Utilization of raw, cooked or fermented cassava-urea meal in a total diet for growing ewe-lambs

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Abstract

The nutritive value of cassava meal (CM), raw cassava-urea meal (RCU), cooked cassava-urea meal (CCU), and fermented cassava-urea meal (FCU) mixed with other ingredients were evaluated in this study using West African dwarf sheep. Twenty ewe-lambs (6 months old) and twelve ewes (12 months old) were respectively used for growth and metabolic investigations. Dry matter (DM) intake was 2.13, 3.25, 3.20 and 3.35 % BW; growth rate 48.3, 67.5, 86.9 and 88.3 g/day; and feed conversion ratio (FCR) was 8.76, 7.54, 6.49 and 6.52 for CM, RCU, CCU and FCU respectively. DM digestibility was 58.5, 68.4, 73.3 and 72.5 % while nitrogen retention was 40.5, 30.9, 46.3 and 45.4 % for CM, RCU, CCU and FCU respectively. Nutrient utilization and growth of ewe-lambs fed cassava-based diets improved with addition of urea to cassava meal. Cooking or fermentation further improved nutritive value and feed conversion ratio of cassava-urea meal. Since fermentation requires less labour and energy costs than cooking, it may be the preferred option for processing cassava-urea mixtures for ruminant feeds by resource-poor farmers in Nigeria.

Key words: cassava meal, urea, sheep, utilization

Introduction

Cassava (*Manihot esculenta*, Crantz) is a root crop widely grown in the southern Nigeria. When soil fertility is medium to high, cassava is capable of very high dry matter yield. Dry matter yield of up to 12 tonnes per hectare has been documented (Losada and Alderete, 1977). Cassava is also known to adapt well to poor soil conditions with reasonable yields (Chantaprasam and Wanapat, 2003).

Cassava root meal is a cheap and valuable source of energy for ruminants in many parts of the humid tropics. The energy content of cassava meal is similar to that of maize but its protein content is very low (Garcia and Dale, 1999; Wanapat, 2003) thereby limiting its usefulness as a feed resource. The feeding value of cassava meal has been shown in several studies to be lower than that of maize (Oke, 1978; Adeyanju, 1979; Garcia and Dale, 1999; Adeyemi *et al.*,

2007). In these studies, performance of animals fed cassava meal as a partial or total replacement for maize in the diet were lower than those fed maize. Low crude protein content, presence of hydrocyanic acid and low content of certain minerals such as P, Na, Mo and Fe in cassava root were given as some of the reasons limiting its feeding value for livestock. DePeters and Zinn (1992) observed that cassava pellets could successfully replace maize in diets of dairy cows up to 12%, however, when cassava meal forms a substantial part of non-ruminant diets, there is need to supplement the diets with expensive protein feeds, thus removing the advantage of low cost in cassava-based diets.

Ruminants are known to utilize non-protein nitrogen (NPN) to synthesize microbial protein which is later digested by the animal and used for body processes (Preston and Leng, 1987). Urea is a cheap source of NPN which has been used extensively to increase nitrogen content of low-protein feeds for ruminants (Shultz *et al.*, 1972; Khampa and Wanapat, 2006; Olorunnisomo *et al.*, 2006; Chanjula *et al.*, 2007). Urea is better utilized by rumen microbes when readily fermentable carbohydrates are supplied together with urea in ruminant diets to provide adequate energy for microbial protein synthesis (Dewhurst *et al.*, 2000; Chanjula *et al.*, 2007). Cooking starchy feeds together with urea has also been reported to improve utilization of urea in ruminant diets (Shultz *et al.*, 1972).

The purpose of this study was to estimate the nutritive value and the effect of feeding cassava meal and cassava-urea mixture (raw, cooked or fermented) on performance of growing ewe-lambs.

Materials and Methods

This study was conducted at the University of Ado-Ekiti (7° 37' N, 5° 13' E) which lies within the rainforest with a typical hot-humid climate and distinct wet and dry seasons. Mean annual rainfall, temperature and humidity are 1367mm, 27°C and 80% respectively.

