutritive value and influence on the rumen environment

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Abstract

A study was made of the chemical composition and *in vitro* and *in sacco* digestibility of water melon (*Citrullus vulgaris*) seeds, *Acacia tortilis* pods and sunflower-seed cake and their effect on the rumen environment of a steer fed a basal diet of *Cenchrus ciliaris* hay.

Water melon seeds contained 15.5–18.5% crude protein (CP) and 24% ether extract (EE). Levels of soluble and condensed phenolics were negligible. CP level of *Acacia* seeds (18.6%) was higher than that of the empty pods (9.3%), the average CP content of the whole pod being 13.4%. *Acacia* seeds and empty pods had similar levels (41%) of soluble phenolics, while the level of condensed tannins was higher in the seeds [15 absorbance at 550 nm/g of neutral detergent fibre (abs/g NDF)] than in the empty pods (7.78 abs/g NDF). Similarly, the *Acacia* seeds had higher *in vitro* organic matter digestibility (86%) and total rumen degradable nutrients (82%) than the empty pods (60% and 66%, respectively). Rumen NH_3-N and pH levels were not affected by either water melon seed or *Acacia* pod supplementation.

The role of these supplements in cattle farming systems in central Tanzania is discussed.

Introduction

The major importance of browse trees and shrubs is that they provide protein, vitamins and frequently mineral elements which may be lacking in pastures during the dry season. In Africa, there is only limited information concerning the importance of trees and shrubs for livestock production (Le Houerou 1980; Pellew 1980). Information on their nutritive value and utilisation by animals in Africa has been published sporadically, usually giving only quantitative information on pastoral problems. This also applies to the pods of *Acacia* species, although pods can contribute considerable quantities of high quality feed to grazing animals during the dry season (Lamprey 1967; Gwynne 1969; Tanner *et al.* 1990).

Use of water melons as the main source of water for pigs, donkeys and cattle, particularly young, sick and lactating animals, is increasing in some villages in central Tanzania. The seeds that slip from the mouths of the animals are collected from the feeding containers and fed to other livestock to complement other locally available supplements (Shayo *et al.* 1996). Some seeds are obtained from melons consumed by people. Before the seeds are fed, they are ground, sometimes after brief roasting. There is limited information on the feeding value of water melon seeds other than the data on chemical composition and digestibility reported by Sharma *et al.* (1986) and Kusekwa *et al.* (1990).

The aim of this study was to evaluate the nutritive value of *Acacia* pods and water melon seeds in terms of chemical composition, digestibility and degradability, and to assess their effect on the rumen environment.

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Materials and methods

Sample collection and preparation

Acacia tortilis pods containing seeds were collected during the dry season, the seeds were separated from the pods, and both seeds and pods were weighed. Fresh water melons were obtained from Berege village, about 30 km from Mpwapwa township in central Tanzania, also during the dry season. The melons were chopped and the seeds separated from the rind. The feed samples for chemical analysis and *in vitro* organic matter digestibility (IVOMD) determinations were pre-dried in a forced-air oven at 65°C for 12 h. Samples intended for further analysis were ground to pass through a 1 mm screen, and those for *in sacco* degradation were milled through a 3 mm screen.

Chemical analyses

Dry matter (DM), ash, ether extract (EE) and crude protein (CP) concentrations were determined according to procedures of AOAC (1985). Neutral detergent fibre (NDF), acid detergent fibre (ADF), acid detergent lignin (ADL) and acid detergent fibre-bound nitrogen (ADF-N) concentrations were determined according to the procedure of Goering and Van Soest (1970). Hemicellulose (HEM) was calculated as the difference between NDF and ADF, while cellulose (CEL) was presented as the difference between ADF and ADL.

Soluble phenolics-tannins (SPHEN) were determined using a gravimetric technique based on precipitation with trivalent ytterbium (ytterbium acetate) according to Reed *et al.* (1985). Condensed tannins-proanthocyanidins (CPRC) were measured by heating NDF (5 mg) in butan-1-ol (5 ml) containing 5% concentrated HCl at 100°C for 1 h. On heating, the colour concentrations of the contents were read using an atomic absorption spectrophotometer, at an absorbance of 550 nm (Reed *et al.* 1985).

