

COMPARATIVE EVALUATION OF CASSAVA FOLIAGE AND GROUNDNUT
HAULMS AS PROTEIN SUPPLEMENTS FOR SHEEP

BY

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A Thesis

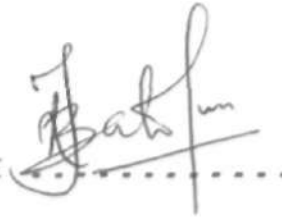
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DECLARATION

I Kayode J. Alli-Balogun hereby declare that the whole of the work now submitted as a thesis for the award of Master of science degree, Animal Science of Ahmadu Bello University is the result of my investigation (except where reference is made to published literature and where assistance is acknowledged) and has not been part of any presentation for any other qualification.

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CERTIFICATION

This thesis "Comparative evaluation of Cassava Foliage and Groundnut haulms as a protein supplements for sheep" by Kayode J. Alli-Balogun meets the requirements governing the award of the degree Masters of Science of Ahmadu Bello University and is approved for its contribution to Scientific knowledge and literary presentation.



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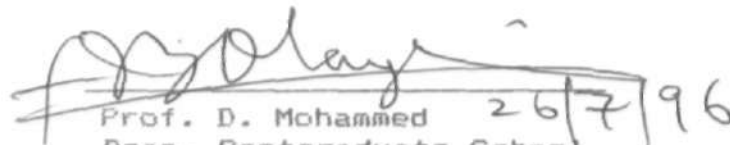


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DEDICATION

This work is dedicated to Almighty God, my parents and all those who did not discourage me.

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ABSTRACT

Three? trials were conducted to evaluate **the** potential of cassava (Manihot esculenta) foliage (leaves and petioles) as a protein supplement for ruminants. In the **first trial** duplicated nylon-bags containing weighed samples of sundried cassava foliage were incubated in the rumen of two rumen fistulated ewes for 0, 8, 16, 24, 48, 72 **and** 96 hours to determine degradability. Proximate analysis of cassava foliage was conducted before and after the incubation. Rumen ammonia concentration (RAG) and pH were determined at 0, 4 and 8 hours after feeding a 30% cassava foliage diet.

Proximate composition of sundried cassava foliage was found to be (%) Dry Matter, 91.25; Crude Protein, 18.55; Neutral Detergent Fiber, 31.41; Acid Detergent Fiber, 29.2; Ether Extract 6.6 and ash 12.95. Nylon-bag dry matter disappearance (DMD %) in the rumen from 0 - 96 hrs increased from 15.76 to 75.5. The DMD % in the rumen significantly ($P < 0.05$) increased from 0 to 48 hours but. further increases became non-significant between 48 - 96 hours.. RAG increased significantly ($P < 0.05$) from 8.20 mg NH_3 /100 ml at zero hour to 17.52 mg NH_3 /100 ml at 4 hours post feeding and decreased to 11.41 mg NH_3 /100 ml at 8 hours. Rumen fluid pH was not significantly ($P > 0.05$) changed by the 30% cassava foliage diet.

In the second trial lasting 56 days, twenty eight Yankasa/West African dwarf yearling rams with an initial

weight of 18 kg were randomly allocated to seven treatments and were balanced for weight- Each treatment consisted of four rams and were all stall-fed Gamba hay (Adropogon gayanus) as a basal diet supplemented with cassava foliage or groundnut haulms or a combination of both at 1.0% or 1.5% of body weight (BW). Rams in the control group were fed only Gamba hay and no supplement.

Feeding Gamba hay alone (control) resulted in weight loss (-30.5g/d) but with cassava foliage or groundnut haulms supplementation at 1.0%- BW, significantly better ($P < 0.05$) weight gains of 39.2 and 44.6 g/day were achieved. At 1.5% BW level of supplementation, with cassava foliage or groundnut haulms, higher weight gains of 45.2 and 51.7 g/day were achieved respectively. Feeding the combined supplements of cassava foliage *and* groundnut haulms at 1.0% and 1.5% BW levels of supplementation resulted in daily live-weight gains of 65.1 and 69.3 g/day-

The third trial consisted of a four week grazing trial followed by a metabolic study. Twenty-one Yankasa/West Africa Dwarf yearling rams were randomly allocated to seven treatments and were balanced for live-weight. All rams were allowed to graze standing digitaria hay as a basal diet. With exception of rams in the control group, all the rams diet were supplemented with cassava foliage or groundnut haulms or a combination of both at 0.5% and 1.0% BW. The metabolic study consisted of a 7 day adjustment period and a 7 day total collection period.

Rams in the control group, the group fed groundnut haulms at 0.5 BW and the groups fed cassava foliage at 0.5% and 1.0% BW had similar live-weight gains, and these were significantly ($P < 0.05$) lower than the weight gains of other groups. But rams in the group fed a combination of cassava foliage and groundnut haulms at 1.0% had significantly ($P < 0.03$) higher live-weight gains compared to other groups. Feed intake was not significantly ($P > 0.03$) changed by feeding either supplement. Supplementing digitaria hay with cassava foliage at both 0.5% and 1.0% BW did not significantly increase the nitrogen retention values, but groundnut haulms supplemented at 1.0% BW and the combined supplements at 0.5% and 1.0% BW significantly ($P < 0.05$) increased the nitrogen retention values.

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EVALUATION OF CASSAVA FOLIAGE AS A
PROTEIN SUPPLEMENT TO RUMINANTS

GENERAL INTRODUCTION

According to FAO (1994) figures, Nigerians intake of animal protein is 6g per day which is far below the recommended minimum level of 35g per day. The main reason for this poor intake of animal protein is poor livestock productivity which is as a result of poor nutrition, breeding, management and disease control. Of these factors, nutrition appears to be the most important, because the gains of selective breeding, management and disease control can only be realised with an adequate plane of nutrition. Hence the search not only for feedstuff but also for methods of improving their efficiency of utilization.

Recently, most work has concentrated on utilization of crop residue and pasture species because of their availability during the long dry season. The major problem with crop residues as a feedstuff is that of poor efficiency of utilization probably as a result of its generally high fibre and low soluble carbohydrate contents. Various methods of improving their efficiency of utilization focus on enhancing rumen microbial fermentation either by physical treatment or chemical treatment. Unfortunately, these methods are not popular because of high cost or unavailability of inputs. A more practical approach to increasing the efficiency of

utilization of crop residues is the addition of protein or non protein nitrogen to the diets consisting of crop residues or poor quality hay. The case for cassava foliage as a protein supplement rests not only on the relatively high crude protein content but also on its availability in most parts of the country throughout the year.

These studies were therefore conducted to evaluate cassava foliage as a protein supplement for small ruminants. The evaluation consisted of three experiments. The first experiment consisted of assessing the degradability of cassava foliage using the nylon-bag technique. The second experiment was a feeding trial in which either cassava foliage or groundnut haulms were fed alone or a (50:50) combination of both as supplement to a poor quality hay (*Andropogon gayanus*). The third experiment was a metabolic trial in which cassava foliage or groundnut haulms or a combination of both were used as a protein supplement to an improved pasture (*Digitaria Smutsii*).

CHAPTER I

LITERATURE REVIEW

Cassava (*Manihot esculenta Crantz*) is an important staple food grown in the tropics. It has year round availability tolerance to extreme ecological stress and high photosynthetic potential. It plays an important role in efforts to alleviate the African food crises (Hahn 1992). It grows well in sandy soils and warm tropical climate ranging in annual rainfall of 700 - 1000mm with a temperature of 15°C and above (Choleva 1968). The plant is tall with thin stems attaining a height varying between 6 - 8ft when fully grown. The stem is marked along its entire length by numerous leaf scars which indicate the position from where the palmate leaves consisting of 5-6 leaflets had dropped off. The plant produces many elongated irregularly arranged tubers. The sweet variety of cassava tubers are shorter and smaller than those of the bitter variety.

The cultivation of cassava is confined to the tropics. It does not tolerate very cold temperatures as this causes leaf shedding and consequently smaller tubers. It is usually cultivated from stem cutting and requires very little weeding. It yields 4 - 12 tonnes per hectare. According to FAO (1985) total world production of cassava in 1968 was 85.6 million tonnes grown on 9.8million hectares. By 1979 the cultivated land area was 13.5million hectare with a total production of 123.3million tonnes. The area cultivated in 1985 increased to

14.2 million hectares with a total production of 136.5 million tonnes.

Khajarern *et al* (1979) compared the production potential and energy yield of some tropical food crop and indicated that cassava gives the second highest energy yield per unit area after sugar cane. Data from low rainfall regions such as in Nigeria indicate that cassava yields 13 times more energy per hectare than maize or sorghum (Oyenuga 1961). It is also estimated that cassava plant yields 1 tonne of valuable protein and 2.5 tonnes of carbohydrate per hectare. (Khajarern *et al* 1979) and Montaldo (1977) estimated that foliage of cassava presently planted around the world had a potential of supplying approximately 48 million tonnes of crude protein per year.

1.1 Chemical Composition of Cassava leaves and roots

Table 1.1. Proximate Analysis

Component %	Leaves ¹	Roots ²
Crude protein	23.2	2.2
Crude fibre	21.9	2.7
Ether Extract	4.8	0.6
Nitrogen Free Extract	42.2	92.2
ASH	7.8	2.2
Ca	0.97	0.17
P	0.58	0.16
Insoluble Ash	n.a	0.06
ADF	n.a	5.0

Source: ¹From Devendra (1977) ²From Khajarern (1978)

Table 1.2 Vitamin Content:

<u>Vitamin</u>	<u>Leaf Content</u>	<u>Tuber Content</u>
Vitamin A (IU)	1-3 x 10 ⁶	550
Riboflavin (mg)	2.5-4.3	0.3-0.8
Thiamin (mg)	0.3-2.7	0.4-1.6
Niacin (mg)	8.5-35.3	0.6-1.6
Vitamin C (IV)	520 - 1800	5-360

Source: DeBrochard et al (1957), Jones (1959), Chadha (1961), Muller et al (1975), Hutagalung (1977) and Montaldo (1977) as cited and compiled by Smith (1988).

Table 1.1 shows cassava root contains very high amount of carbohydrate and low crude protein, fat and minerals. The peels contain greater amounts of crude protein than the fleshy part but total crude protein is generally considered low. The root carbohydrate is mainly nitrogen free extract 80% of which is starch while the remaining 20% is sugars and amides (Vogt 1966 as cited by Khajarern, 1980). This makes cassava root readily digestible to all classes of livestock. The leaves are good sources of high quality protein which compares favourably with soyabean meal protein (Khajarern, 1980). It is low in sulphur amino acids but high in lysine and also crude fibre which makes it a suitable roughage.

As shown in table 1.2 cassava generally has low vitamin content with the exception of ascorbic acid. Oyenuga (1961) reports that cassava contains 3 times the ascorbic acid of

yellow maize.

