GRAIN REPLACEMENT VALUE OF CASSAVA AND SWEET POTATOES IN RATIONS FOR GROWING LAMBS 2. ENERGY AND PROTEIN UTILIZATION

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SUMMARY

27 LAMBS made up of 24 West African Dwarf (WAD)X Yankasa crosses aged 6 to 7 months old of 11 to 14kg weight and 3 WAD wether sheep, about 3 years old and weighing 34 to 39kg were used in this experiment designed to evaluate the maize replacement value of sweet potato and cassava tubers in sheep diet through energy and protein utilization. Each of the wether sheep carried permanent rumen cannula.

The results showed that the maize, sweet potato and cassava based concentrates fed as supplement to grass (*Cynodon nlemfuensis*) improved the digestibilities of crude fibre, crude protein, organic matter, NFE and N-balance. The treatment effect was significant ($P<0.05$) with the highest coefficients and N-retention values recorded for animals fed sweet potato based concentrate. The ruminal VFA's production, ammonia and blood urea levels followed the same trend for all the three energy sources but the treatment effect was not significant. All the parameters so obtained on energy and protein utilization, however, indicated that the dried milled sweet potato and cassava tubers can successfully replace maize grains in sheep diet.

INTRODUCTION

Maize and guinea corn have always been incorporated into concentrates as the major sources of energy. These concentrates are then fed to ruminants as supplement to forage in order to meet their energy and protein requirements for growth, reproduction lactation and other production processes in a normal farming operation. With the current rise in prices of feed ingredients for livestock in general and of cereals in particular, there is an urgent need to exploit other available but cheaper sources of feedingstuff which could replace the cereals in ruminant diets and so lower the cost of feeding in ruminant livestock production.

From previous work (Tewe, Akinsoyinu and Sulemon-Oba, 1977) it was observed that the dried milled sweet potato and cassava tubers could successfully replace maize grains in sheep diet without any adverse effect on growth rate, dressing out percentages, major cuts, quality of the organs and the general performances of the animals. Sweet potato based diet even improved the feed efficiency ratio (feed/gain) and the leanest meat was recorded for the animals fed cassava-based diet.

1. The energy and protein utilization of these experimental animals need to be highlighted in order to evaluate the limitation of the previous findings. However, a lot of information has accummulated on the digestion and fermentation of carbohydrate in the rumen. The major end products of the processes are acetic, propionic, butryric, iso-butyric, valeric and iso-valeric acids which are the steam volatile fatty acids (VFA's) (Bacroft, McAnally and Phillipson, 1944a and 1944b; Elsden 1945 and 1946; Mba and Olatunji, 1972). These VFA's serve as the major source of energy for the ruminants in maintenance and synthesis of tissue constituents (Carroll and Hungate, 1954; Armstrong, 1965).

There is sufficient evidence as well to show that the activities of the microorganisms in the rumen result in the breakdown of protein and non protein nitrogen to produce ammonia (Mangold and Schmitt Krahmer, 1927; El-Shazley, 1958; Mba, Adegbola and Oyenuga, 1971; Mba, Faoye and Oyenuga, 1974). The ruminal NH_3 is then utilized by the micro organisms for the synthesis of microbial cell constituents of high biological value (Pilgrim *et al,* 1970). The ruminal NH_3 if absorbed is wasteful in that it is converted into urea in the liver and ultimately excreted in the kidney. (Loosli *et al.,* 1949). There is a high degre of correlation between the ruminal NH_3 and blood urea level. Thus the two parameters are indices of the extent to which the dietary protein or non-protein-nitrogen (NPN) has been utilized.

