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Nutritive value of breadfruit (*Artocarpus altilis*, Park) and cassava (*Manihot dulcis*) in concentrate supplements of goats fed a basal diet of batiki grass

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ABSTRACT

In a completely randomized design experiment, the nutritive value of breadfruit and cassava flours was compared using 12 growing goats, 18-20 months old, with a pre-experimental body weight of 21.1±0.22 kg in an experiment lasting 56 days. Voluntary feed intake, liveweight and apparent digestibility of nutrients were measured. Voluntary feed intake (concentrate + forage) did not differ ($P>0.05$) among the goats fed the two carbohydrate sources. Daily liveweight gain was higher ($P<0.05$) in goats fed the breadfruit flour concentrate. Dry matter digestibility was better ($P<0.05$) in goats on the breadfruit diet. However, the digestibilities of crude protein and total digestible nutrients were similar in both breadfruit and cassava flour diets. Crude fibre and ether extract were better ($P<0.05$) digested in goats on the cassava flour diet, however, nitrogen-free extracts and metabolisable energy were higher ($P<0.05$) in goats on the breadfruit flour diet. The growth rate, voluntary feed intake and apparent nutrient digestibility coefficients of the goats demonstrated that breadfruit is also a good source of energy and carbohydrate compared with cassava. It is therefore recommended that the fruits of breadfruit could be processed and fed to goats and other ruminant livestock. However, breadfruit's importance in human nutrition may restrict its use in Pacific Island countries as a carbohydrate and energy source in livestock nutrition.

KEY WORDS: breadfruit, cassava, concentrate, intake, growth, digestibility, goats

INTRODUCTION

In Pacific Island countries (PIC), the traditional system of feeding goats is based on the use of kitchen waste, browsing and, to a lesser extent, crop residues. This

practice is perhaps the major cause of low productivity from these animals, as the feed consumed may be inadequate both in quality and quantity to meet their requirements (Aregheore, 1999). In the Pacific Island countries, production of cereal grains is insufficient to meet livestock feed demands (Ainuu, 1985). However, many countries in the region have the potential to, or are already producing large quantities of other feed sources that, if properly processed and supplemented, could support large and efficient commercial feed production (Ochietim, 1993) as well as a traditional system of goat production.

Breadfruit trees yield heavily during the fruiting season and the surplus fruits are often boiled and then fed to pigs or wasted (Udo, 1981; Naidu, 1989). The fruit can be processed into livestock feed. It has eighty percent starch (Graham and de Bravo, 1981) and the available carbohydrate content is similar to that of maize (Ravindran and Sivakanesan, 1995). On the other hand, cassava is typically a high energy, low protein, mineral-vitamin feed (Agudu and Thomas, 1982). The use of cassava in livestock feeds depends on how effectively the nutrient deficiency can be overcome by using cheap and abundant good quality protein and mineral sources.

Since the efficiency of animal production depends on utilisation of available feed resources for growth, development and reproduction, it is therefore imperative that animal nutritionists investigate the potentials of locally available feed resources in the Pacific Island countries (PIC). Breadfruit and cassava are readily available in PIC and these could be processed as energy sources in livestock nutrition. Except for the report of Susumu (1999) on the use of breadfruit in ruminant nutrition, other reports in the region are centered on its utilisation in the nutrition of monogastric animals (Udo, 1981; Ochietim, 1987). The utilisation of cassava in the nutrition of monogastric animals has been reported in the region (Ochietim, 1993; Ajuyah and Tofinga, 1999).

There is no information, however, on its usage in feeding ruminants. Also, there is no scientific literature that deals on comparative studies of the utilisation of breadfruit and cassava as carbohydrate sources in the nutrition of ruminant livestock. This trial therefore aims at comparing the nutritive value of breadfruit and cassava flours in concentrate mixtures for growing goats fed a basal diet of batiki grass (*Ischaemum aristatum* var. *indicum*) under intensive management in Samoa.