Table 1.3 Amino acid levels (g/16gN) of cassava foliage and other feedstuff

	CASSAVA LEAVES	FOLIAGE	ELEPHANT GRASS	GUINEA CORN	SOYBEAN
Crude protein	27.0	20.3	12.6	11.9	45.7
Arginine	5.21	3.89	6.10	5.64	7.41
Cystine	1.18	0.98	0.51	-	1.57
Glycine	4.92	5.10	5.85	5.0	5.23
Histidine	2.47	2.32	2.54	2.82	2.39
Isoleucine	4.12	4.40	4.32	3.45	5.45
Leucine	10.0	8.75	8.64	7.55	6.97
Lysine	7.11	5.89	6.02	4.82	6.32
Methionine	1.45	1.83	1.86	1.36	1.52
Phenylalanine	3.87	4.37	5.42	5.82	4.79
Threonine	4.7	5.70	4.41	4.73	4.14
Tryptophan	1.09	1.24	-	-	1.30
Tyrosine	3.97	4.12	3.73	3.18	3.27
Valine	6.18	8.43	6.27	5.18	5.23

Source: Muller *et al* (1974) as cited by Khajerern *et al* (1980)

As can be observed from table 1.3 Amino acid profile of cassava foliage or leaves is comparable to that of soyabean. However the amino acid content depends on age of plant and soil condition.

Table 1.4: Mineral content of cassava Plant Components.

Mineral (mg/kg)	LEAVES	PEEL	TUBERS
Calcium	1.1 - 1.4	0.31	0.02 - 0.35
Phosphorus	0.25 - 0.30	0.13	0.07 - 0.46
Magnesium	nd	0.22	1.10
Copper	8.0	nd	nd
Iron	450	904	8 - 65
Manganese	46.0	nd	18.0
Zinc	28.0	nd	nd

Source: Chadha (1961), Barrios and Bressani: (1967), Devendra (1977) and Hutagalung (1977) as cited by Smith (1992).

The mineral content of cassava root is relatively low and it may contain excessive amounts of calcium depending on the availability in the soil. Oke (1966) reported that the roots contain 0.1 - 0.32% oxalic acid which along with phytic acid in fibre could easily upset the balance of dietary calcium phosphorus and zinc.

Hudson and Ogunsa (1974) observed that cassava root is deficient in essential fatty acid, containing only 14.6% linoleic acid compared with 60.8% maize oil.

1.2 Hydrocyanic acid toxicity in cassava

The greatest constraint to feeding cassava to livestock is hydrocyanic acid (HCN) toxicity. The HCN content of cassava varies with variety growing conditions, age of plant and the part of plant (Smith, 1992) cassava contains the cyanogenic glucosides linamarin and lotaustralin which after tissue damage are hydrolysed by the endogenous enzyme

linamarase to the corresponding cyanohydrin and eventually HCN. The level of HCN ranged from 400 - 600ppm in fresh leaves (Godndwe, 1974) and 15 - 400ppm in the fresh root (Rogers, 1963). Maner (1973) observed that processing methods such as sundrying, shredding and ensiling substantially reduced the amount of HCN contained in cassava products. HCN has high affinity for metal ions such as copper and iron thus rendering them unavailable for metabolic processes. HCN also combines with haemoglobin to form cyanohaemoglobin which is not an oxygen carrier. It forms a reversible combination with copper ion of the cytochrome oxidase system which might inhibit the enzyme function and energy metabolism. Prolonged consumption of cassava results in metabolic disorders reported to be associated with human ataxic neuropathy (Osuntokun, 1973) cretinism in rats (Ekpechi, 1973) and depressed voluntary feed intake, diarrhoea and growth retardation in pigs (Maner, 1973). Oke (1973) suggested that vitamin B₁₂ (hydroxocobalamin) plays a part in cyanide detoxification. It reacts with cyanide to form cyanocobalamin the active form of vitamin B₁₂. Leng (1933 cited by Oke 1973) postulated that thiocyanate formation is another pathway for cyanide detoxification in animals. Thiocyanate is formed by reaction of enzyme rhodanase under aerobic conditions in the presence of thiosulfate.



Maner and Gomez (1973) confirmed that sulfur amino acids have cyanide detoxifying effect. Job *et al* (1975) demonstrated that sulfur is as good as sulfur amino acid in HCN detoxification.

Processing techniques like cooking, sun drying, soaking, pulping, ensiling and fermenting are effective in eliminating most of the HCN content. Devendra (1977) showed (table 1.5) that sun drying cassava leaves substantially reduces the HCN content. Gomez *et al* (1984) also reported a reduction in HCN content by 86% after sun-drying. It has been suggested that the heating process during rapid drying may degrade the hydrolytic enzymes of glycosides and thereby prevent release of free HCN (Omole, 1977).

More studies are needed to determine the safest form of processing to detoxify cassava products.

Table 1.5: Effect of sun-drying on HCN content of cassava leaves

<u>No. of hours in sun</u>	<u>HCN content (mg/100kg)</u>
0	235
2	470
4	475
6	470
8	445
10	324
<u>24 (Oven 36°C)</u>	<u>120</u>

Source Devendra (1977)

1.3 Cassava products in monogastric diets

1.3.1: Poultry: Incorporation of cassava products in monogastric animals diets particularly poultry is limited by the cyanide, high fibre, low essential fatty acid and sulphur amino acids contents. Tejada de Hernandez *et al* (1969) stated that diets of 50% cassava root meal for broiler chicks resulted in lower feed efficiency. Growth problems were also reported by Montilla *et al* (1976) when they incorporated cassava root meal in poultry diets at 0, 15, 30% levels. Feed consumption and feed efficiency also decreased as cassava root meal levels increased. However, once the diets were supplemented with 5% animal fat and 5% molasses the trend was reversed. Researchers are of the opinion that the deterioration was probably caused by the powdery characteristic of cassava root meal rations which was overcome by addition of fat. Hutagalung *et al* (1974) also confirmed that fat acts as a better dust control and increases palatability and absorption.

Enriquez and Ross (1972) obtained satisfactory egg production for layers on a 50 - 60% cassava flour replacement of maize diets. Hamid and Jalaludin (1972) carried out a similar trial and obtained satisfactory egg production. Khajarern *et al* (1978) reported findings from 12 experiments that successful substitution levels were 58 - 60% for broilers (in 3 trials using 3000 birds) and 60% for replacement layers (2 trials using 1600 birds). Substitution of cassava root

products for maize at 50% of the ration for laying birds caused a significantly lower egg production on hen day basis (64.6% Vs 58.9%) over 10, 28 day production but did not affect egg interior quality or shell thickness. All cassava based diets in these trials were pelletized. They finally concluded that:

- a) Total substitution of cassava for cereals could be possible if the diets were:
 - i) duely balanced for all micronutrients
 - ii) fibre ash and Ca were kept as low as possible
 - iii) diets were fed in a form to minimize dustiness and support optimal feedintake
- b) Pelletization of cassava based diets enhance digestibility but also destroyed some vitamins
- c) Livestock increased their ability to utilize nutrients from cassava with age and that there is no carry over effect in rations of replacement pullets on their laying performance.

Tewe (1983) reported that cassava peel when fed to broilers and layers increased feed intake, reduced body weight as well as nutrient utilization when fed to starter and finisher broilers at levels of 0 - 30% replacement of maize. Even when the finisher broiler ration were supplemented with palm oil and groundnut cake to ensure rations were isocaloric and isonitrogenous the performance of the broilers did not appreciably improve. In another trial inclusion levels of 27%

cassava peels at the expense of maize gave satisfactory feed intake, egg production and feed per unit egg produced. They also noted that the economy of conversion was consistently more efficient with rations based on cassava peel than maize.

Ross and Enriquez (1969) fed cassava leaf meal at 0, 3, 5, 10, 15, or 20% levels to one day old male leghorn chicks. They reported that incorporation of the meal at levels higher than 3% would decrease chick weight gain and feed efficiency. Supplementation of 0.15% methionine and 3% maize oil overcame the adverse effect at all levels.

Montilla *et al* (1976) incorporated 10, 20, 30% of cassava leaf meal into broiler diets. Each 10% of cassava leaf meal replaced 7.5% of sesame - cotteseed meal mixture (3:1) and 2.5% maize. The diets were fed as mash or pellet. With mash diets, body weight gain and feed efficiency of chicks was depressed with incorporation of any level of cassava leaf meal in diets during 0 - 6 weeks of age. Body weight gain of all chicks was similar during 6 - 10 weeks of age, whereas the feed efficiency of the 30% group was significantly poorer than the rest. The pelleted diets containing up to 20% cassava leaf meal supported a similar body weight gain to the control. It was concluded that cassava leaf meal could successfully be incorporated into pelleted broiler diets at 16 - 20%.

The European Economic Commission (EEC) has fixed a maximum of 20% inclusion of cassava in poultry rations to

obtain desired carcass traits.

1.3.2 Swine: Lee and Hutagalung (1972) fed 0, 10 or 20% cassava leaf meal to piglets averaging 13.6kg body weight for 4 weeks. It was observed that as the cassava leaf meal content of the diet increased feed intake, daily gain and feed efficiency was significantly decreased. They obtained improved performance when the 20% cassava leaf meal was supplemented with 0.2% methionine. In a subsequent 6 week experiment with larger pigs (30.9kg) supplementation with palm oil, molasses and methionine to the 20% cassava leaf meal, significantly improved performance compared to pigs supplemented with molasses or palm oil alone or palm oil and methionine. They reported that pigs on the basal diets performed significantly better than the rest. It is obvious from the foregoing that more research evidence is required regarding the appropriate level of inclusion of cassava leaf meal in monogastric diets.

Several researchers on the other hand confirmed the potential of cassava root meal as a substitute for maize meal for all classes of pigs (Maner, 1972, Tewe, 1975, 1982 Adegbola, 1977, and Gomez, 1976,). Iyayi *et al* (1988) reported that a 40% level of cassava peel in place of maize was adequate for growing pigs. Performance in terms of feed intake and growth rate was enhanced when the diets were supplemented with plant and animal protein. A dietary protein

level of at least 15% was necessary for satisfactory growth. Cassava root meal or cassava peel based diets because of its low energy content, low protein content and dustiness must be supplemented with a protein source and oil to improve their palatability and digestibility.

The EEC countries maximum level of incorporation of cassava root in pigs is 40%. Tawe (1982, 1984) demonstrated that cyanide levels greater than 100ppm HCN reduced performance and prevented haematological changes of growing pigs fed sundried cassava based rations.