As part of a general study on the grain replacement value of sweet potato and cassava tubers in ruminants' diet, the present experiment was designed to investigate the effect of feeding maize, sweet potato and cassava based supplemental concentrate on energy and protein utilization, total VFA's production, ruminal — NH_3 and blood urea levels of sheep maintained on a basal forage of grass *(Cynodon nlemfuenssis).*

MATERIALS AND METHODS

Animals:

24 male lambs of the West African dwarf X Yankasa crosses, 6 to 7 months old and and weighing between 11 and 14 kg were used in Trial 1 for growth and feeding studies. The experimental animals in Trial 11 were 3 West African dwarf wether sheep, about 3 years old and weighing between 34 and 39kg. Each of the wether sheep was fitted with a permanent rumen cannula. The animals were kept in individual sheep — pens except during collecton periods when they were kept in individual metabolism cages. Wherever they were kept, they always had free access to salt licks and fresh clean water.

Plan of experiment and diets.

The experiment consisted of three trials. Three concentrates were compounded from dried milled tubers of cassava (C) sweet potato (SP) and maize (M) along with brewer's grain, vitamin, salt additives and groundnut cake in such a way that the crude protein content of each concentrate was 16%.

In Stage 1, the 24 lambs were randomized into three groups of 8 animals. Each group was then fed each concentrate as supplement to a basal diet of grass *(Cynodon nlemfuensis)* 0.5 kg of the grass was offered twice daily at about 8.00 and 14.00 hrs. Any grass or concentrate residues were collected, weighed and stored for chemical analysis. This trial lasted twenty weeks. In the last II days four animals in each group were transferred to individual metabolism cages (Oyenuga, 1961) for separate collection of faeces and urine for 9 days and blood sample for 2 days.

Stage II witnessed a digestibility experiment designed to evaluate the basal forage so that the digestibility of the concentrate supplement could be calculated by difference, using the formula of Crampton and Lloyd (1959) as outlined by Mba, Oruru and Oyenuga (1976). Three lambs were fed the basal forage for 22 days. The lambs were kept in individual metabolism cages for collection of faeces for six days and blood for two days.

Stage III involved 3 West African dwarf wether sheep each one carrying a permanent rumen cannula. This stage consisted of 4 periods of 17 days per period. The last three days witnessed collection of rumen liquor. In period 1, the animals were fed grass alone *ad lib.* In period 2 to 4, each animal was fed each of the concentrate supplements in rotation and the basal forage as in stage 1 of the entire experiment.

The composition with the results of chemical analysis of the concentrate supplements and the basal forage including their gross energy values are as reported earlier (Tewe *et al.,* 1977).

Collection of faeces and urine:

Faeces and urine were collected each

morning just before feeding. The urine was preserved with 3ml of 10% mercuric chloride and 10% of total daily output were retained. The daily aliquots for seven days were bulked for each sheep and stored in a deep freezer (—5°C) until required for analysis. Total daily samples of faeces, dried at 80°C in a forced — drought oven, were bulked, milled and stored in air-tight bottles until required for analysis.

Sampling of rumen liquor:

For each experimental period of Stage III, samples of rumen liquor were taken in the last three days, one hour and two hours after feeding. The liquor was obtained from each fistulated sheep in a thermos flask as described by Alexander (1969) as modified by Mba and Olatunji (1971).

About 300ml of rumen liquor were usually collected within 5 minutes.

Sampling of blood:

Blood samples were collected from each animal used for collection of faeces and urine in Stage 1. With sterilized needles, blood samples were obtained from the jugular vein, four hours after feeding for two days. 5ml of each blood sample was kept in a sample bottle containing citrate as anticoagulant. The blood serum was allowed to separate out in a cold room and the serum was kept in a deep freezer at -5°C until required for analysis.

Analytical procedures:

24 OF THE MILLED SAMPLES OF FEEDS AND FAECES WERE FURTHER dried at 150°C to constant weight for residual moisture determination before analysis. The milled samples of faeces, grass, supplementary concentrate and aliquots of urine samples were analysed for nitrogen using semi-micro-kjeldahl technique with Markham's still apparatus either extract, organic matter and ash according to the A.O.A.C. (1970) methods. The gross energy value of the concentrates, grass and faeces, were determined using the Adiabatic Bomb Calorimeter (Gallenkamp, Christopher Street, London).

