The Potential of Cassava Peel for Feeding Goats in Nigeria

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Six rations numbered T_1 to T_6 [T_1: 100% *Gliricidia sepium*, T_2: 100% *Panicum maximum*, T_3: 100% cassava peel, T_4: 35% *G. sepium* + 35% *P. maximum* + 30% cassava peel, T_5: 70% *G. sepium* + 30% cassava peel, and T_6: 70% *P. maximum* + 30% cassava peel] were fed to 24 intact bucks of the West African Dwarf (WAD) breed. Four bucks were randomly assigned to each dietary treatment. The experiment lasted 90 days. Treatment effect on dry matter intake (DMI) was significant ($P<0.05$). Goats on diet T_4 consumed the highest dry matter (DM) and organic matter (OM); those on T_2 consumed the highest acid detergent fiber (ADF) and neutral detergent fiber (NDF), while those on T_1 consumed the highest amount of nitrogen (N). The least N consumption was by goats on diet T_3. Goats on T_3 digested the most DM and OM ($P<0.05$); those on T_2 digested ADF most ($P<0.05$); N and NDF were most digested ($P<0.05$) by goats on T_5; goats on T_3 had negative N digestibility ($P<0.05$). The highest levels of digestible dry matter intake (DDMI) and digestible organic matter intake (DOMI) were by goats on T_4 while those on T_1 had the least DDMI; those on T_2 had the highest digestible ADF intake (DADFI) while those on T_6 received the highest digestible NDF intake (DNDFI); the highest digestible N intake (DNI) was by goats on T_1 while those on T_3 had the least DNI. The diet numbered T_4 significantly ($P<0.05$) promoted positive body weight change while goats on T_3 lost weight daily.

Goats are one of the few trypanotolerant livestock species in the humid zone of Nigeria, where most households keep an average of 9 goats while larger numbers are kept in the savanna parts of the country. FAO (1980) estimated the goat population in Nigeria at 35.7 million.

The major constraint to goat production in Nigeria is the availability of suitable feeds (Adegbola 1982, Olubajo and Oyenuga 1974).

Gliricidia sepium is a perennial fast-growing, highly prolific, leguminous browse plant. The other desirable characteristics of *Gliricidia sepium* have been documented by Thomas (1961), Chadhokar (1982), Falvey and Lindsay (1982), and Sumberg (1984). Its utilization as livestock feed in Nigeria only recently received attention from the International Livestock Centre for Africa (ILCA 1983), Ademosun et al. (1985), Mba, Manigui and Awah (1982), and Onwuka (1983). It has 7.4-34.5 % DM on "as fed" or fresh basis; other contents, on DM basis, are OM (81.9-92.3 %), crude protein (CP, 19.4-26.1 %, i.e. N, 3.1-4.2 %), NDF (30.8 %), crude fiber (CF, 12.7-32.5 %), and 18.5-44.4 % ADF (King 1986, Ngone 1985, Mani 1984, Onwuka 1983, Chadhokar and Sivasupiramaniam 1983, Carew 1983 and Oakes and Skov 1962).

Panicum maximum, a widely distributed grass in Nigeria, is highly relished by ruminant animals. It has 23.5-29.9 % DM at harvest (Gbankoto 1982, Aken'ova and Mohamed-Saleem 1982, Olubajo 1977) and on DM basis, CP content of 4.9-12.8 % (i.e. N, 0.8-2.0 %), and 29.5-49.2 % CF as reported by Gbankoto (1982) and Aken'ova and Mohamed-Saleem (1982).

Cassava peel is a major by-product of the cassava tuberous root processing industry. In parts of Nigeria where cassava is grown and the tubers processed, the peel is largely underutilized as a livestock feed. In Nigeria, the average annual yield of cassava tuberous roots is 21.1t/ha (Hahn and Chukwuma 1986). Since the peel constitutes 20.1 percent of the tuber (Hahn, Chukwuma and Almazan 1986), it follows that about 4.2t of cassava peel per ha are available annually for feeding ruminants, especially goats. The following composition has been reported for cassava peel: residual DM 86.5-94.5 %, OM 89.0-93.9 %, CF 10.0-31.8 %, CP 4.2-6.5 % (i.e. N 0.7-1.0 %) by Onwuka (1983), Carew (1982), Adegbola (1980) and Oyenuga (1968).