1.4 Cassava products in ruminant diets

The potentials of cassava root products as an energy source has been widely acknowledged by ruminant nutritionists (Olaluku et al, 1971, Muller, 1975). Cassava peel is an important source of energy in ruminant feed either as basal diets or as supplement. Although the peel has higher HCN levels than the fleshy tuber, sundrying ensiling and fermentation significantly reduces the concentration of the glycosides to tolerable levels (Smith 1988). Asaolu (1988) reports dry matter losses of 70% (dried peel) and 73% (ensiled peel) after 24 hours in the rumen of sheep. In a study comparing rumen degradability of several crop residues in cattle sheep and goats, high dry matter degradability of cassava foliage was reported in all three ruminant species with a mean value of 83% in 48 hours (Smith et al, 1988). This

suggests cassava peel might be a useful source of energy for ruminants. Fomunyan et al (1987) fed sheep on three levels of dried cassava peel 0, 35, 70% of diet in combination with *Pennisetum purpureum* at 70, 35, and 0% of diets respectively with cotton seed cake supplied as protein source. They reported that as dietary levels of cassava peels increased the dry matter intake, digestibility and growth rate also increased. Ifut (1992) fed West African Dwarf goats six rations (T₁ - T₆) Goats^{fed} 100% cassava peels digested the highest dry matter intake and organic matter (P,0.05) but had the lowest nitrogen consumption and also had negative nitrogen digestibility and consequently lost weight (-54.8g/d) Diet T₄ (consisting of 35% each of Glicidia sepium and P maximum while cassava peel made up 30% of diet) significantly (P,0.05) promoted positive body weight gain (66.3g/day).

Asaolu (1988) observed that sheep fed ensiled cassava peels performed better than those fed dried cassava peel and suggested that this might be due to the lower cyanide content in the ensiled cassava peels. He fed two groups of West African Dwarf sheep diets made up of 80% dried or ensiled cassava peel supplemented in each case with 20% *Gliciridia* leaves. A third group of sheep were fed solely on *Gliciridia* leaves. Results showed that sheep on control diet (100% *Gliciridia* leaves gained 106.0g/day, sheep on 20% *Gliciridia* leaves plus 80% cassava peels (ensiled) gained 81.0g/day while sheep on 20% *Gliciridia* plus 80% dried cassava peels gained

59.0g/day. Larsen and Amaning-Kwarteng (1976) also reported similar results using crossbred cattle. Asaolu (1988) indicated that good quality ensiled cassava peel could be made by chopping to 2cm and air drying for 2 days before ensiling.

It can be concluded that cassava peel diets have great potential as dry season feedstuff for ruminants. Okeke and Oji (1988) recommended that in anticipation of dry season feeding cassava peel should be used as an energy supplement in an ensiled mixture of grass legume foliage and poultry excreta. They fed grass legume foliage cassava peel and poultry excreta in the ration 60:20:20 on wet basis to West African Dwarf goats.

Utilization of cassava leaves or foliage in ruminant diets is not yet a popular practice and thus a limited amount of studies has been reported. Muller (1974) indicated that the amino acid pattern of cassava leaf is comparable to that of soybean and superior to that of cereals. But the methionine content is considered to be deficient when compared to FAO reference figures. According to Eggum (1970) only 50% of cassava leaf methionine is available thus making the biological value range from 49 - 57%, therefore cassava leaf is not a good source of protein for methionine limiting diets. Supplementation with protein sources like sesame seed or animal protein adequately makes up for this deficiency.

Moore (1976) fed steers (weighing 250kg) forages composed of elephant grass or either one or two mixtures of 75.25% or

50:50% of elephant grass and cassava foliage. Results showed steers receiving 75% grass plus 25% foliage gave the best performance (0.56kg average daily gain) Seeres (1969) reported finishing Zebu cattle with cassava leaf, rice and sweet-potato ration successfully. The finished animals became very fat yielding over 65% carcass. In another experiment (Moore 1976) fed steers a basal diet of chopped sugar cane supplemented with either cottenseed cake cassava foliage or Desmodium distortion foliage. Results showed 0.66, 0.62, and 0.58kg/day gains respectively.

Murillo (1952) compared the value of cassava leaf meal with that of alfalfa meal and observed that milk production of dairy cows fed cassava leaf meal was 90-96% of those fed on alfalfa meal. He concluded that cassava leaf meal is an economic replacement for alfalfa meal. Fernandez *et al* (1977) fed growing cattle a basal diet of molasis and urea supplemented with 3% fresh cassava leaves. He reported a live weight daily gain of 0.58 - 0.66kg. Floukes and Preston (1978) fed growing cattle a basal diet of molasses urea and soybean meal combination supplemented with 4.5% fresh cassava leaves. They reported high intake 6.1kg/day and high growth rate 0.9kg/day on cassava foliage diets. Hulman and Preston (1981) fed cassava tops and leucaena forage as a supplement to cattle fed *ad libitum* chopped sugar cane plus urea. They observed increased voluntary intake of the total diet but decreased intake of sugar cane, improvement in growth rate

were low -40 to + 140g/day with cassava supplements and 60 to 200g/day when leucaena was fed.

The foliages of cassava or sweet potato was used as the roughage supplement in a molasses - urea diet for fattening bulls in the presence or absence of a supplement of soyabean meal. With cassava supplementation there was no benefit from adding protein indicating that it may be a better source of bypass protein than sweet potato foliage (Table 1.6).

Table 1.16 Effect of Soyabean Supplementation on basal diets of urea-molasses blocks with cassava or sweet potato foliage

<u>Forage</u>	<u>Sweet potato</u>		<u>Cassava</u>	
Soyabean meal g/day	0	400	0	400
Molasses kg/day	5	6	6	6
<u>Forage kg/day</u>	<u>13</u>	<u>13</u>	<u>10</u>	<u>10</u>
<u>Liveweight kg/day</u>	<u>650</u>	<u>850</u>	<u>850</u>	<u>870</u>

Source: FFloukes and Preston (1978)

Smith *et al* (1988) comparing the rumen degradability of some foliages in cattle and goats reports a similarly high 48 hours degradation of 84.3% for cassava leaves. Ranjham (1980) fed 2.3kg of partially dried cassava leaves to growing calves and observed that it can replace .7kg of groundnut cake. It also gave good results when fed to lactating animals. 50% groundnut cake can be replaced with cassava leaves in the ration of mulch animals. At an intake of 0.5 - 0.8% of the body weight, it doesn't bring about any adverse effect.

In general, from the nutritive composition of cassava leaves or foliage and the high rate of rumen degradation, it can be concluded that cassava foliage is an important protein supplement as long as its processed to reduce the cyanide content to minimal levels.

Fomunyan and Maffeja (1986) reported feeding sundried cassava leaves to rabbits at 50, 62.5 and 75% levels in test diets. Intake was 65.8, 73.5 and 71.8g/day and liveweight gain was 17.4, 19.4 and 18.2g/day respectively. Cassava leaf compares favourably with alfalfa meal which has proved palatable to rabbits and is the largest single component of commercial rabbit feed in USA (Cheek 1987).

1.5 Processing cassava products for animal feed

The root, stem and leaves of cassava plant are good sources of carbohydrate fibre and protein. Due to its relative cheapness it could be used economically as animal feed after appropriate processing which is necessary to reduce the cyanide content and preserve it for storage.

Roots: The roots are popularly used as source of carbohydrate for animal feeds and since it doesn't store for long it is usually processed into chips and pellets. After harvesting the cassava roots are washed and peeled as dirt and peel reduce the quality of the final product. The roots are then dipped in 3% lime (Ca (OH)) solution to neutralize the acid juice and prevent deterioration. Chipping can be done manually or mechanically with chippers which has a power

driven disc with radial chipping slots fitted with cutting blades.

In Nigeria manually operated chippers designed by rural agro-industrial development service and IITA Post Harvest Unit is available but the choice of a chipper depends on the scale of operation.

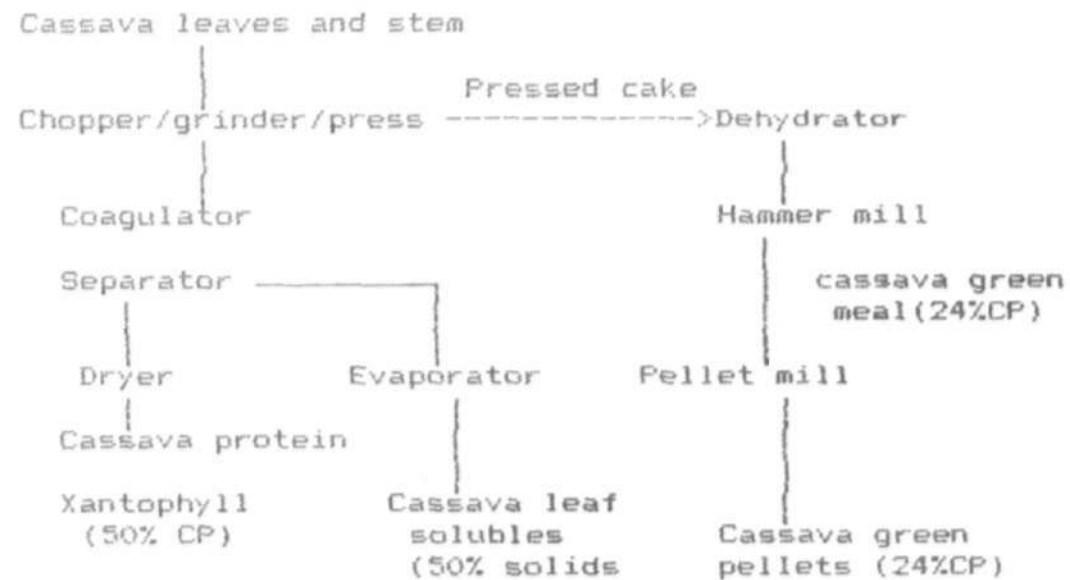
Drying is the next stage. Drying methods depends on the cost and level of technology available. Natural sundrying on blackened concrete floors is a common practice in developing countries. However drying time depends on chip factors and environmental conditions. Chip factors include shape and size of chip, chip loading per unit area and dry matter content of the chip. Air speed temperature, humidity and radiation are determining environmental factors. Artificial drying methods are more effective as all factors are controlled to optimize drying time. There are 3 types of artificial dryers the static bed dryer the moving bed dryer and rotatory bed dryer.

Big sized chips are hammer milled then preconditioned. Preconditioning involves increasing the moisture content to 16 - 18% either by spraying water or by adding steam. The chips are then forced through small holes in die causing a rise in temperature which gives the pellets cohesion but also causes considerable wear on the die making pelletizing energy intensive (60 - 140kwh per hour). Pelletizing decreases the volume by 25 - 40% and this eases transportation cost and eliminates dustiness of the product. It also increases

durability and quality of the product and increases intake by the animal. Small chips with 13 - 14% moisture content which are then heated to 65°C and then moistened to 15 -17% moisture just before pressing give best results. Fetuga and Tewe (1985) suggest that the heat generated by steam treatment and high pressure during pelletization increases the cellulose from lignin - cellulose bonds thereby increasing the digestibility of starch and fibre.

Cassava leaves and stems: Cassava leaves are a good source of protein and the amount of protein contained depends on the stage of growth. Extraction of cassava leaves protein starts (as shown in fig 1) with mixing the stem and leaves in a chopper or grinder and the juice pressed out. The juice so obtained is coagulated with injection of steam and then passed to the hydrator. A separator separates the soluble fraction from the green curd which is then evaporated and concentrated to 50% by volume. The curd is then dried to produce cassava protein concentrate which contains 50% crude protein (Muller, 1977).

Figure 1.0 Flow chart for processing cassava leaves and stems



Adpted from Dguntimein (1992).