Feed preparation

Freshly harvested cassava roots (sweet variety) were washed and grated with the peels. Elemental sulphur granules were mixed with grated cassava at 0.2% of its fresh weight. The grated cassava was divided into 4 parts. The first part was spread and sun-dried on polythene sheets for 5 days. The spread cassava was turned 2-3 times daily until a crumbly meal was obtained. The remaining parts (3/4) of the fresh cassava was mixed with urea at 3% of its fresh weight and sub-divided into three parts. One part of the cassava-urea mixture was sun-dried as described above, while the remaining parts were either cooked in metal drums at 105°C for 45 minutes or fermented in plastic drums for 7 days. The cooked or fermented meals were later sun-dried. The meals formed were ground using a hammer mill with 5mm sieve and mixed with other ingredients to formulate four complete diets which correspond to the experimental diets. Experimental diets consist of cassava meal (with or without urea, 45%); rice husk (35%); palm kernel cake (18.5%); common salt (0.8%); dicalcium phosphate (0.5%) and vitamin-mineral premix (0.2%). Samples of the mixed diets were taken to the laboratory for chemical analysis. Chemical composition of the four diets is shown in Table 1.

Table 1. Chemical composition of experimental diets

Components (%)	Diets*			
	CM	RCU	CCU	FCU
Dry matter	92.5	93.0	93.7	92.5
Crude protein	6.70	14.3	13.4	16.2
Neutral detergent fibre	42.3	42.6	45.0	45.8
Acid detergent fibre	28.4	28.0	27.2	26.5

*Diets contained 45% cassava meal or raw, cooked, or fermented cassava-urea meal

CM: cassava meal without urea; RCU: raw cassava-urea meal;

CCU: cooked cassava-urea meal; FCU: fermented cassava-urea meal

Growth Study

Twenty West African Dwarf ewe-lambs approximately six months old with initial weights between 6.8 and 9.3 kg were used in the growth study. The animals were housed individually in pens with feeding and watering troughs. Animals were divided into four groups according to their weight and animals within the group were randomly assigned to one of the four experimental diets. The animals were bought from the open market with little information on previous management, hence they were all treated with Ivermectin (to take care of internal and external parasites), and injected with oxytetracycline, two weeks before the commencement of the trial as a precautionary measure against bacterial infections. Feed was offered *ad-libitum* once daily at 8.00 hours. Fresh water was offered free choice on a daily basis. The animals were offered the experimental diets for 91 days. Seven days were allowed for adaptation to the pens and diets while experimental measurements were taken in the last 84 days. The treatments correspond to four complete diets containing cassava meal (CM), raw cassava-urea meal (RCU), cooked cassava-urea meal (CCU), or fermented cassava-urea meal (FCU). The experimental design adopted

was the randomized complete block design (RCBD). Feed offered and feed refused were recorded for each animal daily while animal weights were taken on a weekly basis, using a spring balance. Average daily intake (ADI) and average daily gain (ADG) were calculated for each animal over the 84-day period. Feed conversion ratio was also calculated for each treatment from ADI and ADG.

Metabolic Study

Twelve ewes (approximately 12 months old) were placed in metabolic cages with slatted floors adapted for faecal and urine collection. Experimental diets were the same as used in the growth study. Feed and water were offered *ad-libitum* for 14 days. Total faeces, urine and feed refused were collected and weighed in the last 7 days. Feed intake, faecal output and urinary output were determined. Ten percent of faeces and urine collected were taken for analysis. Feed and faecal samples were dried at 65°C to constant weight, milled and kept in airtight containers while urine samples were kept in a deep freezer at -5°C until required for analysis. The experimental design adopted was the completely randomized design. Each treatment was replicated three times.

Nitrogen content of feed, faeces and urine were determined by the Kjeldahl method (AOAC, 1995) while neutral detergent fibre and acid detergent fibre were determined by methods of Van Soest and Robertson (1985). Apparent digestibility of the diets was calculated as the difference between nutrient intake and excretion in the faeces, expressed as a percentage of nutrient intake while nitrogen retained by the animals was calculated as the difference between nitrogen intake and nitrogen excreted as follows:

$$N_{\text{retained}} = N_{\text{intake}} - (\text{Faecal N} + \text{Urinary N})$$

All data obtained were subjected to Analysis of Variance and significant means were separated by Duncan's Multiple Range Tests using the SAS (1995) procedures.