An average intake of 21.3g $kg^{-0.75}$ d^{-1} DM of *Gliricidia* has been reported for goats (Ademosun et al. 1985, Onwuka 1983, Carew 1983). Mba et al. (1982) reported values ranging from 31.4 to 50.2 % for kids on *Gliricidia* while Onwuka (1983) reported gains of 20 g/day for goats on sole *Gliricidia* diet.

Information is lacking on intake and utilization of *Gliricidia* + cassava peel, *Panicum* + cassava peel, and *Gliricidia* + *Panicum* + cassava peel when fed to goats. The present study was therefore conducted to assess the potential of cassava peel as a supplement to *Gliricidia*, *Panicum*, or both in goat feed.

Materials and methods

Twenty-four intact bucks, aged 6 to 9 months and weighing an average of 6.05kg (range = 5.0 to 10.0kg), from the University of Ibadan Teaching and Research Farm, were first purged of internal and external parasites with appropriate drugs. They were then housed in previously disinfected individual metabolism cages, and offered liberal but known quantities of experimental diets daily for a 21-day preliminary period to adapt the animals to the diets and the cage environment. Cool fresh water and salt lick were also offered in the cages. During the period, the daily voluntary feed intake was determined. Total faeces and urine from the experimental animal were collected during the following 7 days (days 22-28) and the last 7 days of the experiment (days 84-90). Confinement and feeding continued until day 90. The animals were weighed once a week (on the same day of every week at about the same time of day) in the morning before feeding and watering so as to minimize error due to "gut fill".

Fresh *G. sepium* branches (about 1.2m long and 1.5cm thick) with leaves and branchlets, and fresh *P. maximum*, chopped to about 2.0cm length, were obtained daily from ILCA in Ibadan, between April and July 1985. Cassava peel was obtained fresh from local cassava grating plants in and around the University of Ibadan campus. The peel was sun-dried for 3 to 4 days, depending on the intensity of the sun, packed in jute bags and stacked away in the store on raised wooden planks until required for feeding.

The diets fed to the goats (table 1) were 100% *G. sepium*, 100% *Panicum*

maximum and 100% cassava peel, in treatments T_1, T_2, and T_3 respectively, and 35% *G. sepium* + 35% *P. maximum* + 30% cassava peel (T_4), 70% *G. sepium* + 30% cassava peel (T_5), and 70% *P. maximum* + 30% cassava peel (T_6). The amount of each diet offered to each experimental animal ensured a 5% leftover. Residues were collected after a 24-h feeding period, then weighed and used to determine the voluntary intake.

Table 1. Feed components in diets offered to West African Dwarf goats

Feed component (% w/w)	Diet					
	T_1	T_2	T_3	T_4	T_5	T_6
Gliricidia	100	0	0	35	70	0
Panicum	0	100	0	35	0	70
Cassava peel	0	0	100	30	30	30

Samples of *G. sepium*, *P. maximum* and cassava peel offered and rejected during the period were collected daily. A subsample of each was dried in a forced draft oven at 100-105°C for 48 h for DM determination. Another subsample was dried at 60°C for 48-72 h for chemical composition analysis. The samples for the whole collection period were bulked, milled in a laboratory hammer mill to pass a 0.6-mm sieve, thoroughly mixed, stored in bottles fitted with air-tight screw caps and kept in a dark cupboard until required for analysis.

Total faeces were collected in the mornings before feeding and watering during days 22-28 and the last 7 days of the experiment. The faeces were weighed fresh and 10% aliquot of each day's collection for each animal was taken, dried at 60°C for 48-72 h in a forced draft oven and bulked. A subsample of faeces from each animal was dried in a forced draft oven at 100-105°C for 48h for DM determination. The two 7-day faecal samples for each experimental animal were thoroughly mixed, milled in a laboratory hammer mill to pass a 0.6 mm sieve and put in sealed polythene bags. These were then stored in a cupboard at room temperature until required for analysis. 5g of the milled faeces were dried in an oven at 100°C-105°C for 48 h to determine its residual moisture content.

Total urine excreted by each experimental animal was collected daily in the morning before feeding and watering. The urine was trapped in a plastic bucket placed under each cage and to which 75ml of 25% H_2SO_4 had been added daily to curtail volatization of ammonia from the urine. The total volume of urine output per animal was measured and aliquots (10%) of daily output were saved in stoppered plastic bottles, numbered and stored in a deep freezer at -5°C. At the end of each 7-day collection period, the sample collections were bulked for each animal and subsamples were taken for analysis.