The data obtained from these analyses were used in computing the digestibility coefficients, nitrogen balance and digestible energy (DE).

The rumen liquor as obtained in the thermos flask was processed and analysed for total volatile fatty acids (A.O.A.C. 1970) and the pH was determined with Pye pH meter using Py-Ingold combined glass reference electrode.

Ammonia — N of the strained rumen liquor and the blood urea level were determined by the method of Fawcett and Scott (1960) as modified by Chaney and Marbach (1962).

RESULTS

Digestibility of Nutrients:

The apparent digestibility coefficients of organic matter (OM), crude protein, ether extracts, soluble sugar, (NFE), crude fibre and ash are shown in Table 1. The results on changes in liveweight and dry matter digestibility had been reported elsewhere (Tewe *et al* 1977). All the supplements were better utilized than the grass and the differences were highly significant ($P < 0.01$).

The treatment effects on the digestibility of crude fibre and NFE were significant ($P < 0.05$) except for crude protein, ether extracts and organic matter which were not significant. An appraisal of the results however showed that the digestibility coefficients for protein, crude fibre, NFE and OM in the sweet potato based concentrate supplement were the highest.

Except for organic matter coefficient, cassava based concentrate comes next. Maize meal based concentrate recorded its highest coefficient under NFE digestion.

Protein (Nitrogen) Utilization:

The mean values (with standard errors) of nitrogen utilization are shown in Table 2 and the effect of the diets on ruminal ammonia-N and blood urea level are

TABLE 1.

Digestibility of nutrients in maize. cassava and sweet potato based concentrate fed as supplement to grass.

	Treatment	*DM*	*CP*	*CF*	*EE*	*NFE*	*OM*
I.	(Maize concentrate)	83.88		69.81^a	89.12	82.92^a	92.05
II.	(Sweet potato)	89.15		81.53^b	88.75	89.15^b	97.46
III.	(Cassava flour)	84.77		76.66^b	82.71	88.45^b	91.16
	Grass	56.96		58.57	23.43	73.68	57.09.

a,b, values without common super scripts in vertical rows are significantly different (P/0.05).

shown in Table 4. Replacement of maize grains with cassava flour or sweet potato as energy source, had an appreciable effect on N-balance (P/0.05).

Duncan's (1955) multiple range test revealed that the N-balance estimated of 18.5 ± 2.9 for sheep fed sweet potato based concentrate was greater than the corresponding estimate of 13.4 ± 3.6 and 15.0 ± 1.5 for sheep feed maize and cassava based concentratre respectively and the differences were significant (P/0.05). The difference between the value of N-balance obtained for sheep fed maize and cassava based concentrate as supplement was not however significant. These trends remained unaltered even when the N-balance estimates were expressed as g/day/unit metabolic size (Table 2).

The ammonia -N (mg/100ml rumen liquor) and blood urea -N mg/100ml) obtained by feeding grass alone were 3.4 and 3.0 respectively. These values increased to about 10.0 and 8.0 respectively by feeding maize, sweet potato or cassava based concentrate as supplement to grass (Table 4). Although the increases were highly significant ($P < 0.01$), the variations within the increase due to the supplementary effect of feeding maize, sweet potato or cassava based concentrate to sheep was not significant. Similar trends were also observed for the blood urea level.

Energy Utilization:

Summaries of the results obtained on energy utilization, ruminal pH and VFA's are shown in Tables 3 and 4. The digestible energy DE coefficients of the supplements were higher than that of the basal forage ($P < 0.05$). The treatment effect on the DE estimates for the supplements was not however significant. The trends of the results showed that the highest DE coefficient of 86% was recorded for animals fed sweet potato based concentrate as supplement while corresponding values of 82 and 83% were

TABLE 2:

Summary of nitrogen metabolism and utilization values of sheep maintained on grass plus maize, sweet potato and cassava based concentrates as supplement.