Rumen environment (NH_3-N and pH) evaluation

The animal, diets (treatments) and feeding procedure. One Boran steer weighing 420 kg and fitted with a permanent rumen fistula was used to determine pH and ammonia-nitrogen (NH_3-N) concentration in the rumen on the following treatments:

Period	Treatment (Daily ration)
1	A, Control (10 kg *Cenchrus ciliaris* hay)
2	B, Control + 1.5 kg *Acacia tortilis* pods
3	C, Control + 1.5 kg water melon-seed meal
4	D, Control + 1 kg sunflower-seed cake

The supplements were formulated to provide equal amounts of CP.

The steer was provided with each test feed (treatment) for 17 days, making a total of 68 days for the whole experimental period. Hay was fed at 09.00, 11.30, 14.30 and 17.00 h at a rate of 2.5 kg at each feeding time. Supplements were provided in 2 equal amounts at 09.00 h and 17.00 h. Water and a mineral block (Maclick super, Welcome Tanzania Ltd) were accessible to the animal throughout the experimental period (see Shayo *et al.* 1996).

Determination of rumen NH_3-N and pH. The rumen pH and NH_3-N were determined from Day 15 on each experimental diet for 3 consecutive days at 09.00 (just before feeding), 11.00, 13.00, 17.00 (just before feeding), 19.00 and 22.00 h. Fluid (approximately 300 ml) was consistently collected from the liquid layer of the rumen, in the ventral sac to minimise variation. After collection, the rumen liquor was divided into 2 portions, one containing about 100 ml and the second about 200 ml. The pH of the 100 ml sample was determined immediately (within 60 seconds of collection) using a pH meter. The other sample was treated with 10 ml of 10M sulphuric acid to prevent loss of ammonia, was centrifuged, and the supernatant was stored at about −20°C, for subsequent determination of NH_3-N by the Kjeldahl method.

In sacco *DM degradation of the feeds.* The rate and extent of degradation of the supplements in the rumen were determined when the animal was provided with the control diet of hay and mineral licks. Samples of the supplements in nylon bags were introduced into the rumen of the same fistulated steer after 15 d on the control diet. Nylon bags, measuring 8 × 15 cm and containing 3–5 g ground material, were suspended from a nylon string in the rumen of the steer. The bags were tied together with a lead weight in order to hold the samples in the liquid layer of the rumen. Duplicate bags were removed from the rumen after incubation for 6, 12, 18, 24, 48 and 72 h, washed with running tap water for about 5 minutes, dried at 100°C overnight and weighed. The difference in pre-incubation and post-incubation dried samples was the amount of supplement degraded.

In vitro *OM digestibility of the feeds.* Rumen liquor from the fistulated steer was collected on Day 15 of feeding the control diet and used to incubate the *Acacia* pods and water melon samples for *in vitro* digestibility determination.

The determination was performed following the single-stage procedure of Goering and Van Soest (1970) as modified by Mbwile and Udén (1991).

Results

On average, *Acacia tortilis* seeds comprised 44.6% of the total pod weight. Seeds of *Acacia tortilis* contained higher CP, EE, HEM (Table 1), CPRC, P and Mg (Table 2) than the empty pods. Concentrations of soluble phenolics, ADF-N, Na, Ca, ADL and ash in the *Acacia* seeds and empty pods were similar. Generally, CP, soluble phenolics and condensed proanthocyanidin concentrations in *Acacia* pods were fairly high. It is interesting to note that EE concentrations in water melon seeds were very high. Sunflower-seed cake had higher CP values than water melon seeds and *Acacia* pods. It contained considerable EE and high fibre.

Generally, *Acacia tortilis* seeds had higher *in vitro* OM digestibility values than the empty pods, water melon seeds and sunflower-seed cake. DM degradability *in sacco* was highest for *Acacia tortilis* seeds followed by *Acacia* empty pods (Figure 1). Water melon seeds and sunflower-seed cake had similar and fairly low *in sacco* degradability values. The degradable components in water melon seeds and sunflower-seed cake were degraded very quickly and most had disappeared during the first 6 h of incubation.