The milled samples of *G. sepium*, *P. maximum*, cassava peel and faeces were analyzed for DM, OM and N according to AOAC (1975) procedures, and

ADF and NDF according to the methods of Goering and Van Soest (1970) and Van Soest and Robertson (1980).

The data obtained were subjected to analysis of variance. Differences between treatment means were determined by Duncan's Multiple Range Test with computers at IITA, Ibadan, using Genstat V Release 4.04B program of 1984 by Lawes Agricultural Trust (Rothamsted Experimental Station).

Results and discussion

The chemical composition of the experimental diets is shown in table 2. The chemical components of *G. sepium*, *P. maximum* and cassava peel of this study compared favorably with values reported in the literature (Carew 1983, Chadhokar and Sivasupiramaniam 1983, Onwuka 1983, Aken'ova and Mohamed-Saleem 1982, Adegbola 1980, Olubajo 1977, Oyenuga 1968).

Table 2. Chemical composition of *Gliricidia sepium*, *Panicum maximum* and cassava peel fed to West African Dwarf goats

Chemical component (%)	Diet					
	T_1	T_2	T_3	T_4	T_5	T_6
Dry matter	31.0±0.6	24.7±0.4	86.4±0.2	45.4±0.4	47.7±0.5	43.2±0.3
Organic matter	91.3±1.3	87.7±0.6	89.3±1.8	89.4±1.6	90.7±1.5	88.1±0.9
Acid detergent fiber	28.3±3.7	40.2±1.4	23.9±3.5	31.1±2.8	27.0±3.0	35.3±2.1
Neutral detergent fiber	41.5±3.4	65.5±1.5	34.3±4.3	47.7±3.0	39.3±3.7	56.1±2.3
Nitrogen	3.8±0.1	1.7±0.2	1.0±0.4	2.2±0.2	2.9±0.2	1.5±0.3

Notes: The diets T_1 - T_6 are as composed in table 1

The DM and nutrient intakes by WAD goats are summarized in table 3. The highest DM and OM intakes were from T_4 diet, probably because the combination was palatable. Goats on T_3 had the least DM intake (DMI) despite the low ADF and NDF content of the peel. An inverse relationship has long been reported between the DMI and the fiber content of feed (Reid and

Table 3. Dry matter and nutrient intake (g $kg^{-0.75}$ d^{-1}) by West African Dwarf goats fed *Gliricidia sepium*, *Panicum maximum* and cassava peel

Nutrient	Diet					
	T_1	T_2	T_3	T_4	T_5	T_6
Dry matter	46.3±12.7c	63.5±8.8b	41.5±1.0c	86.4±7.4a	76.0±3.4ab	73.8±8.6ab
Organic matter	43.0±11.7d	55.1±7.6c	37.7±0.9d	77.3±6.6a	67.5±3.0ab	64.6±7.5bc
Acid detergent fiber	18.7±5.0c	27.5±4.7a	8.3±0.2d	20.8±3.2bc	20.5±1.8bc	26.9±3.7a
Neutral detergent fiber	27.7±7.1de	44.4±7.0a	10.9±0.7f	36.2±4.8abc	36.9±2.8abc	41.1±5.3ab
Nitrogen	1.8±0.5ab	1.1±0.2d	0.4±0.0e	1.5±0.1bc	1.5±0.1bc	1.1±0.2d

Notes: [a] The diets T_1-T_6 are as composed in table 1
Means with the same letters in each row are not significantly different (P>0.05)

Klopfenstein 1983, Leaver 1974). The least DMI from T_3 was probably due to the lowest N content of the peel. This is supported by Rajpoot et al. (1981), Malachek and Provenza (1981) and Preston and Leng (1986) who had earlier reported that the low N content of feeds significantly ($P<0.05$) reduced the DMI from such feeds. The results of the present study, however, suggest that the relationship between dietary N content of feed and the feed DMI per metabolic size was rather weak ($r=0.03$, $P<0.05$). Nevertheless, the positive though weak relationship between N (or CP) and DMI from diet was similar to the stronger relationship ($r=0.86$, $P<0.05$) reported by Lippke (1980).

When dietary N content was correlated with the absolute DMI of the animals, the relationship was negatively significant ($r=-0.43$, $P<0.01$). This makes biological sense in terms of nutrient density of the diet because it suggests that an animal offered a low-N diet would tend to consume more of the diet in order to derive more of the needed N from the feed. However, this argument was not supported in the present study because the lowest DMI was recorded for goats on the lowest N containing diet (T_3).