Parameters	*Maize* I	*SP* II	*Cassava* III
DM intake g/day	919.8 ± 48.1	1099.8 ± 67.7	961.3 ± 60.1
Initial liveweight (kg)	11.9 ± 0.41	12.2 ± 0.60	12.1 ± 0.43
Final liveweight (kg)	27.2 ± 0.95	27.3 ± 0.79	27.5 ± 0.93
Mean liveweight (kg)	19.6 ± 10.8	19.8 ± 10.7	19.8 ± 10.9
Mean liveweight W kg 0.734	8.88	8.95	8.95
Liveweight gain g/day	121.1 ± 9.2	119.9 ± 13.0	122.2 ± 18.4
N-intake (g/day)	24.15 ± 3.60	30.51 ± 2.9	25.52 ± 1.5
Faecal-N (g/day)	6.42	7.63	6.38
Urine-N (g/day)	4.33	4.34	4.11
N-balance (g/day)	13.40	18.54	15.03
N-balance (g/day/$W^{0.734}_{kg}$	1.506	2.06	1.67

obtained for maize and cassava based concentrate respectively. The variations in the DE (kcal/g) of the supplements were not significant.

The total VFA's for the various diets are shown in Table 4. In most cases the total acid production was at its peak 1 hour after feeding, declining slightly 2 hours after feeding. The maize, sweet potato and cassava based supplement tended to stimulate increased acid production in the rumen. The mean highest concentration of 6.3 milliequivalent/100ml rumen liquor was obtained when sweet potato based concentrate was fed as supplement. Although the marginal increase so produced by these supplements over the basal grass diet was highly significant ($P < 0.01$) the treatment effect on these increases was not significant. The mean highest ruminal pH 6.99 was recorded when the animals were maintained on basal grass alone. This pH was however depressed by feeding the supplements.

DISCUSSION

The essence of the present study is to evaluate the replacement value of maize grains by dried milled sweet potato and cassava tubers in ruminants' diets.

Replacement of maize grains with sweet potato or cassava had a significant effect on crude fibre and NFE digestibility. This could be due to the appreciable dif-

TABLE 3:

Energy value of sheep fed maize cassava and sweet potato based concentrate as supplement to grass.

Parameters	*I*	*II*	*III*	*Grass*
Digestible energy (DE) (% of gross energy)	81.59±5.62	86.31±7.21	83.33±8.13	75.07±9.01
DE (kcal/g)	3.23±0.51	3.20±0.32	3.26±0.40	2.32±0.51
DE intake (kcal/d/$W_{kg}^{0.734}$	303.7±8.6	342.0±7.5	305.7±9.7	—
Total DM consumed g/d/$W_{kg}^{0.734}$	103.3±5.3	122.2±7.2	106.8±6.4	—

TABLE 4.

Effect of feeding maize, cassava and sweet potato based concentrate as supplement to grass on ruminal ammonia, blood urea and VFA's production in sheep.

Treatment	*Time of sampling*	*pH of rumen liquor*	*Total VFA m-eq/100ml. liquor*	*NH_3-N/mg/ 100ml rumen blood.*	*Blood urea-N mg/100ml of*
I	1hr. after feeding	6.22	6.42	9.72	—
	2hrs. after feeding	6.10	6.15	9.89	—
	Mean	6.15	6.29	9.81	7.78
II	1 hr after feeding	6.17	6.12	9.87	—
	2hrs. after feeding	6.13	6.48	10.09	—
	Mean	6.15	6.30	9.98	7.87
III	1hr. after feeding	6.20	6.47	10.00	—
	2hrs. after feeding	6.17	6.21	10.07	—
	Mean	6.19	6.34	10.04	7.89
Grass alone	1hr. after feeding	6.95	3.18	3.30	—
	2hrs. after feeding	7.03	3.00	3.42	—
	Mean	6.99	3.09	3.36	3.02