Results and Discussion

The chemical composition of experimental diets is given in Table 1. Crude protein content of the diet containing cassava meal without urea (CM) was low compared to diets containing cassava-urea meal. Among the cassava-urea based diets, CCU had the lowest protein content while FCU had the highest. A significant proportion of the urea-nitrogen may have been lost in the water used for cooking which was decanted after the cooking process, leading to lower protein content in CCU. There was very little variation in the fibre content of the diets.

Dry matter intake

Dry matter intake varied significantly ($P < 0.05$) among dietary treatments (Table 2). When expressed on body weight basis, dry matter intake of ewe-lambs varied from 2.13 to 3.35 percent of body weight. Lambs fed fermented cassava-

urea meal (FCU) in the diet showed the highest intake, followed by raw cassava-urea (RCU) and cooked cassava-urea (CCU) diets while cassava meal diet had the least intake. The higher nitrogen content of cassava-urea diets compared to cassava meal is partly responsible for the higher intakes observed for these diets (Olorunnisomo *et al.*, 2006). While it was expected that cooking would improve the palatability of cassava-urea meal, statistical analysis showed that there was no significant difference in the dry matter intake of raw and cooked cassava-urea diets among the lambs. It is possible that the effect of cooking on taste of the meal was masked by the presence of other ingredients in the total diet. Dry matter intake observed in this study is lower than the range of 3.14 - 4.30 % BW reported by Chanjula *et al.* (2007) and Marjuki *et al.* (2008) for sheep and goats in a tropical environment.

Growth rate

The growth rate of lambs fed cassava meal or cassava-urea based diets are shown in Table 2. There were significant differences in the growth rate of lambs fed the various diets. Cassava-urea-based diets had higher growth rates than cassava meal-based diet. This is related to the higher nitrogen content of these diets which promoted microbial growth in the rumen, improved energy-nitrogen ratios and consequently improved growth of the animals. It is also possible that supply of nitrogen from dietary urea (which is a source of readily available nitrogen to rumen microbes) may have a sparing effect on intact proteins in the diet, making them escape rumen degradation. This idea however needs to be further investigated. Lambs fed fermented and

Table 2. Dry matter intake, growth rate and feed conversion ratio of ewe lambs fed experimental diets

Measurement	Diets ^a				SEM
	CM	RCU	CCU	FCU	
No. of animals	5	5	5	5	-
Initial weight (kg)	7.82	7.56	7.88	7.64	0.56
Final weight (kg)	11.90 ^b	12.86 ^b	15.21 ^c	15.21 ^c	1.39
ADI (g/day)	424.3 ^c	508.8 ^b	564.2 ^{ab}	575.9 ^a	12.23
ADI (% BW)	2.13 ^b	3.23 ^a	3.20 ^a	3.33 ^b	0.49
ADG (g/day)	48.3 ^c	67.5 ^b	86.9 ^a	88.3 ^a	2.82
FCR	8.76 ^a	7.54 ^b	6.49 ^c	6.52 ^c	0.41

^{abc}Means with same superscript within the row are significantly different ($P < 0.05$)

^aDiets contained 45% of cassava meal or raw, cooked, or fermented cassava-urea meal

CM: cassava meal without urea; RCU: raw cassava-urea meal;

CCU: cooked cassava-urea meal; FCU: fermented cassava-urea meal

ADG: average daily gain; ADI: average daily intake;

FCR: feed conversion ratio (intake/gain); BW: body weight

cooked cassava-urea diets had the highest growth rates, followed by lambs on raw cassava-urea diet. The lowest growth rate was recorded for lambs on cassava meal-based diet. There was no significant difference ($P > 0.05$) in growth of lambs fed fermented cassava-urea or cooked cassava-urea diets, however growth rate of lambs fed these diets were significantly ($P < 0.05$) higher than those on raw cassava-urea diet. This shows that cooking or fermentation improved the utilization of cassava-urea meal. Growth of animals fed raw cassava-urea meal in the diet was higher than growth of animals fed cassava meal in the diet, suggesting that addition of urea to cassava meal improved its utilization by sheep. The growth rate of ewe lambs in this study varied from 48.3 - 88.3 g/day. These values are higher than 41.4 - 50.0 g/day obtained by Marjuki *et al.* (2008) for sheep fed elephant grass supplemented with cassava leaf silage, and comparable to 70.9 - 86.4 g/day obtained by

Olorunnisomo (2008) for sheep fed mixtures of sweet potato forage and root in a total diet.