The highest average daily OM intake (OMI) was by goats on T_4 diet. This tended to suggest that goats would benefit more from being fed *Gliricidia*, *Panicum* and cassava peel in approximately equal proportions. However, in the absence of *Panicum*, feeding of 70% *Gliricidia* + 30% cassava peel (T_5) to goats could be beneficial. This is probably because the high N content of *Gliricidia* complemented the high DM content of the cassava peel. The exclusion of *Gliricidia* from the diet would render diet T_6 (70% *Panicum* + 30% cassava peel) the best option for maximum OMI by goats. In general, however, the pattern of OMI followed that of DMI, since OM is an important component of DM.

The highest intake of NDF and ADF was by goats on T_2. The cassava peel (T_3) provided these in the lowest amounts to the experimental animals. The supplementation of 70% *Gliricidia* with 30% cassava peel (T_5) resulted in an ADFI which was 2.5 times, and an NDFI which was 3.4 times, that from T_2. This was probably because *Gliricidia* was more fibrous than the peel; indicating that the combination (T_5) was likely to result in gastrointestinal disorder which the peel alone is prone to induce. The ADFI from T_6 was significantly ($P<0.05$) the highest among the combined diets probably because *Panicum* contained the greatest amount of ADF. However, there was no significant difference ($P>0.05$) in NDFI between the treatment diets T_4-T_6.

Dry matter and nutrient digestibility coefficients and digestible DM and digestible nutrient intakes are presented in tables 4 and 5. The DM and OM of T_3 were the most digested by goats (table 3). Consequently, the digestible DM intake (DDMI) and digestible OM intake (DOMI) from T_3 were also the least. This very low DDMI and DOMI by goats on T_3 was reflected in the negative daily body weight change (-54.0g) as shown in table 6. It appears, therefore, that cassava peel alone is not suitable as goat feed. The DM of T_5 was digested most by goats, probably due to a better balance of nutrients resulting from the simultaneous feeding of N-rich *Gliricidia* (70%) and soluble carbohydrate-rich cassava peel (30%). Even the DM digestibility of T_6 was superior ($P<0.05$) to that of T_2, probably because the readily fermentable carbohydrates of the peel

stimulated a large microbial population and acitivity within the gastrointestinal tract.

Diets significantly influenced ($P<0.05$) N digestibility. The N of T_5 was digested most though it was not significantly different ($P>0.05$) from T_1 or T_2.

Table 4. Dry matter and nutrient digestibility coefficients (%) by West African Dwarf goats fed *Gliricidia sepium*, *Panicum maximum* and cassava peel

Nutrient	Diet					
	T_1	T_2	T_3	T_4	T_5	T_6
Dry matter	54.2±5.7d	58.8±0.4d	75.0±1.8a	71.9±0.9ab	74.3±2.4a	65.2±6.7c
Organic matter	56.8±3.9c	61.1±4.4c	77.4±1.9a	73.1±0.9ab	76.6±2.3a	67.5±6.4b
Acid detergent fiber	42.9±5.5c	60.1±2.0a	33.4±0.8d	36.1±2.5d	46.2±3.8bc	58.4±3.3a
Neutral detergent fiber	48.2±6.9de	54.5±1.7cd	38.6±1.0f	57.4±1.4bc	67.7±2.9a	62.6±7.2ab
Nitrogen	56.5±3.2a	27.1±14.3c	-6.4±0.2d	41.0±0.8b	57.3±3.8a	56.7±5.4a

Notes: The diets T_1-T_6 are as composed in table 1
Means with the same letters in each row are not significantly different ($P>0.05$)

Table 5. Digestible dry matter and nutrient intake (g $kg^{-0.75}$ d^{-1}) by West African Dwarf goats fed *Gliricidia sepium*, *Panicum maximum* and cassava peel

Nutrient	Diet					
	T_1	T_2	T_3	T_4	T_5	T_6
Dry matter	25.4±8.8f	37.4±5.4de	31.1±1.5ef	62.1±5.3a	56.4±2.7ab	47.8±5.4bc
Organic matter	24.8±8.6f	33.7±4.9de	29.2±1.4ef	56.5±4.7a	51.7±2.4ab	43.4±4.6c
Acid detergent fiber	8.2±2.8c	16.6±3.3a	2.7±0.1d	7.5±1.2c	9.4±1.2c	15.7±1.7ab
Neutral detergent fiber	13.8±5.4b	24.3±4.5a	4.2±0.2c	20.8±3.2a	24.9±1.8a	25.6±3.3a
Nitrogen	1.0±0.3ab	0.3±0.2e	0.0±0.0f	0.6±0.1cd	0.9±0.1bc	0.6±0.1cd