Sunflower-seed cake induced higher NH_3-N production in the rumen than the other feeds, with a maximum of 29 mg/100 ml of rumen fluid 3 h after the morning feeding (Figure 2). There was no increase in rumen NH_3-N due to water melon-seed meal supplementation.

Rumen pH levels for all treatments declined slowly from the morning feeding until about 2 h after the evening feeding (Figure 3). The *Acacia* pod supplement produced consistently lower pH values than the other treatments.

Table 1. Chemical composition and *in vitro* organic matter digestibility (IVOMD) of water melon seeds, sunflower-seed cake, *Cenchrus ciliaris* hay and some components of *Acacia tortilis* pods.

Feedstuff	Composition[1]								IVOMD
	Ash	CP	NDF	ADF	ADL	EE	HEM	CEL	
				(% DM)					(%)
Water melon seeds	2.6	16.8	61.5	43.8	12.2	24.4	17.0	31.8	51.4
Acacia tortilis seeds	3.7	18.6	42.8	25.3	6.8	1.4	17.5	18.5	86.4
Acacia tortilis empty pods	4.5	9.3	45.0	37.7	7.7	0.8	7.3	30.0	59.7
Acacia tortilis whole pods	4.1	13.4	44.0	32.2	7.7	1.1	11.8	24.9	NA[2]
Sunflower-seed cake	6.6	25.8	62.3	41.9	12.9	13.1	20.4	29.0	56.1
Cenchrus ciliaris hay	9.5	4.7	72.5	40.8	8.1	1.4	31.7	32.7	61.0

[1]CP — crude protein; NDF — neutral detergent fibre; ADF — acid detergent fibre; ADL — acid detergent lignin; EE — ether extract; HEM — hemicellulose; CEL — cellulose.
[2]Not analysed.

Table 2. Mineral composition, acid detergent fibre-bound N (ADF-N), soluble phenolics (SPHEN), and condensed proanthocyanidins (CPRC) of water melon seeds, sunflower-seed cake, *Cenchrus ciliaris* hay and some components of *Acacia tortilis* pods.

Feedstuff	ADF-N	Available N	SPHEN	CPRC	Minerals				
					Ca	P	K	Mg	Na
	(% of total N)	(g/100 g)		(abs/gNDF)			(g/kg)		
Water melon seeds	6.8	2.76	<1.0	1.16	0.96	5.9	4.3	2.7	0.07
Acacia tortilis seeds	31.6	2.04	40.14	15.06	6.20	2.4	8.0	2.1	0.11
Acacia tortilis empty pods	29.6	1.05	42.93	7.78	6.60	1.0	14.8	0.7	0.11
Acacia tortilis whole pods	30.8	1.48	41.77	11.04	6.42	1.6	11.7	1.3	0.11
Sunflower-seed cake	8.2	3.75	<1.0	5.08	2.70	5.4	8.8	3.2	0.09
Cenchrus ciliaris hay	55.9	0.33	NA[1]	2.81	NA	NA	NA	NA	NA

[1]Not analysed.