Feed conversion ratio

The feed conversion ratio of lambs fed cassava meal or cassava-urea meal in a complete diet are shown in Table 2. Animals fed cassava-urea-based diets had better feed conversion than animals on cassava meal diet. This corroborates earlier observation on growth rate of the lambs, that addition of urea to cassava meal improved the utilization of cassava meal. Utilization of low protein feeds by ruminants has been reported to improve when urea was added to such feeds (Shultz *et al.*, 1972; Khampa and Wanapat, 2006; Olorunnisomo *et al.*, 2006; Chanjula *et al.*, 2007). The best feed conversion was observed for animals on cooked cassava-urea and fermented cassava-urea diets. Cooking has been reported to improve the utilization of starch-urea mixtures by gelatinizing the starch component

with urea such that starch is degraded at the same rate with urea in the rumen, thus providing the right energy-nitrogen ratio for microbial synthesis and minimising nitrogen loss through slow release of ammonia in the rumen (Shultz et al., 1972; Shieh-zadeh and Harbers, 1974). The solid state fermentation to which the fermented meal was subjected may also have converted some of the nitrogen in urea to microbial protein which may have been spared from degradation in the rumen, thus providing intact protein in the small intestine. Proteins that escape rumen degradation are known to be more beneficial to ruminants than rumen degradable proteins (Preston and Leng, 1987).

Digestibility

Apparent digestibility of the various diets by West African dwarf ewes is presented in Table 3.

Dry matter digestibility was not significantly ($P > 0.05$) different among cassava-urea diets (RCU,

CCU and FCU) but cooked and fermented cassava-urea diets had significantly ($P < 0.05$) higher digestibility than cassava meal diet. Dry matter digestibility of raw cassava-urea diet was also not significantly different ($P > 0.05$) from that of cassava meal diet. These observations suggest that benefits from addition of urea to cassava meal in ruminant diets is best realised when cassava and urea mixtures are either cooked or fermented. There was no significant difference ($P > 0.05$) in crude protein digestibility of the diets. Neutral detergent and acid detergent fibre digestibility followed a similar trend with dry matter digestibility, showing that dry matter digestibility of the diets is largely a reflection of fibre digestion in these diets and improved microbial activity in the rumen.

Nitrogen balance

Nitrogen utilization in West African Dwarf ewes fed cassava-based diets is given in Table 4. There

Table 3. Apparent digestibility (%) of diets containing raw, cooked, or fermented cassava-urea meal by West African dwarf ewes

Measurement	Diets				SEM
	CM	RCU	CCU	FCU	
No. of animals	3	3	3	3	-
Feed intake (g/day)	455.2 ^a	524.8 ^a	581.3 ^a	684.8 ^a	13.32
Faecal output (g/day)	188.9 ^a	165.8 ^a	155.2 ^a	188.3 ^a	4.01
Digestibility					
Dry matter (%)	58.5 ^b	68.4 ^{cd}	73.3 ^d	72.5 ^d	2.23
Crude protein (%)	56.2	56.1	61.8	63.1	2.59
Neutral detergent fibre (%)	56.8 ^b	66.8 ^a	71.0 ^a	70.6 ^a	2.84
Acid detergent fibre (%)	52.5 ^b	61.8 ^{ab}	68.0 ^a	67.8 ^a	2.23

^{abcde} Means with same superscript within the row are significantly different ($P < 0.05$); CM: cassava meal without urea; RCU: raw cassava-urea meal; CCU: cooked cassava-urea meal; FCU: fermented cassava-urea meal.

were significant differences ($P < 0.05$) in the nitrogen intake of ewes fed the various diets. Animals fed fermented cassava-urea diet had the highest N intake while those fed cassava meal diet had the least. Faecal nitrogen output followed the same trend as N intake, however, urinary nitrogen output followed a slightly different trend. Animals on fermented cassava-urea diet and raw cassava-urea diet had the highest urinary output while cassava meal diet had the least. The high urinary nitrogen loss by animals fed cassava-urea diets is largely a reflection of the higher nitrogen intake from these diets.