MATERIAL AND METHODS

Feed ingredients and preparation of experimental diets

The feed ingredients used were breadfruit flour, cassava flour, brewers' dried grains, urea (46% N), salt and mineral/vitamin premix. Breadfruits were purchased from Fugalei crop market, Apia. Cassava tubers of a sweet variety (*Manihot dul-*

cis) were harvested from the Crop Science Discipline Farm located in the School of Agriculture, The University of the South Pacific, Apia, Samoa. Whole breadfruits were peeled with a knife to obtain the pulp. The pulps were manually sliced into chips of about 1-cm thickness to facilitate drying. Cassava tubers were also peeled and the pulp cut into chips. Both breadfruit and cassava were sun dried to constant moisture content and ground in a stainless steel mill through 1-mm screen into fine flour or meal. The resultant products after milling were designated as breadfruit and cassava flours, respectively. Also the brewers' dried grains were collected wet, spread on an open concrete floor and turned regularly until they were dry. The feedstuffs were compounded into two diets (Table 1) to provide the carbohydrate sources. The diets were formulated to be isocaloric and, by adjusting the level of urea inclusion, isonitrogenous.

TABLE 1

Composition of experimental diets, % air dry

Ingredients, %	Diet	
	breadfruit flour	cassava flour
Breadfruit flour	57.0	-
Cassava flour	-	48.50
Dried brewers' grains	37.0	46.00
Urea (46 % N)	4.0	3.50
Mineral/vitamin*	1.5	1.50
Salt	0.5	0.50

* summit multi-mineral salt/vitamin: contains salt, calcium, magnesium, copper, colbalt, iodine, phosphorus, manganese, iron, zinc, selenium (3 ppm), vit. A, D and E with added copra meal and molasses

Animals, management and feeding

Twelve growing crossbred Anglo-Nubian goats between 18-20 months of age and average pre-experimental body weight of 21.1±0.22 kg were randomly divided into two groups on the basis of weight. Each group had six goats per treatment in a completely randomized design experiment. The goats were housed and fed individually in pens with concrete floors covered with wood shavings for bedding. Prior to the start of the experiment the housing unit was disinfected with dettol (a disinfectant). Also the goats were drenched with Levicare (Ancare, Auckland, New Zealand). The litter was changed periodically. One and a half kilograms of the basal diet made of batiki grass (*Ischaemum aristatum* var. *indicum*) were divided into two equal portions and offered at 09.00 and 17.00 h. The concentrate portion of each diet was offered *ad libitum* to the goats (10% in excess of the

previous day's intake) during which they also had free access to fresh clean water. Records of individual feed intake and weekly body weight changes were kept. Feeds not consumed within 24 h were collected, weighed, the amount recorded and feed residue discarded. The animals were allowed a 5-day adaptation period to get used to the concentrate supplement followed by 56 d of feeding. The difference between the initial and final average liveweights was used to compute liveweight gain.

Digestibility experiment

At the end of the growth phase of the experiment, a digestibility study was carried out using the total faecal collection method (Aregheore, 1997). The goats received a daily ration of 1.5 kg of each diet, which was fed in two equal amounts at 9.00 and 16.00 h and the forage portion (1 kg) was fed in two equal portions. Fresh and clean drinking water was provided. Prior to the morning feeding, the faeces voided by each goat for the preceding 24 h were carefully collected, weighed and recorded to determine the actual faecal output before a sample of 25% was taken for moisture determination. Faeces were dried in a forced-draught oven at 70°C for 24 h. Daily dried faeces for each goat over the collection period were bulked, sampled and milled in a hammer mill to pass through a 1.66 mm sieve and stored in airtight bottles until required for analysis. The diets, breadfruit, cassava flour and brewers' dried grains were also processed for analysis.

Analytical procedures

AOAC (1995) methods were used to determine nutrient contents of the experimental diets, breadfruit, cassava, forage and faecal samples. All analyses were done in triplicate. Dry matter was determined by drying at 102°C for 24 h, ash by firing at 600°C for 24 h, protein by the micro-Kjeldahl procedure (N x 6.25). Crude fibre of the feeds was determined according to the procedure of Naumann and Bassler (1976). The metabolisable energy (MJ/kg) value of experimental diets, breadfruit, cassava flours, forage and faecal samples was determined by a bomb calorimeter (Adiabatic bomb, Parr Instrument Co., Moline, IL) using thermochemical benzoic acid as the standard. Feed refusals were not analyzed because it was assumed that the composition of feed consumed was the same as that offered.

Statistical analysis

Data on voluntary feed intake, growth, feed conversion efficiency and apparent nutrient digestibility coefficients were analyzed using Student's *t*-test (Snedecor and Cochran, 1967).