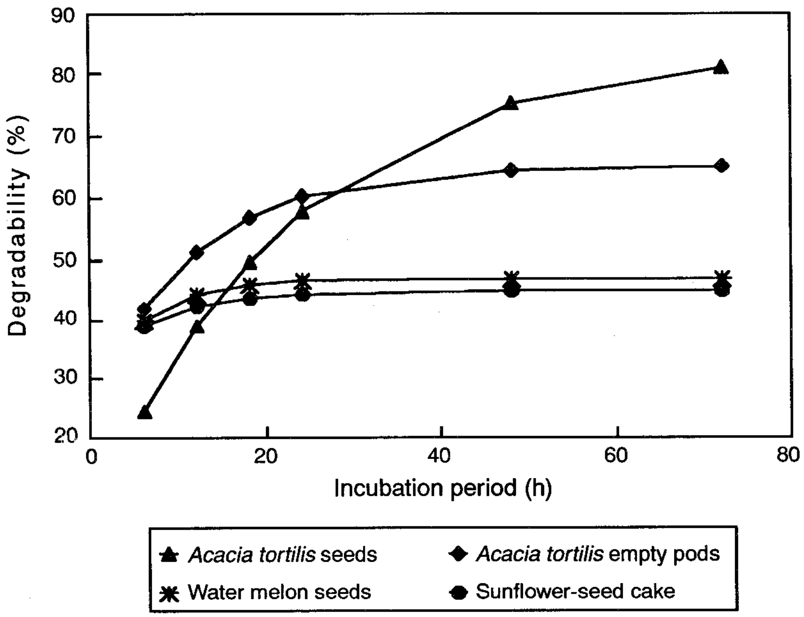

Figure 1. *In sacco* degradability of sunflower-seed cake, water melon seeds and components of *Acacia tortilis* pods.

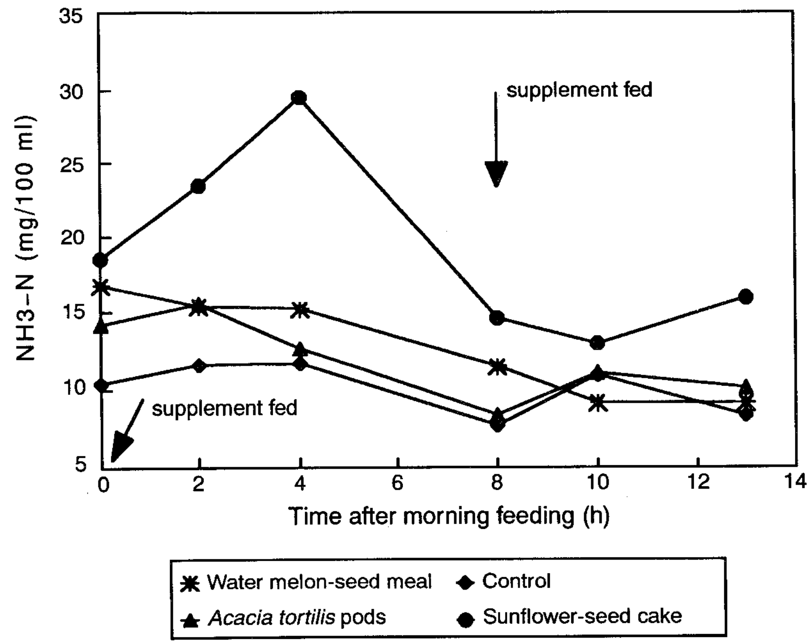

Figure 2. Rumen NH_3–N production following supplementation with *Acacia tortilis* pods, water melon-seed meal and sunflower-seed cake on a *Cenchrus ciliaris*-based diet.