Nitrogen retained is the proportion of N utilized by animal from total N intake for body processes. In this study, % N retained was highest for cooked cassava-urea and fermented cassava-

urea diets and lowest for raw cassava-urea diet. This indicates that processing cassava-urea meal by cooking or fermentation improves nitrogen utilization in ruminants fed such mixtures. It has been reported that when starchy feeds are cooked with urea, a gelatinized starch-urea complex is formed which ensures that energy and nitrogen are released at the same rate in the rumen for microbial growth and protein synthesis when fed to ruminants (Shultz *et al.*, 1972; Shiehzadeh and Harbers, 1974). Nitrogen retained (% of N intake) in this study ranged from 30.9 – 46.3%. This is lower than the range of 55.6 – 61.4% reported by Marjuki *et al.* (2008) for sheep fed elephant grass supplemented with cassava leaf silage but falls within the range of 29.5 – 51.0% obtained by Olorunnisomo (2008) for sheep fed mixtures of sweet potato forage and roots.

Table 4. Nitrogen balance of West African dwarf ewes fed diets containing cassava meal and raw, cooked, or fermented cassava-urea meal

Measurement, g/day	Diets				SEM
	CM	RCU	CCU	FCU	
No. of animals	3	3	3	3	-
% N in feed	1.07	2.29	2.14	2.59	-
Faecal output	188.9 ^a	165.8 ^b	155.2 ^b	188.3 ^a	4.01
% N in faeces	1.13 ^b	3.18 ^a	3.06 ^a	3.48 ^a	0.30
Urinary output	161.2 ^b	192.3 ^a	185.8 ^a	196.5 ^a	4.85
% N in urine	0.48 ^b	1.58 ^a	1.04 ^{ab}	1.60 ^a	0.13
N intake	4.87 ^c	12.02 ^b	12.44 ^b	17.74 ^a	0.60
Faecal N	2.13 ^c	5.27 ^{ab}	4.75 ^b	6.55 ^a	0.28
Urinary N	0.77 ^c	3.04 ^a	1.93 ^b	3.14 ^a	0.16
N retained	1.97 ^c	3.71 ^{bc}	5.76 ^b	8.05 ^a	0.37
% N retained	40.45 ^c	30.87 ^b	46.30 ^b	45.38 ^b	1.41

a, b, c: Means with same superscript within the row are significantly different ($P < 0.05$); CM: cassava meal without urea; RCU: raw cassava-urea meal; CCU: cooked cassava-urea meal; FCU: fermented cassava-urea meal

Conclusions

Feed intake, growth rate and feed conversion ratio of sheep improved when urea was added to cassava meal. Although cooking or fermentation did not increase the intake of lambs fed cassava-urea meal, these treatments significantly ($P < 0.05$) improved the utilization of cassava-urea mixture by the lambs. While the highest growth rate was recorded for animals on fermented cassava-urea meal, this was not significantly different from growth rate of animals fed cooked cassava-urea meal. Feed conversion ratio was lowest for cooked cassava-urea diet, showing that cassava was best utilized by sheep when cooked with urea. Dry matter and fibre digestibility of diet improved slightly when urea was added to cassava meal but there was no improvement in crude protein digestibility. However, when cassava-urea mixture was either fermented or cooked, there were marked improvements in dry matter and fibre digestibility of sheep diets. This probably explains the high feed conversion efficiency displayed by animals on these diets.

It is therefore concluded that addition of urea to cassava meal improved nutrient utilization and growth of ewe-lambs fed cassava-based diets. These improvements were however more pronounced when cassava-urea mixtures were either cooked or fermented.

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