1.6 Enhanced pasture utilization through protein or non-protein nitrogen supplementation

Pasture grasses form the major part of ruminant diet constituting more than 75% of all animal rations in Nigeria (Fitzhugh *et al* 1978). The tribes *Andropogoneae* and *Panicaceae* constitute approximately 43% of total classified forage grasses (Agishi 85). *Andropogon gayanus* (gamba grass) when fresh is very palatable to ruminant and is high yielding reaching 4 tonnes per ha in the wet season (August) (Haggar, 1970). As tropical grasses mature, they undergo chemical and structural changes resulting from translocation of soluble carbohydrates from the stem and leaves to the inflorescence thus increasing the relative proportions of lignified cell walls in the leaves and stem. Comparatively the digestibility

of tropical pasture species declines much more rapidly than that of temperate species hereby pasture intake for tropical forages is less than that of temperate forages (Minson, 1980, 1982). He observed that at a digestibility of 60% which is high for tropical pastures, forage intake of sheep is greater on tropical pasture than on temperate pasture of the same digestibility. As growth advances palatability and consequently intake decreases due to lignification (Muller 1961). Lignin encrusts the fibre reducing the digestibility and also inhibits the digestion of carbohydrate thus intake of poor quality herbage is low because of rumen - fill up and distension (Campling et al 1961).

With intake lowered and digestibility impaired animals fed poor quality roughages without supplementation starve, lose condition and suffer decreased reproductive activity and prolonged maturity (Zimmerlink, 1973). Adu and Adamu (1982) showed that tropical animals cannot consume enough poor quality pasture to meet body maintenance requirements. Consequently methods of improving digestibility of poor quality roughage involving physical or chemical treatments can only have limited effectiveness unless other nutrients are provided in the rumen and balanced to support efficient rumen ecosystem (Preston and Leng, 1984).

Improvement in the voluntary intake of poor quality hay due to supplementation with urea has been reported by several investigators (Wanapat, 1985, Ibrahim and Schiere, 1985). The

most promising treatment procedure is the addition of fertilizer grade urea and water, storage for sufficient time for urea to hydrolyse into ammonia for roughage treatment (Dixon et al 1987). Ferdok et al (1982) Using Sahiwal heifers reported that urea treated straws gave total DM intake (% of liveweight) liveweight gain and feed efficiency of 2.6%, 346g/d, and 13 compared to 2.3%, 73g/d and 53 respectively for untreated straws. Most experiments where urea sprayed over the straw has been compared with urea treated straw suggests that the action of the urea is principally by the alkali effect on the fibre (Ferdok et al 1982, Dryden and Kempton 1984). Warambwa et al (1992) using small East African goats fed maize stover and groundnut haulms with either urea or sunflower reported that sunflower supplemented diets contained more readily degradable fraction than urea supplemented diets (11.45 Vs 4.65) but had a lower DM degradation (45.08 Vs 56.62%). In the subsequent feeding trial they reported no significant differences between the 2 diets in terms of liveweight gain and that both were adequate to maintain weight.

Compared with non-protein nitrogen, protein - Nitrogen has better potentials for eliciting better voluntary intake and growth rates because

1. Some microbes require pre-formed peptides or amino acids for metabolism (Cotta & Russel 1982, Czerkawski 1986)
2. Protein-N also serves as a source for other mineral i.e.

sulphur which is usually lacking in poor quality roughage. Supplementation of poor quality roughage with sulphur increased digestion of cellulose (Gulati 1985).

3. Slower release of NH_3 due to complex peptide bonds therefore more likely to coincide with release of energy thus enhancing microbial protein synthesis (Yilala, 1989).

The enhancement by supplementary protein source on poor roughage diets has been demonstrated by Preston and Willis (1974) with their work in Cuba. Addition of small quantities of by pass protein (fish meal) to poor roughage diets produced dramatic improvements in terms of intake, digestibility and liveweight gains. Church and Santos (1981) reported increased voluntary intake of wheat straw in lambs when 1 - 4g/kg $\text{w}^{0.75}$ of soybean meal was fed. Digestibility reached maximum with 3 - 4g crude protein supplement regardless of nitrogen source. Similar increased voluntary intake was reported (Farero *et al* 1980) when 40 and 15% soybean meal protein was supplemented to dormant range forage. Coombe (1983) reported that supplementation of oat straw with protein meal (rape and sunflower meal) improved straw digestibility when compared with urea alone. Improvement in voluntary intake of low quality forage is usually attributed to increased rate of forage digestion and passage (Ellis, 1978). This may be due to enhancement of ruminal escape of amino acid of supplemental protein and subsequent effect on voluntary intake (Lufadeju

1988). Ndlovu *et al* (1989) also reports similar results from feeding hydrated maize stover to steers. The diets were supplemented with three protein supplements (i.e. soybean meal, urea or bloodmeal). They concluded that protein type had no effect on voluntary intake. Mccollum and Galyean (1985) reported lower proportions of acetate higher propionate and butyrate as a result of supplementation with cottseed meal. Provision of required concentration of rumen NH_3 at 150 - 250mg/l of rumen liquid (Krebs *et al* 1985) and administration of small quantities of readily fermentable carbohydrate have greatly improved fibre digestion.

1.6.1 PROTEIN METABOLISM

Major aim of protein supplementation is to increase the availability of amino acid at the tissue level for the animal and consequently obtain better productivity. Two possible methods of achieving this is by either increasing the rumen microbial population which leads to greater amounts of microbial protein being washed into the small intestine, or by feeding proteins that can partly escape rumen degradation and still be available for intestinal digestion. Proteins are degraded by hydrolysis to peptides and amino acids by bacterial and protozoal proteases peptidases and deaminases. Factors determining rate and extent of degradation include rate of solubility and time while important chemical factors are cross-linkages, number of accessible hydrolysable sites in the protein, molecule, enzyme concentration and pH. (Preston and

Leng, 1987).

Amino acids are rapidly deaminated in the rumen giving rise to branched chain volatile fatty acids (VFA) ammonia and CO_2 (Chalupa 1976). The microbial population derive 20-50% of their nitrogen from sources other than ammonia. These are presumably from intact amino acids or peptides which originate from food proteins, recycled proteins (largely salivary mucoproteins) or from turn-over of bacterial and protozoal protein in the rumen (Oldham, 1981). Satter and Roffler (1981) observed that the amount of NH_3 that can be utilized in microbial protein synthesis by bacteria will depend on the number of bacteria and how rapidly they are growing. In other words it would depend on the amount of energy available for the bacteria or the amount of fermentable feed consumed. Rations high in grain or digestible dry matter are more fermentable than high forage rations consequently more NH_3 can be utilized. Hagemeister et al (1981) reported that the energy source for microbial protein synthesis in the rumen is derived mainly from dietary carbohydrates as neither lipids or proteins play any major role in energy supply for protein synthesis. Preston and Leng (1987) reported the critical level of NH_3 that supports the maximum digestibility in the rumen and therefore the largest microbial population would vary between 50-250mg $\text{NH}_3\text{-N/litre}$ rumen liquor.

Conversion of dietary protein to microbial protein is wasteful since if deamination is rapid NH_3 released is not

completely trapped by microbes for synthesis of amino acids. Some NH_3 is absorbed, passes into portal circulation to liver and is converted to urea (through the krebs-Henseleit pathway) which can be partly excreted in urine or recycled back to the rumen via saliva (Hibbits, 1984). The extent to which urea is returned to the rumen via saliva is proportional to the blood urea concentration and rate of saliva secretion (Nolan et al, 1973) Secretion of Saliva reaches 6-16 litres/day in sheep and up to 100-190 litres/day in cattle (Kay, 1960) Rumen ammonia concentration influences and regulates urea entry into the rumen from blood and saliva. When concentration of NH_3 in rumen is high the transfer of urea from blood to rumen is reduced. (Kennedy and Milligan 1980) Rumen epithelial bacteria urease has been implicated in facilitating this transport of plasma urea into the rumen (Cheng and Wallace, 1979) Kennedy and Milligan (1978) showed that the relationship between rumen NH_3 level and transfer of plasma urea to the rumen is inversely correlated.

Various methods are been used to assist protein escape ruminal degradation by reducing its solubility. Methods using this principle are heat treatment (Beever et al; 1976), grinding and pelleting (Osburn et al 1976), or use of chemical treatment such as formaldehyde (Ferguson et al 1967), all have been shown to increase the percentage of dietary protein escaping degradation in the rumen. However a balanced supply of amino acids to the rumen micro-organism in addition

to a non-protein nitrogen (NPN) source may be essential and the substitution of NPN for protected protein in the nutrition of rumen micro-organisms may lead to a depression in microbial growth and structural carbohydrate degradation when a major part of the dietary protein has been protected. (Beever et al 1981). More recently attention has shifted to the use of chemicals such as ionophores or halogen containing compounds which inhibit methanogenesis and also reduce acetate production, while increasing that of butyrate. The primary mechanism of these carboxylic polyether ionophores is to alter the flow of cations across the cell membrane. Avoparcin (antibiotic) decreases acetate: propionate ratio while chemicals like diaryliodonium suppress degradation of protein and also adjust proportions of VFA favourably (Chalupa, 1984). In the present Nigerian circumstances the use of these chemicals might not be practical but heat treatment, grinding and pelleting might have their benefits.

From the foregoing it is obvious that protein supplementation of low quality roughage alter ruminal fermentation by providing higher rumen ammonia concentration, lower molar proportions of acetate and high propionate (Kempton et al 1977) higher rate of rumen fluid dilution and passage rate (Mc collum and Galyean 1985).

CHAPTER 11 EXPERIMENTS**2.1.1 EXPERIMENT I EVALUATION OF CASSAVA FOILAGE
DEGRADATION USING NYLON BAG TECHNIQUE****2.1.2 INTRODUCTION**

In the tropics livestock diets are primarily composed of crop residues and fibrous feed of low quality particularly during the long dry season. Degradation of specialized plant material by rumen microbes varies from tissue to tissue decreasing in the order, mesophyll and phloem to epidermis and parenchyma sheath to sclerenchyma and lignified vascular tissue (Akins, 1982). Tropical grasses have few mesophyll cells between vascular bundles (as a consequence of adaptation to C-4 photosynthesis pathway) and have high proportion of lignified vascular tissues. Both factors combine to lower the degradability of tropical forages generally. As plants mature their cell walls thicken and deposition of hemicellulose and lignin increases, further reducing degradability (Ndlovu, 1992). Factors determining plant and protein degradation are the physical nature of the proteins and their release from plant cells, the concentration of proteolytic enzymes and the time available for proteolysis. Feed resources with less than 40% dry matter disappearance in 48 hours has little or no potential for supporting growth and lactation but may have application in diets of working animals (Preston and Leng, 1987).

Methods of evaluating the degradability of a feedstuff includes the in-vitro method (Tilley and Terry, 1963) and the nylon-bag technique (Orskov and McDonald, 1979). The advantage of the nylon-bag technique is not only in the ease of application but also it is more precise as microbial fermentation occurs in the microbes own environment. It involves incubating samples of feed material in the rumen of fistulated animals for periods of 60-120 hours and the subsequent determination of the disappearance of different feed components (Osuji *et al* 1993).