ferences in the availability of easily digestible carbohydrates (Phillipson, 1952; Sutton and Johnson 1969). To this end, Adebanjo (1972) indicated that the differences in fibre digestion may also stem from the character of the fibre itself both the physical and chemical structure and particularly the presence of certain substances, notably lignin, which lowers the digestibility of cellulose and other complexes. This also explains why sweet potato and cassava based concentrate improved crude fibre digestibility more than the maize based concentrate. The highest digestibility coefficients for organic matter, crude protein and crude fibre were obtained for animals fed sweet potato based diet. A good reason that can be adduced for this is that the sweet potato contained the highest level of soluble carbohydrate (Oyenuga, 1968) and these observations are in agreement with similar report elsewhere (Mba, Omole and Oyenuga 1976).

The results of the N-balance also revealed that the sweet potato and cassava tubers could successfully replace the maize grains. The sweet potato based, diet favoured a comparatively higher N-retention than either the maize or cassava based diet. This was due to the easily digestible and fermentable nature of the carbohydrate content of sweet potato (Oyenuga, 1968) which provided a readily available energy substrate for the micro-organisms of the rumen. Such rations are known to enhance N-retention, depress ruminal NH_3-N and blood urea levels (Storry and Rook, 1966; Sutton 1970; Mba, Faoye and Oyenuga, 1974). It was highly evident from Table 4 that the three sources of the concentrate supplement could have depressed ruminal NH_3-N and blood urea levels to the same extent since the treatment effect on these parameters was not significant.

The total VFA's was always at its highest peak 1 hour after feeding, declining only slightly 2 hours after feeding, an observation which is in agreement with similar report elsewhere (Mba and Olatunji, 1972). Supplementation of the basal forage with maize, sweet potato or cassava based concentrate increased acid production in the rumen by about 50% (Table 4). The sources of carbohydrate stimulated the increase to the same extent. Available evidence in literature showed that the major products of VFA's carbohydrate digestion are made up of acetic, propionic, butyric acid with traces of iso-butyric, valeric and iso-valeric acids (Bacroft, McAnally and Phillipson 1944 a and b; Elsden, 1945 and 1946; Adebanjo, 1972; Mba and Olatunji, 1972).

Although the proportion of these acids was not determined, it has been fully documented that at similar pH values such diets that favoured increased acid production in the rumen resulted in the production of higher proportion of propionic acid at the expense of other acids. (Bath and Rock, 1963; Sutton and Johnson, 1969; Mba, Oruru and Olatunji 1976). VFA's serve as a major source of energy for the ruminants in maintainance and synthesis of tissue constituents (Carroll and Hungate, 1954; Armstrong, 1965). From studies of metabolic pathways, N-butyric and iso-butyric acids are the condensation products of two moles of acetic acid. While acetic and butyric acids are lipogenic, propionic acid is in fact, glucogenic and has protein — sparing effect (Armstrong and Blaxter, 1957; Blaxter, 1967, Mba, *et al.,* 1976). Thus the replacement of maize grains with dried milled sweet potato or cassava tubers would equally enhance higher VFA's level with a consequent increase in the proportion of propionic acid. Such diets are also known to depress butterfat and increase the solids-not-fat in milk (Balch, Bartlett, Holking, Johnson, Rowland and Turner, 1965; Sutton, 1970).

Every available information on digestibility, energy and protein utilization, volatile fatty acids and ruminal ammonia production with blood urea level revealed that sweet potato and cassava tubers so dried and milled can replace maize grains, the major energy sources, in sheep diets in particular and ruminants' diets in general. Moreover, the higher energy digestibility and nitrogen retention of the sweet potato based ration, coupled with its higher sugar content reveals its potential in ration both as a sweetening agent and in rations of the sheep during gestation and lactation when high quality feed is necessary. Further studies are needed to confirm this.

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