RESULTS AND DISCUSSION

The chemical composition of the experimental diets, feed ingredients and forage are presented in Table 2. Nutrient composition of cassava and breadfruit flours used in the diets is similar value to that reported earlier by Gohl (1981), Graham and de Bravo (1981), Udo (1981), Aregheore (1988), Ravindran and Sivakanesan (1995) and Susumu (1999). The composition of the forage is similar to values reported by Solomona (1988) and Aregheore (1999). The two flours were close in crude protein values but not in crude fibre and nitrogen-free extractives. However, both came out as fine flours for mixing with other feed ingredients after the milling process.

TABLE 2

Chemical composition of experimental diets, breadfruit flour, cassava flour, brewers' grains and forage

Nutrients, %	Diets		Feed ingredients			
	breadfruit flour	cassava flour	breadfruit flour	cassava flour	brewers' grains	forage
Dry matter (DM)	91.2	92.1	92.0	90.7	96.1	85.2
Analysis of DM						
crude protein	13.4	13.4	4.1	4.6	23.5	6.6
crude fibre	10.2	6.8	6.5	2.6	38.3	34.8
ether extract	4.6	5.3	1.0	1.0	8.5	1.5
ash	5.0	5.6	5.0	0.8	5.6	9.4
NFE*	52.3	61.0	74.1	82.0	20.2	32.9
ME, MJ/kg DM	11.7	11.6	13.6	13.1	15.8	12.3

* NFE = Nitrogen free extractives
ME = Metabolisable energy

The performance of goats fed the experimental diets is given in Table 3. Concentrate intakes were close in both groups ($P>0.05$), however, forage intake was higher in the goats on the cassava flour diet ($P<0.05$). Although there was no significant difference between the two groups in concentrate intake and total daily feed intake (concentrate + forage), the feed efficiency ratio was better ($P<0.05$) in the goats fed the breadfruit flour diet.

Average daily liveweight gain of goats was affected by the source of carbohydrate. Goats on the breadfruit diet had better ($P<0.05$) liveweight gain. The maximum calculated daily protein intakes were 5.53 and 5.86 g/day/ $W_{kg}^{0.734}$ for breadfruit and cassava diets, respectively. Also using the mean apparent digestibility coefficients of 73.8 and 72.9% for crude protein, digestible crude protein (DCP)

TABLE 3

Performance characteristics of goats fed the experimental diets

Parameters	Diets	
	breadfruit flour	cassava flour
Initial liveweight, kg	21.3 ± 0.24	20.8 ± 0.20
Final weight, kg	30.4 ± 0.70	28.1 ± 0.46
Body weight gain, kg	9.1 ± 0.46	7.3 ± 0.37[b]
Daily gain, g	163[a]	130[b]
Average daily concentrate intake, g/day	559	600
Average daily forage intake, g/day	452[b]	458[a]
Total daily average feed intake (concentrate + forage), kg	1.01	1.06
Daily protein (N) intake, g/day/ $W_{kg}^{0.734}$	5.53	5.86
ME intakes, MJ ME/day	6.9	6.7
Feed efficiency, feed/gain	6.2[a]	8.2[b]
Protein efficiency, protein intake/body gain	3.4	4.5
ME efficiency, ME intake/body gain	4.2	5.1

[a,b] $P<0.05$

± standard error of mean

requirements of 9.9 and 9.8 g DCP/day/$W_{kg}^{0.734}$ were estimated for the goats on the breadfruit and cassava diets, respectively. The similarities in protein levels of the diets may be responsible for the close values in the daily N (protein) intake of the goats.

The metabolisable energy (ME) contents of the breadfruit- and cassava-based diets were similar. However, using the equation ME = DE x 0.82 and estimated ME intakes (5.1 MJ ME/day), the calculated ME for the goats on the breadfruit- and cassava-based diets were 6.9 and 6.7 MJ ME/day, respectively.

The better liveweight gain achieved in the goats fed the breadfruit flour diet may indicate efficient utilisation of energy and probably urea-N by rumen microbes. Susumu (1999) reported a significantly higher liveweight gain in goats that received a diet formulated from breadfruit flour. The liveweight gains of goats in this trial, especially those on breadfruit, are slightly lower than the values of Susumu (1999) but higher than values reported by Solomona (1988) for the same breed and age of goats used. The period of the year and not diets may be implicated in the variations observed in the liveweight gains of goats in the different experiments. Feed efficiency (feed/gain) was 6.2 and 8.2, respectively, for the goats on breadfruit- and cassava-based diets, while protein and energy efficiencies of the goats were 3.4, 4.2 and 4.5, 5.1, respectively, for the breadfruit- and cassava-based diets.