With knowledge of the degradation characteristics of protein sources it is now possible to combine them with a source of energy having similar degradation characteristics. This synchronized release of nitrogen and energy ensures optimal microbial utilization in the rumen and it is most likely to translate into better liveweight gains.

Cassava foliage has long been recognised as available protein source (Muller 1974, Montaldo 1977). It has been fed as a protein supplement not only to ruminants (Seres, 1969, Moore 1979) but also to pigs (Lee and Hutagalung 1972) and poultry (Ross and Enriques 1969). In Nigeria very little or no work has been reported on the nutritive value and dry matter disappearance of local varieties of cassava foliage, as most works concentrate on the tuber.

Therefore, the prime objective of this study is to

- i. determine the nutritive value of cassava foliage (leaves

and petioles) by proximate analysis.

- ii. determine the rate of dry matter disappearance using the nylon-bag technique.

2.1.3 MATERIALS AND METHODS

2.1.1.3 ANIMALS PREPARATION AND MANAGEMENT

Two Yankasa rumen fistulated ewes average weight 20kg and age of 1.5 years respectively were used in this study. The technique of rumen fistulation used was a modification of the single abdominal wall incision method as described by Lufadeju (1988). After the operation the ewes were housed and fed for a month in individual pens measuring 1.0 x 2.0m) with concrete floor and open sides.

2.1.2.3 INCUBATION PROCEDURE AND TREATMENT

Three weeks before commencement of the experiment the ewes were given a supplement containing 30% cassava foliage 42% maize bran 25% maize, 1.5% salt, and 1.5% bone meal daily after which the ewes were allowed to graze *Brachiaria* pastures.

Sundried cassava foliage (leaves and petioles) was ground using a laboratory hammer mill fitted with a 2.5mm screen mesh. Approximately 2.5-3.5g of cassava foliage samples were weighed into 10 x 8cm nylon-bags with 20-40 micro mesh size. The nylon-bags were sealed and attached by means of elastic rubber bands to a 40cm flexible rubber tube which was attached to the cannular cover with a nylon string. Nylon-bags

containing samples of cassava foliage were inserted in duplicates in the rumen of the ewes for 0, 8, 16, 24, 48, 72 and 96 hours. Upon withdrawal the bags were washed under running water until the water was clear. They were then dried at 70°C for 24 hours and weighed according to procedure described by Mehrez and Orskov (1977). Dry matter losses were calculated as estimates of dry matter degradation.

Sundried samples of cassava foliage were subjected to proximal analysis using AOAC (1984) procedure, the sample residues after incubation in the rumen were also subjected to CP, NDF and ADF analysis. Samples of rumen fluid were taken into a 30cm pipette using a hand pump to provide suction. To prevent blockage of the pipette a Muslin cloth was tied around the aperture to strain out rumen particles. Rumen fluid collected was mixed with an equal volume of 0.1N H₂SO₄ and immediately stored in a freezer, for subsequent rumen NH₃ determination - Rumen fluid was centrifuged at 300 r.p.m for 10 minutes and a 5ml portion was mixed with 2ml of 40% NaOH and distilled using a markham distillation apparatus. The distillate was collected in 5ml of 2% boric acid was titrated against N/70 H₂SO₄ (Whitehead 1967). Rumen fluid was also collected at 0, 4, and 8 hours post feeding 30% cassava foliage diet to determine the pH using a Phillip digital pH meter (model Pro 9409).

2.1.4 Results

The proximate analysis of cassava foliage is shown in Table 2.1. It has 18.55% crude protein. ADF and NDF values were 29.2% and 31.41% respectively, while dry matter and ash were 91.25% and 12.93% respectively.

Dry matter disappearance (DMD%) of cassava foliage is shown in table 2.2. Values ranged from 15.74% at zero hours to 75.57% at 96 hours. The dry matter disappearance rate in the rumen of the ewes significantly increased ($P < 0.05$) between 0 to 48 hours but further increases became non-significant between 48 to 96 hours. Results of DMD% were fitted into an exponential equation of the form $P = a + b(1 - e^{-ct})$ (Orskov and McDonald 1979) where

P = degradation taking place at time t = 0.226809.

A = Proportion of feed rapidly degraded (intercept) = 15.72

B = Proportion of feed gradually degraded = 59.83

C = Rate constant for degradation of "b" = 0.098909

$(a + b)$ = asymptote

DMD% was plotted against time (fig.1) to obtain the characteristic degradation curve. The rumen ammonia concentration (RAC) after feeding 30% cassava diet was 8.193mg $\text{NH}_3/100\text{ml}$ at zero hours, (table 2.3) which was significantly ($P < 0.05$) lower than values obtained at 4 and 8 hours (17.510 and 11.406mg $\text{NH}_3/100\text{ml}$ respectively). pH values of rumen fluid at 0, 4 and 8 hours post feeding were 7.37, 6.425 and 6.385 respectively. NDF and ADF content of the sample residue

after incubation (table 2.4) was twice the initial value of the original sample. There was no correlation between duration of incubation and the NDF, ADF content of the incubated samples. Analysis for crude protein content of the sample residue showed increased crude protein levels.

2.1.5 DISCUSSION

The high dry matter content (91.25%) and relatively high crude protein content 18.55% make cassava foliage a valuable protein source. Preston (1985) reported that minimum crude protein level in feedstuff (dry matter) for efficient rumen fermentation is 9.3% coupled with high neutral detergent fibre (NDF) and acid detergent fibre (ADF) values, cassava foliage could be classified as a proteinaceous roughage.

Smith et al (1988) reported the rate of dry matter disappearance of cassava leaves within 48 hours incubation in the rumen of cattle and goats as being 83.3%. This is higher than the rate obtained (70.59%) in this study using cassava foliage (leaves and petioles) within the same period. The difference between the two values could be due to the presence of petioles which have high fibre content resulting from the presence of structural vascular bundles. Abate (1992) observed that fibrous materials are less soluble because of the dominance of structural over soluble carbohydrates in the cell wall. Also differences might be due to different stage of maturity of cassava foliage. Significant differences ($P < 0.05$) were observed in the dry matter disappearance for 0,

16, 24 and 48 hours incubations while no significant difference ($P > 0.05$) were observed between the DMD% values to 48, 72, 96 hours when the DMD% seemed to have stabilized. This suggests that most of the potentially degradable fraction had been removed by 48 hours in the rumen. With the knowledge of cassava foliage degradation characteristics it is possible to estimate supplementation levels and evolve strategies to elicit maximum utilization and production.

High rate of DMD% suggests that cassava foliage constitutes low rumen load thus optimizing voluntary intake and probably enhances its bypass qualities. FFloukes and Preston (1987) reported that cassava foliage has high rumen bypass qualities much more than sweet potato foliage, which is also highly degradable (Santana and Howell 1979). This bypass protein might result from the water soluble fraction escaping intact to the intestine and being available for enzymatic digestion.

Leng and Nolan (1984) reported optimum rumen ammonia concentration (RAC) ranging between 15-20mgN/100ml depending on the diet, higher levels of RAC being required for roughage degradation. On a 30% cassava foliage diet mean RAC values at 4 hour post feeding was 17.51mg NH_3 /100ml. This is well within range suggested although Lufadeju (1988) cited lower figures (12mg NH_3 /100ml) as being the optimum rumen ammonia concentration that elicits maximum degradation of roughage (*Andropogon gayanus*) for cattle. At 8 hours post feeding the

RAC value was 11.406mgNH₃/100ml which shows a reduction compared to the 4 hour value. The reduction in RAC at 8 hours post feeding is probably due to rumen microbes utilizing the NH₃ to produce microbial protein or the NH₃ simply diffuses through the rumen walls into the blood stream. Some of NH₃ absorbed passes into the portal circulation to liver and is converted to urea (through Krebs-Henseleit pathway) which can be partly excreted out as urine or recycled back to the rumen via saliva (Hibbit, 1984). Hibbit (1984) also observed that the efficiency of N capture within the rumen depends upon the degradability of the dietary protein and also on the provision of readily available energy in the form of dietary carbohydrates for microbial protein synthesis. Thus for optimum utilization of cassava foliage there is need to incorporate it with grains or any source of readily available energy. Alternatively cassava foliage can be fed several times a day to maintain continuously high RAC levels with poorly degradable roughages as basal diets as described by Preston and Leng (1987) for urea.

The pH of rumen fluid at zero hour of feeding 30% cassava foliage diet was 7.37. This is slightly higher than the optimum range (6.5 - 6.8) as reported by Ndlovu (1992) but at 4 hours post feeding pH was 6.42. This shows a reduction although it is still close to range suggested as optimal for maximum cellulolysis. The lower pH at 4 hours post feeding was due to the presence of grains (maize) in the diet also

production of VFA's tend to lower the rumen pH (Ndlovu, 1992). At 8 hours post feeding the pH was slightly lower 6.385, this is most likely due to the combined effect of the grains in the diet and VFA produced.

Results also showed that the soluble portion of cassava foliage had been degraded leaving the fibrous residue which had higher NDF and ADF values. It was expected that as period of incubation increased the NDF and ADF values would also increase but in this regard results from this study were inconclusive. The increased level of crude protein content in the sample residue between 8 hrs to 24 hrs after incubation is probably due to the presence of rumen microbes in the residue. Also there was no apparent correlation between the level of crude protein in the residue and the length of incubation time.

2.1.6 Conclusion and Recommendation

From literature cited and results from this study it can be concluded that cassava foliage has relatively high levels of crude protein, also with its relatively high DM% it would likely constitute low rumen load thus optimizing voluntary intake. It is most likely best liveweight gains would be obtained if cassava foliage is fed with a readily available source of energy. This synchronized release of protein and energy would promote maximum microbial synthesis in the rumen.