Notes: [a] The diets T_1-T_6 are as composed in table 1
Means with the same letter in the same row are not significantly different ($P>0.05$)

Table 6. Body weight changes in West African dwarf goats fed *Gliricidia sepium*, *Panicum maximum* and cassava peel

Diet	Daily body weight change (g)
T_1	51.0d
T_2	25.7b
T_3	-54.8a
T_4	66.3f
T_5	54.2e
T_6	41.5c

Notes: The diets T_1-T_6 are as composed in table 1
Means with the same letter within a column are not significantly different ($P>0.05$)

The N digestibility of T_3 was negative due, probably, to the low N content of the peel. This is because the apparent digestibility coefficient of dietary N is dependent mainly upon the proportion of N in the feed. Consequently, T_3 actually reduced the digestible N supply of the goats. Hence, cassava peel is not suitable as the sole feed for goats.

The ADF and NDF of T_3 had the lowest digestibility of all the six diets, indicating that the fibers in the peel are probably resistant to degradation by rumen microbes. The feeding of *Gliricidia*, *Panicum* and cassava peel in almost equal proportions (T_4) did not significantly improve ($P>0.05$) the ADF digestibility of the cassava peel; the digestibility of ADF in *Gliricidia* and *Panicum* was, however, significantly ($P<0.05$) reduced. Supplementation of either *Gliricidia* and *Panicum* with 30% cassava peel (T_5 and T_6 respectively) did not seem to have any effect ($P>0.05$) on the ADF digestibility of either *Gliricidia* and *Panicum*. This suggests that the digestibility of ADF fraction of a feed is only partially affected by other nutrients.

The NDF fraction appears to be of more variable digestibility, depending on the composition of the diet. Diets T_4-T_6 contained NDF which was distinctly superior ($P<0.05$) in digestibility to that contained in either T_1 or T_3 but not T_2. The NDF digestibility is highest for T_5 and this might have been due to a better balance of nutrients, particularly N from *Gliricidia* and soluble carbohydrates from the cassava peel. It thus appears that the nutritional potential of cassava peel is best realized when fed to goats as a supplement to a leguminous browse feed.

The highest digestible DM intake (DDMI) was by goats on T_4, though this did differ significantly ($P>0.05$) from T_5.

Similarly, the highest digestible OM intake (DOMI) by goats on T_4 was similar to that by goats on T_5. Both DDMI and DOMI of T_4-T_6 differed significantly ($P<0.05$) from those of the sole diets T_1-T_3. These results indicated that supplementation of *Gliricidia* and *Panicum* with peel enhanced DDMI and DOMI by goats. Digestible N intake (DNI) from T_4-T_6 was superior ($P<0.05$) to that from T_2 and T_3. DNI from T_1, however, was similar ($P>0.05$) to that from T_5 probably due to the high proportion (70%) of *Gliricidia* in it.

Diets had a significant ($P<0.05$) effect on body weight changes of goats (table 6). Goats on T_3 lost an average of 54.8 g/day probably due to the very low DMI coupled with low N content. This suggests that cassava peel is a poor feed when taken as the sole feed. Trial with T_3 had to be suspended after the initial collection period (day 28) due to excessive body weight loss by the goats. It would, therefore, be undesirable to feed a sole cassava peel diet to goats. The highest daily body weight gain was by goats on T_4, probably because T_4 provided a better balance of nutrients for growth. Goats gained more weight when *Gliricidia* or *Panicum* were supplemented with cassava peel than when each was fed sole. This indicates that cassava peel is potentially beneficial to goats by improving the balance of nutrients.

Earlier workers have indicated inclusion of cassava peel in varying degrees in livestock feeds. Adegbola (1980) concluded that a 10% cassava peel meal inclusion in pig ration induced the fastest rate of weight gain and highest feed conversion efficiency. Onwuka (1983), concluded that 25% cassava peel+75%

browse was the best proportion for goats in terms of intake, digestibility and other performance parameters. In the present study, a 30% level of cassava peel has been shown to be beneficial to goats, but the actual amount of cassava peel suitable for inclusion in goat feeds needs further investigation.

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