Apparent nutrient digestibility coefficients are presented in Table 4. Dry matter digestibility was better ($P<0.05$) in goats on the breadfruit diet. However, the

digestibility of crude protein and total digestible nutrients were similar in both breadfruit and cassava flour diets. Crude fibre and ether extract were better ($P<0.05$) digested in goats on the cassava flour diet. But, nitrogen-free extractives and metabolisable energy were higher ($P<0.05$) in goats on the breadfruit flour diet.

The favourable digestibility of DM, NFE and ME in the breadfruit flour diet in this investigation may be due to the amount of urea present in that diet (Table 1). The differences observed could also be attributed to the percentage composition of the various feed ingredients used in the experimental diets. Compositions of feed ingredients in a diet influence feed intake and diet utilisation for growth.

TABLE 4

Apparent digestibility coefficients of nutrients*

Nutrients, %	Diets	
	breadfruit flour	cassava flour
Dry matter	70.3 ± 0.09[a]	67.2 ± 0.06[b]
Crude protein	73.8 ± 0.18	72.9 ± 0.02
Crude fibre	56.1 ± 0.14[b]	60.3 ± 0.26[a]
Ether extract	53.6 ± 0.38[b]	58.7 ± 0.14[a]
Nitrogen free extractives	68.8 ± 0.06[a]	60.1 ± 0.12[b]
Total digestible nutrients	57.2 ± 0.03	57.5 ± 0.04
Energy	68.4 ± 0.10[a]	62.8 ± 0.08[b]

* mean of six goats

[a,b] $P<0.05$

± standard error of mean

CONCLUSIONS

In conclusion, the results obtained in this comparative study indicate that both breadfruit and cassava can be utilized in ruminant livestock diets in Pacific Island countries. However, breadfruit flour seems a superior carbohydrate to cassava for goat nutrition. Breadfruit and cassava are ubiquitous crops with reasonable yields in Pacific Island countries. Data on growth rate, voluntary feed intake and nutrient digestibility, indicate that breadfruit is a good source of energy and carbohydrate in goat nutrition compared with cassava.

It is therefore recommended that the fruits of breadfruit be processed and fed to goats and other ruminant livestock. However, breadfruit's importance in human nutrition may restrict its use in Pacific Island countries as a carbohydrate and energy source in livestock nutrition.

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STRESZCZENIE

Wartość pokarmowa owoców drzewa chlebowego (*Artocarpus altilis*, Park) i manioku (*Manihot dulcis*) jako składników mieszanki treściwej dla kóz żywionych trawą batiki (*Ischaemum aristatum* var. *indicum*)

W 56-dniowym doświadczeniu, o układzie losowym, porównano wartość pokarmową mączek z owoców drzewa chlebowego i manioku, na 12 rosnących kozach w wieku 18-20 miesięcy o m.c. 21,1±0,22 kg. Oznaczono pobranie paszy, masę ciała oraz strawność składników pokarmowych. Pobranie paszy (treściwa + objętościowa) nie różniło się (P>0,05) w zależności od rodzaju węglowodanów w dawce. Strawność s.m. i dzienne przyrosty kóz otrzymujących w dawce mączkę z owoców drzewa chlebowego były lepsze (P<0,05) niż zwierząt otrzymujących maniok. Strawność białka ogólnego oraz suma strawnych składników pokarmowych (TDN) były podobne w obydwóch grupach. Strawność włókna i ekstraktu eterowego były większe u kóz żywionych dietą z maniokiem, natomiast związków bezazotowych wyciągowych większe przy podawaniu dawki z owocami drzewa chlebowego. Wartość energetyczna, wyrażona w energii metabolicznej, tej dawki była też większa (P<0,05). Pobranie paszy, strawność składników pokarmowych dawek oraz tempo przyrostów wskazują, że mączka z owoców drzewa chlebowego jest tak samo dobrym źródłem energii i węglowodanów jak mączka z manioku, stąd zaleca się podawanie tej paszy kozom i innym gatunkom przeżuwaczy. Znaczenie jej w żywieniu ludzi może jednak ograniczać jej stosowanie w żywieniu zwierząt na wyspach Pacyfiku.