MEAN DRY MATTER DISAPPEARANCE
OF CASSAVA FOLIAGE

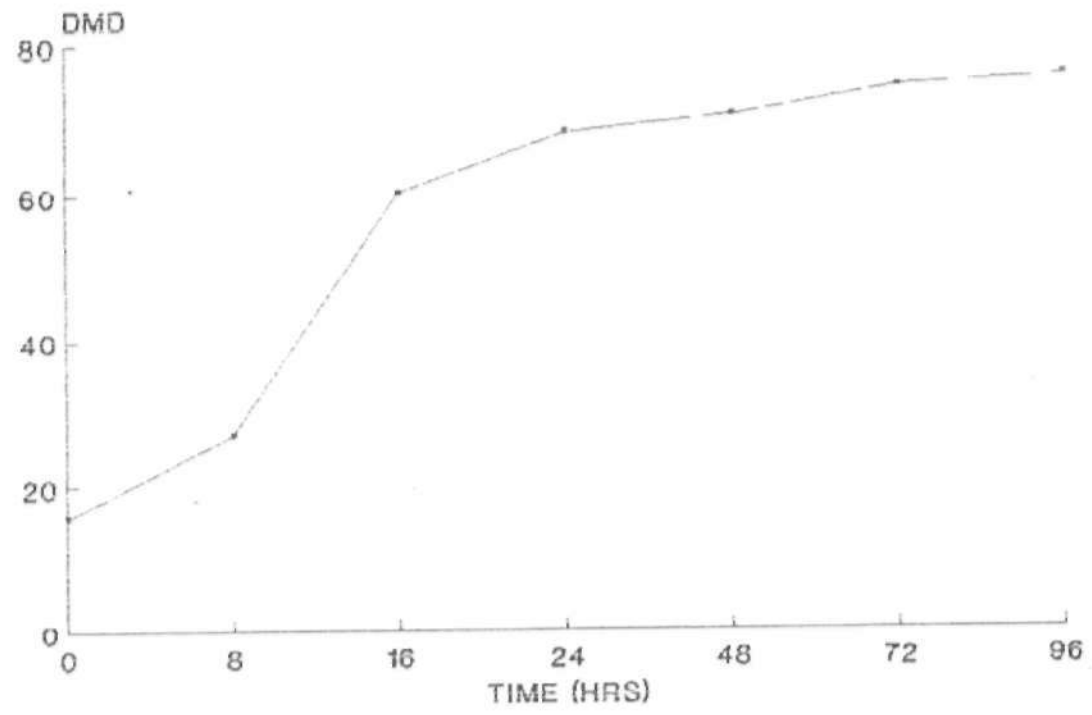


Fig 1

Table 2.1: Proximate Composition of Cassava foliage

Dry Matter	Crude Protein	Ash	NDF	ADF	Ether Extract
% 91.25	18.55	12.93	31.41	29.2	6.67

Table 2.2. MEAN DRY MATTER DISAPPEARANCE OF CASSAVA FOLIAGE

TIME (HRS)	DMD ^a	±	SE
0	15.74 ^a	±	0.17625
8	26.87 ^b	±	0.925
16	60.09 ^c	±	3.532
24	68.35 ^c	±	1.3872
48	70.59 ^c	±	0.8461
72	74.28 ^c	±	0.4878
96	75.57 ^c	±	1.0881

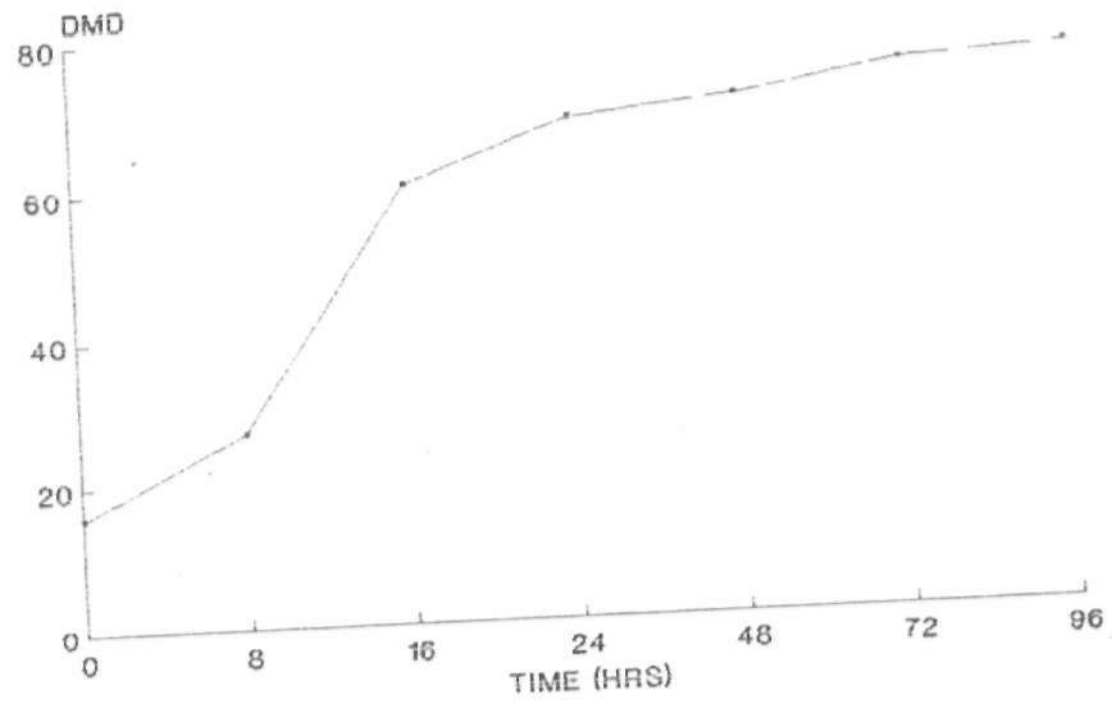
*Mean within the same column bearing different superscripts are significantly different.

^aEach value is a mean of 4 observations.

Table 2.3 Rumens Ammonia Concentration (RAC) and pH of rumen fluid.

Hours	RAC(mg NH ₃ /100ml)	SE	PH	
0	8.19315 ^a	±	0.2409	7.37
4	17.51085 ^b	±	0.4016	6.425
8	11.40615	±	0.8032	6.385

MEAN DRY MATTER DISAPPEARANCE OF CASSAVA FOLIAGE



Delayed when to start

Table 2.4 Crude Protein, NDF & ADF Composition of Cassava Foliage Sample residue

Incubation Hours	NDF	ADF	Crude protein
0	31.41	29.2	18.55
8	74.82	53.43	24.84
16	74.15	65.47	26.42
24	74.057	66.36	21.70
48	70.63	61.92	17.53
72	70.13	61.36	18.51
96	72.33	62.72	18.83

EXPERIMENT II

EVALUATION OF CASSAVA FOLIAGE AND GROUNDNUT HAULMS
AS PROTEIN SUPPLEMENTS TO GAMBIA HAY

2.2.2 INTRODUCTION

Enhanced utilization of poor quality roughage can be achieved through chemical or physical treatments but low nitrogen content of the roughage limits protein synthesis of rumen microbes and thus reduces outflow of microbial protein from the rumen. It is generally accepted that protein supplementation of low quality roughage is one of the best ways of increasing voluntary intake and nutritive value. It also maximizes fermentation and increases outflow of microbial protein from the rumen (Adu *et al* 1984).

Moore (1976) demonstrated the feed value of cassava foliage for ruminants in a trial in which steers weighing 250kg were fed *Pennisetum purpureum* with varying levels of cassava foliage. Feed intake growth rate and feed efficiency were improved in diets containing cassava foliage supplements.

The case for cassava foliage as a protein supplement is mainly rooted in its relatively high crude protein content (14.7-36.4%) (Smith, 1988), high rate of degradability and its availability particularly during the dry season. Furthermore the only processing required to reduce the cyanide content is chopping and or sundrying for 7 days (Devendra 1977).

Groundnut haulms is popularly used to fatten animals

particularly in the northern parts of Nigeria. Supplementation with leguminous residues has been shown to increase the digestibility and intake of poor quality roughages or cereal crop residues (Mosi and Butterworth, 1985, Lane, 1982, Moran *et al*, 1983; McMeniman *et al* 1983). Ngwa *et al* (1992) fed a) 300g of groundnut haulms b) 45g of cottenseed cake and c) 210g of chopped cowpea vines daily as supplements to a basal diets of rice straw fed *ad libitum*. The control animals had no supplements. They reported significant differences (<0.05) in liveweight gain between the supplemented groups and the control group but the liveweight changes of the supplemented groups did not differ significantly. They concluded that cottenseed cake was the most effective supplement in terms of liveweight gains and intake of rice straw. However because crop residues are readily available to farms its worthwhile to pay some attention to them.

The objectives of this study are:

- i. to compare the optimum level of cassava foliage and groundnut haulms supplementation to Gamba hay that gives best performance of rams.
- ii. To compare the optimal level of the combination of cassava foliage and groundnut haulms to either of the supplements that gives the best performance.

2.2.3. MATERIALS AND METHOD

2.2.3.1 Experimental animals and Management

Twenty-eight Yankasa/West African Dwarf rams of various crosses were used in this study. They had an initial average live weight of 18kg and were aged 1.5 - 2 years. They were allotted into 7 groups of 4 rams, each group balanced for body weight and were randomly assigned to different treatment groups.

Animals were housed in individual pens with concrete floors measuring 3.0m x 1.5m with open sided walls. The rams were allowed out into holding pens twice weekly while the individual pens were washed and disinfected. All animals were dewormed and deticked before commencement of the trial. All animals were also placed on a 30 day quarantine period.

2.2.3.2 Feed preparation and feeding

Cassava foliage utilized in this trial was harvested fresh and then sundried for 7 days. Foliage was fed as brittle small particles. The groundnut haulms were purchased from the local market but care was taken to ensure they had high proportion of green leaves and were thoroughly dried. The Gamba hay fed was cut late in November at the onset of the dry season of the previous year.

All rams except those on the control diet were fed cassava foliage or groundnut haulms or a (50:50) combination of both, as supplements at 1.0 and 1.5% of the body weight to

a basal diet of Gamba hay. All animals were stall fed. The supplements were given first in the mornings (7.30am) and after consumption gamba hay was offered *ad libitum* in a manner to allow 15% rejection. As shown in table 3.1 two levels of supplementation were given to determine the optimum level of supplementation. Bone meal and saltlicks were provided. Animals were weighed weekly for liveweight gains and the feeding trial lasted 56 days. Body condition scoring was conducted by 2 individual scorers using visual assessment. Data was analysed statistically using missing data technique (Snedecor *et al*, 1967) as some rams were lost in the course of the experiment.

Table 3.2 shows the chemical composition of various feedstuff used in the feeding trial.

2.2.4 RESULTS

2.2.4.1 LIVELWEIGHT GAINS

Table 3.3. shows the daily liveweight gains. Feeding of Gamba hay alone (control) to rams resulted in weight loss (-30.5g/d) but with 1.0% body weight cassava foliage supplementation there was a positive and significantly ($P < 0.05$) better daily liveweight gain (39.2g). Daily liveweight gains of rams on cassava foliage supplementation at 1.0% and 1.5% body weight and groundnut haulms at 1.0% body weight were not significantly different ($P > 0.05$) although 1.5%

body weight of groundnut haulms supplementation was significantly ($P < 0.05$) better than 1.0% body weight cassava foliage supplementation, but not different from cassava foliage at 1.5% supplementation. A combination of cassava leaves and groundnut haulms at 1.0% and 1.5% of body weight supplementation resulted in a significantly ($P < 0.05$) higher daily liveweight gains than either of the supplements alone at both levels. Supplementation of either of the combination at 1.5% body weight performed better than at 1.0% level, although this difference was not statistically significant ($P > 0.05$).

2.2.4.2 BODY CONDITION SCORE AND MORTALITY

Average body weight condition score before commencement the trial are shown on table 3.5. Cumulative body condition score at the end of the feeding trial showed treatment group 1 had the lowest body condition score (1) and mortality was high (50%). Treatment group 2 had moderate body condition score (2.0), mortality was also high (50%). Treatment groups 3 and 4 had similar body condition score of 3.0 while treatment group 5 had slightly better body condition score (3.5) however they had mortality of (2.5%). Treatment group 6 and 7 had similar body condition score of 4.0 each, while group 6 had 25% mortality, treatment group 7 had 0% mortality four rams (1 from group 6, 1 from group 5, 1 from group 2 and 1 from group 4) died from suspected snake bites..