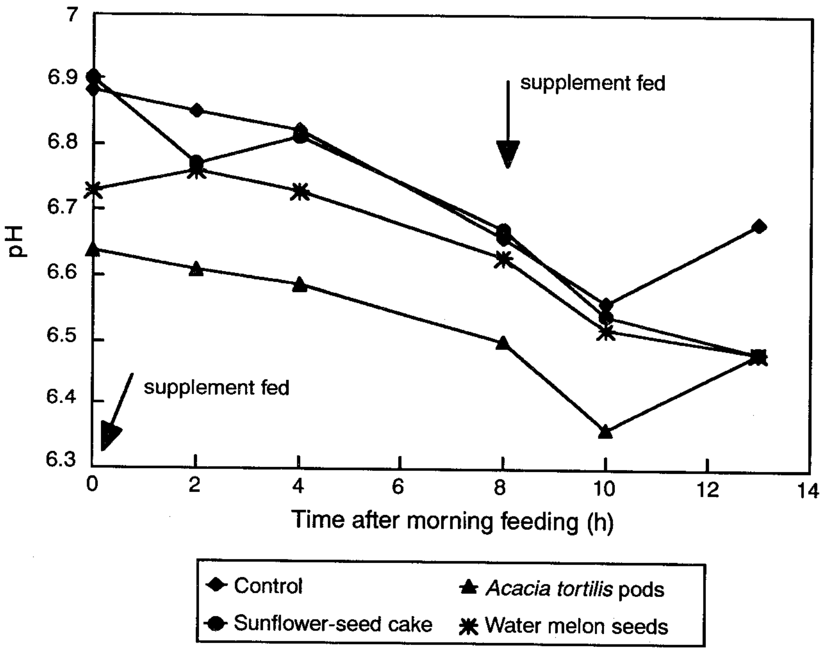

Figure 3. Rumen pH following supplementation with *Acacia tortilis* pods, water melon-seed meal and sunflower-seed cake on a *Cenchrus ciliaris*-based diet.

Discussion

This study has shown that *Acacia tortilis* pods contain fairly high amounts of nutrients, particularly CP, concentrated mainly in the seeds. This emphasises the need to grind the pods before they are fed in order to take advantage of the nutrients, which would otherwise be lost, as most seeds pass through the alimentary tract of domestic and wild grazing animals undigested (Lamprey 1967; Tanner *et al.* 1990). Studies conducted in central Tanzania have shown that *Acacia tortilis* pod production ranges from 30–210 kg/tree/yr (mean = 93 ± 44 SD) depending on season, location, age and size of the tree (Shayo 1992). Therefore, one *Acacia tortilis* tree is capable of producing sufficient pods to feed an animal for 20–140 d at 1.5 kg/d.

Levels of soluble phenolics in water melon seeds were very low (< 1.0%), so by-pass proteins are not likely to be present. The high level of soluble phenolics in the *Acacia tortilis* seeds and empty pods, and the low rumen NH_3-N produced from *Acacia* pod supplementation, may imply a possibility of by-pass nutrients (particularly protein) important for livestock productivity, although protein utilisation might be reduced by the high levels of condensed proanthocyanidins (Reed and Soller 1987) and fibre-bound nitrogen (Van Soest 1982). However, Shayo *et al.* (1997) found that supplementing with sunflower-seed cake, water melon-seed meal and *Acacia tortilis* pods failed to affect hay intake. Total DM intakes and milk yields were similar for all three supplements, indicating that by-pass proteins were not present in sufficiently high concentrations to have any effects on production.

The high fat content of water melon seeds could be an important source of energy for livestock (Palmquist and Jenkins 1980), a deficiency of which is one of the limiting factors in livestock production in the tropics (Van Soest 1982). CP concentration in water melon-seed meal is fairly high, suggesting that the seeds could be used to minimise CP deficiencies faced by grazing animals in the semi-arid areas of central Tanzania, particularly during the dry season. It has been reported that water melon seed production ranges between 30–95 kg/ha (Shayo *et al.* 1996). This implies that an average farmer (with 2.5 ha) in Berege village may obtain about 75–240 kg of melon seeds per year. This amount is sufficient to supplement an animal for 50–160 d at 1.5 kg/d.

NH_3-N levels recorded on all the feeds at any time after feeding were below the toxic level of 100 mg/100 ml of rumen fluid (Owens and Zinn 1988). The levels were within the range for maximum microbial synthesis (Houpt 1970; Pisulewski *et al.* 1981) and maximum OM digestion (Journet *et al.* 1983). Likewise, pH values for all the diets were within the range favourable for optimum microbial performance (Hungate 1988). Sunflower-seed cake produced relatively higher levels of NH_3-N, an indication of the presence of a readily fermentable source of protein (Madsen and Hvelplund 1985; NRC 1985).

Conclusions

Acacia seeds and pods and water melon-seed meal have been shown to contain high levels of nutrients, and to have moderate digestibility and rumen degradability. They represent possible alternative concentrate sources for cattle, which would ease the conflict between humans, monogastrics and ruminants for grains. Household production of water melon seeds is inadequate to supplement an animal for the whole dry season, which lasts for 6–8 months per year.

It is suggested that further studies are needed to determine the optimum levels of *Acacia* pods and water melon-seed meal in the rations of lactating cattle and other classes of livestock in the semi-arid areas of central Tanzania.

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