2.2.5 DISCUSSION

The weight loss and high mortality of rams in the control group was most likely due to inability of Gamba hay to provide adequate levels of nitrogen and energy for microbial utilization. This results from poor degradation of Gamba hay as evidenced from its 48 hours nylon-bag dry matter disappearance (DMD) of 45.8% (Lufadeju 1988). Microbial outflow from the rumen would be low and glucogenic compounds to provide energy would be lacking. This cumulates in animals utilizing body tissues to provide energy and protein for maintenance, thus the consequent weight loss observed in rams of the control group. It was noticed that rams with body weights below 17kg were unable to withstand this nutritional stress and eventually died, while rams with heavier body weights survived but had drastic weight loss.

Rams on 1.0% level of cassava foliage supplement did not lose weight but made very poor weight gains. Within the first 3 weeks of the trial the rams lost weight but later were able to maintain their weight and even showed minimum weight gains towards the end of the trial. Cassava foliage from the nylon-bag experiment (Experiment I) showed very high rumen degradation. It is suggested that most of the nitrogen released from cassava foliage was absorbed across the rumen wall into the blood stream and consequently passed out with urine. The absence of readily available carbohydrate source impeded incorporation of nitrogen from cassava foliage into

microbial protein and the two rams lost in this treatment group showed symptoms of emaciation and exhaustion, surviving rams eventually gained weight although weight gains were low.

Rams on 1.0% level of groundnut haulms supplementation (group 3) had better liveweight gains but not significantly ($P > 0.05$) different from that of 1.0% cassava foliage supplementation. This might be due to the slower degradability of groundnut haulms, resulting from the higher crude fibre content of groundnut haulms 32.8% (Adu and Lakpini 1983) compared to crude fibre content of cassava foliage 4.8-15.8% (Smith 1992). Ganer *et al* (1979) reported that differences in the degradation of protein supplements may be due to their varying fibre contents. In a study by Lufadeju *et al* (1988) he concluded that by-products with low acid detergent fibre were more highly degraded. Liveweight gains were however low in this group most likely due to absence of readily available glucogenic compounds. Thomas and Rook (1981) confirmed that fermentation of poor quality roughage such as cereal residues normally leads to production of high proportion of acetic acid which are non-glycogenic.

The amount of cassava foliage supplementation fed in treatment group 4 (1.5% of body weight) is higher (than group 2) and this might result in greater availability of nitrogen in the rumen. This could lead to a more prolonged peak of NH_3 in the rumen coinciding with the availability of glycogenic compounds from degradation of Gamba hay. It is also possible

some amount of protein passed the rumen intact and was available for intestinal digestion. This might account for better liveweights obtained here. However, the low gains in liveweight are most likely due to the slow release of glyco-genic compounds which would hinder incorporation of nitrogen from cassava foliage into microbial protein. Efficiency of utilization of rapidly degradable proteins is low when used with cellulosic diets which yield energy too slowly for efficient capture of NH_3 by rumen micro-organisms (Meggison et al 1979). This might also account for the similar weight gains of rams on 1.5% groundnut haulms supplemented group.

Rams fed both groundnut haulms and cassava foliage performed better than animals fed either of the supplements at any level. Higher fibre content of the combined supplements might have prolonged the degradation and thus the release of nitrogen. It is suggested that a prolonged peak availability of nitrogen allowed synchronized release of glyco-genic compounds from Gamba hay and nitrogen from the supplements. Higher liveweight gains are most likely due to a higher degree of conversion of nitrogen into microbial protein in treatment group 6 and 7. Rams on 1.5% level of combined supplements had better liveweight gains but were not significantly (>0.05) higher than liveweight gains of rams on 1.0% level of combined supplements. Better gains in the 1.5% level of combined supplements might be due to the higher availability of

nutrients as compared to to 1.0% level of combined supplements. Post-mortem of the dead rams suggested death from snake bite in four rams but did not indicate conclusively the cause of the death of the other four rams.

2.2.6 CONCLUSION

Rams on groundnut haulms supplementation at either level had higher liveweight gains than rams on cassava foliage but the differences were not statistically significant ($P>0.05$). Therefore cassava foliage with adequate sundrying could completely replace groundnut haulm supplementation. Also a combination of groundnut haulm and cassava foliage as supplements gave significantly better ($P<0.05$) performance than rams on either of the supplements at both levels of supplementation.

Major limitation of cassava foliage as a protein supplement to poor quality roughage is its high rate of degradation since most of the nitrogen would be released before optimal fermentation of the basal roughage. It is expected that with readily available carbohydrate sources greater levels of nitrogen would be converted to microbial protein and subsequently translate into better liveweight gains.

Table 3.1. EXPERIMENTAL DESIGN

	Control	Cassava foliage		Groundnut haulms		Cassava foliage plus Groundnut haulms	
Treatment	T ₁	T ₂	T ₄	T ₃	T ₅	T ₆	T ₇
% of BODY WEIGHT FED	0%	1.0%	1.5%	1.0%	1.5%	1.0%	1.5%

Table 3.2. PROXIMATE COMPOSITION OF FEEDSTUFF USED

	DM%	CP%	NDF%	ADF%	CF%	ASH%	48 hours degradation
CASSAVA FOLIAGE	91.25	18.55	31.41	29.30	-	12.93	70.59
GROUNDNUT HAULMS	87.5	12.87	35.89	31.49	32.8	11.41	-
GAMBA ¹ HAY	90.3	3.43	76.4	56.2	-	5.4	45.8

1 Lufadeju (1988)

Table 3.3. AVERAGE DAILY GAINS

PARAMETERS	TREATMENTS						
	1	2	3	4	5	6	7
MEAN INITIAL WEIGHT Kg	18.25	17.6	17.3	18.37	17.75	18.13	17.87
MEAN FINAL WEIGHT Kg	16.57	19.79	19.79	20.90	20.64	21.77	21.75
MEAN WEIGHT GAINS g/day	-30.5 ^a	39.2 ^b	44.6 ^{bc}	45.2 ^{bc}	51.7 ^{cd}	65.1 ^d	69.3 ^d
Mortality %	50	50	25	25	25	25	-

*Mean within the same row bearing different superscript are significantly different (P<0.05)

Table 3.4 BODY CONDITION SCORE

	TREATMENTS						
	T ₁	T ₂	T ₃	T ₄	T ₅	T ₆	T ₇
INITIAL BODY CONDITION SCORE	3.0	3.0	3.0	3.0	3.0	3.0	3.0
FINAL BODY CONDITION SCORE	1.0	2.0	3.4	3.4	3.8	4.0	4.0

*Subjective scoring on a scale of 1 = Poor, 2 = Moderate
 3 = good, 4 = very good 5= Excellent.
 (Honhold et al (1989)).

2.3.1 EXKPERIMENT III METABOLIC TRIAL

2.3.2 Introduction

An estimated 90% of Nigeria's cattle population are reared by the Fulani agropastoralist. These animals mainly graze natural pastures consisting of grasses, legumes and browses. During the wet season these forages grow rapidly becoming fibrous and coarse and are largely undergrazed because of the large amounts that become rapidly available. Their quality declines further during the dry season when they become standing hay and are subject to overgrazing (Atta-Krah and Reynolds, 1989). Thus tropical livestock have an intake of digestible energy and protein far below their requirement for maintenance and production (Umunna, 1990). With the expected increased pressure on land due to growing population, grazing lands would be fewer and livestock productivity is likely to fall.

A long-term strategy in solving this problem would be to establish grazing reserves that utilize improved sown pastures. This requires capital investment, planning and a sustained effort based on a background of coordinated and well researched information on adaptation, establishment, nutritive qualities, management, seed production and distribution (Adegbola, 1982). The Latin American countries have obtained some striking results in animal production by developing productive and nutritive pastures as animal feeds and utilizing rapidly growing crops that are rich in fermentable

carbohydrate, e.g. sugar cane, cassava, sweet potato, banana, etc. in combination with various proteins as animal feeds (Mahadevan, 1981).

An immediate solution lies in increasing the efficiency of utilization of pasture and crop residues through supplementation with a protein source. Muinga (1992), showed that supplementation with leucaena tended to increase Napier fodder intake and milk yield significantly and reduce liveweight loss. Also Lemma *et al.* (1991) using young Horro sheep reported lamb growth rates were significantly increased ($P < 0.05$) by daily supplementation with 238g dry leucaena per lamb offered alone or with dry or wetted teff straw (79,69 and 78g/day).

Traditionally under the extensive system of rearing livestock efforts are made by the herdsman to supplement the intake of grazing animals. This involves provision of maize or maize bran with potash to supplement whatever the animals graze in the field. However supplementation with a protein source is rare or non-existent particularly in big herds. This is primarily due to the high cost or unavailability of common protein sources i.e. cotton-seed cake, groundnut cake, legumes etcetera. This problem could be solved by supplementing the ruminants diet with cassava foliage, It is rich in crude protein (25%)[Smith, 1988] and has an amino acid profile comparable with soyabeans (Khajjarern *et al.*, 1977). It also grows practically all over Nigeria throughout

the year. Thus it is available in the rural areas where the bulk of livestock farmers are situated. The only processing required of cassava foliage is sun-drying to reduce the cyanide content and facilitate storage.

This study attempts to investigate the effect of feeding cassava foliage as a protein supplement to a basal diet of digitaria hay in comparison with groundnut haulm supplementation. Parameters studied included liveweight gain dry matter intake and nitrogen metabolism.

2.3.3 Materials and Methods

2.3.3.1 Feeding trial

Twenty-one Yankasa/West African dwarf rams of various crosses were used in this study. They had an initial average weight of 20 kg and age of 1.5-2 years. They were allotted into 7 groups of 3 rams each group balanced for body weight and were randomly assigned into different treatment groups (as shown in Table 4.2). The animals were housed in individual pens with concrete floor measuring 1.5m x 2.5m with open-sided walls. The rams had been dewormed and deticked before the commencement of the trial.

Cassava foliage fed was harvested fresh and sun-dried for 7 days until the leaves and petioles were brittle. The groundnut haulms fed were purchased from the local market but care was taken to ensure they had high proportion of dry green leaves and devoid of signs of fungal infection. The animals

were fed dried cassava foliage, groundnut haulms or a 50:50 combination of both as protein supplement at 0.5 and 1.0% of their body weight to a basal diet of standing digitaria hay. Animals on control diet (no supplement) grazed digitaria alone. These supplements were fed 7.30 a.m. in the mornings and after complete consumption the animals were released to graze standing ditaria hay until the evenings (5.00 p.m.) when they were then returned to their pens. Water and salt lick were provided in the pens. Rams were weighed weekly for liveweight gain. The trial lasted 4 weeks.

2.3.3.2 Metabolic trial

The rams were initially weighed and housed in individual pens measuring 1.0m x 1.5m in a room measuring 25m x 5m. The floor of the pens consisted of raised slatted wooden platform which allowed the faecal droppings to pass into a container below it. The container also had a fine wire mesh covering which allowed separation of collected urine from faeces dropped by the rams. The rams were stall fed digitaria hay as a basal diet and all except the control group were fed cassava foliage, groundnut haulms or combinations of both as supplements. The supplements were given in the mornings (7.30 a.m.) and after complete consumption, digitaria hay was offered in a manner to allow 15% rejection. Left-over feed of the previous day was removed and weighed before new ones were offered. Water and salt lick was also provided. The rams were

allowed a 7 day adjustment period before the 7 day total faeces and urine collection. Collection of faeces, urine and left-over feed was done every morning (7.00 a.m.). The procedure for the collection and sampling of faeces and urine as well as their chemical analysis were as outlined by Adu and Adamu (1982). Data analysis was as described by Steel and Torrie (1960).

2.3.4 Results

2.3.4.1 Liveweight gain

As shown in Table 4.2 there was no significant difference ($P>0.05$) in liveweight gains between rams on control diet and rams fed cassava foliage at 0.5%, 1.0% BW and groundnut haulms fed at 0.5% BW. There was significant difference ($P<0.05$) in the liveweight gains of rams fed groundnut haulms at 1.0% BW and rams fed cassava foliage at 1.0% BW. But there was no significant difference ($P>0.05$) between the liveweight gains of rams fed groundnut haulms at 1.0% BW and rams fed the combined supplements at 0.5% and 1.0% BW. Comparatively there was no significant difference ($P>0.05$) in liveweight gains between cassava foliage and groundnut haulms at 0.5% BW there was significant ($P<0.05$) difference at 1.0% BW. With either supplement higher liveweight gains were achieved with 1.0% BW level of supplementation compared to 0.5% BW level.

2.3.4.2 Feed intake

As shown in Table 4.2 dry matter intake was not significantly ($P < 0.05$) changed by addition of cassava foliage or groundnut haulms supplement at either 0.5% or 1.0% BW. Though there was an increase in DM feed intake due to feeding both supplements, it was not significant ($P < 0.05$).

2.3.4.3 Nitrogen metabolism

As shown in Table 4.2 there was no significant ($P > 0.05$) difference in the daily nitrogen retention (DNR) values for rams in the control group, the group fed groundnut haulms at 0.5% BW and the groups fed cassava foliage at 0.5% and 1.0% BW. These groups also had significantly lower ($P < 0.05$) DNR values compared to the other groups.

Rams in the control group, the group fed 0.5% BW groundnut haulms, the group fed cassava foliage supplements at 0.5% and 1.0% BW showed no significant difference ($P > 0.05$) in nitrogen retention percentage (NR%). Rams in the group fed combined supplements at 1.0% BW had significantly higher ($P < 0.05$) NR% values.

2.3.4.4 Approximate digestion coefficient (DM)

Rams in the control group, the group fed cassava foliage at 0.5% and 1.0% BW had similar dry matter digestion coefficient values and was significantly ($P < 0.05$) lower,

compared to values for other groups.

2.3.5 Discussion

2.3.5.1 Liveweight gain

Similar liveweight gains exhibited by rams on control diet and rams fed either of the supplements at 0.5% BW suggests that 0.5% BW level of supplementation with either cassava foliage or groundnut haulms is too small to effectively stimulate additional microbial protein synthesis. It is possible that most of the supplements would have been degraded before digitaria starts been degraded. Ikhatua and Adu (1984) reported digitaria hay having 30.6% crude fibre, this might result in its slower rate of degradation compared to cassava foliage which has 11.4% crude fibre (Smith, 1988) and groundnut haulms which has 19.4% crude fibre (Ikhatua and Adu, 1984). The absence of a synchronized release of protein and energy might have resulted in the poor response.

Rams on groundnut haulms supplement at 1.0% gave significantly higher gains ($P < 0.05$) than rams on cassava foliage supplement at 1.0% BW, despite the higher crude protein content of cassava foliage (18.55%) compared to groundnut haulms (12.87%). Two possible reasons for lower gains from cassava foliage supplemented group is either the absence of glucogenic compounds or the presence of cyanide. Rams on cassava foliage diet did not show any symptom of

cyanide toxicity so it is less likely. Despite the absence of laboratory analysis, low response to cassava foliage suggests low availability of fermentable energy in cassava foliage. Silver and Orskov (1985) reported legume crop residues ability to provide fermentable energy to the rumen in the form of available cellulose and hemicellulose which stimulate fibre digestion. This might explain why groundnut haulms achieved better liveweight gains than cassava foliage.

The combined supplements at either level of supplementation performed better than any of the supplements alone. This is most likely due to the presence of additional crude protein from cassava foliage and fermentable energy from the groundnut haulms. This is most likely to facilitate rumen microbial protein synthesis, thus the host animal achieves better weight gains.

2.3.5.2 Dry matter intake

Addition of cassava foliage or groundnut haulms or both as supplements to a basal diet of digitaria hay did not significantly ($P > 0.05$) change the dry matter intake. This might result from the fact that cassava foliage is rapidly degradable (referring to experiment 1) in the rumen. Also groundnut haulms has a high digestion coefficient 72% (Ikhatua and Adu, 1984). Higher dry matter intakes (although not significant [$P > 0.05$]) were observed for rams fed 1.0% BW groundnut haulms and 1.0% BW cassava foliage. This could be

due to the ability of the supplements to provide a better rumen environment required for fibre degradation i.e. protein and energy levels. A more rapid degradation mostly results in greater dry matter intake. Moran *et al.* (1984) described an ideal supplement as one which maintains or increases the intake of the basal diet rather than one which substitutes for it hence cassava foliage or groundnut haulms could be described as ideal supplements in terms of dry matter intake.

2.3.5.3 Nitrogen metabolism

The control group, the group fed 0.5% BW groundnut haulms and the group fed cassava foliage at 0.5% BW showed no significant difference ($P > 0.05$) in their average nitrogen retention values. This is indicative that the additional nitrogen from cassava foliage was poorly utilized as evidenced by the high levels of faecal and urinary nitrogen.

The retention and utilization of dietary nitrogen are influenced to a large extent by the type and quantity of carbohydrate present. (Karue, 1973) Most likely, in the absence of readily fermentable energy source which enables rumen microbes to trap nitrogen, most of the additional nitrogen simply diffused through the walls of the rumen into the blood system from where it was eventually passed out of the body with urine and faeces. Kennedy and Milligan (1988) observed that NH_3 not captured in the rumen is absorbed and converted into urea partly to be transferred to the rumen and

influence the digestion rate of cellulose or be lost in urine depending on the concentration of NH_3 in the rumen.

Rams fed groundnut haulms at 1.0% BW and those fed the combined supplements at 0.5% and 1.0% BW exhibited significantly ($P < 0.05$) higher daily nitrogen retention values. This might be due to the presence of readily fermentable energy sources from groundnut haulms which enable the microbes to utilize additional nitrogen for protein synthesis. Diets involving cassava foliage without readily fermentable energy source would most likely be poorly utilized.

2.3.5.4 Approximate digestion coefficient

Rams in the control group, and the group fed cassava foliage at 0.5% and 1.0% BW had similar dry matter digestion coefficient values which was significantly ($P < 0.05$) lower compared to other groups. This is most likely due to the fact that other groups i.e. combined supplements at 0.5% and 1.0% or 1.0% BW groundnut haulms had a better fermentable energy profile. This facilitated microbial degradation or digestion activities better comparatively.

2.3.6 CONCLUSION

The similar weight gains of rams in the control group and rams in the groups fed cassava foliage at 0.5% and 1.0% BW indicates that the rams on cassava foliage supplementation did not benefit from the additional nitrogen derived from cassava foliage. The fact that rams on the combined supplements of

cassava foliage and groundnut haulms gave significantly higher ($P < 0.05$) weight gains and the fact that rams on cassava foliage recorded higher urinary and faecal nitrogen levels strongly suggests inadequate levels of fermentable energy in cassava foliage.

It is expected that with sources of fermentable energy cassava foliage supplementation would elicit a better response in terms of live-weight gains.

Table 2.9 Nutritive Value of Feedstuff.

	Dry Matter	crude Protein	NDF	ADF	Ether extract	Ash	Lignin	Ca ppm	Mg ppm
Cassava Foliage	91.25	18.55	31.41	29.2	6.67	12.93	14.14	462.91	363.72
Groundnut Haulms	87.05	12.87	35.89	31.49	-	11.41	6.38	484.46	350.52
Digitaria Hay	87.6	5.7	76.99	52.32	-	8.3	-	-	-

Table 3.0: Live-Weight gain DM intake and Nitrogen Balance.

Level of Supplement as % of body Weight	Control	CF	GNH	CF	GNH	CF&GNH	CF&GNH
	T1	T2	T3	T4	T5	T6	T7
Weight gain g/day	53.57a	53.57a	62.49ab	59.52a	95.23b	83.32ab	95.23b
DM intake g/day	786.4	789.66	894.91	863.95	912.98	807.3	792.55
Dry matter Digestibility %	67.8a	68.63a	77.64b	69.85a	78.3b	78.6b	81.06b
Nitrogen Metabolism							
N intake g/day	7.17	9.04	8.98	11.21	10.44	8.79	9.57
Faecal N g/day	3.98	4.44	4.51	5.72	3.11	2.63	2.65
Urinary N g/day	0.86	0.93	0.42	0.86	0.63	0.75	0.62
Total N Excreted g/day	4.84	5.37	4.93	6.58	3.74	3.38	3.27
N Retained g/day	2.33a	3.67ab	4.05bc	4.63bcd	6.70d	5.41bcd	6.30cd
% N Retained of N intake	32.50a	40.6a	45.10ab	41.3a	64.17bc	61.54bc	65.83c

Means on the same row bearing different superscripts are significantly different (P<0.05)

CF - Cassava Foliage

GNH - Groundnut Haulms

CHAPTER 3**GENERAL CONCLUSION AND RECOMMENDATIONS**

Data from nylon bag experiment indicates that cassava foliage is rapidly degraded. This suggests a rapid generation of nitrogen in the rumen. To enhance utilization of this nitrogen there is need to include in the diet a source of rapidly fermentable energy. This would enable the rumen microbes utilize the nitrogen for microbial protein synthesis which is the largest source of protein available to the ruminant. Cassava foliage generated nitrogen peaks approximately four hours post feeding, consequently with adequate fermentable energy. It is expected that the increased microbial population would facilitate increased degradation of the poor quality roughage.

Feeding cassava foliage to a basal diet of gamba hay prevented weight loss but weight gains were low compared with weight gain from groundnut haulms. But when both cassava foliage and groundnut haulms were fed as supplement to gamba hay, the rams showed significantly higher weight gains than either of the supplements fed alone. This suggests inadequate fermentable energy content in cassava foliage.

Similar weight gains of rams fed digitaria hay alone and rams fed 0.5% and 1.0% BW cassava foliage supplement shows the poor utilization of supplemental cassava foliage. This is confirmed by the high levels of urinary and faecal nitrogen

Delayed

65

Table 2.9 Nutritive Value of Feedstuff.

	Dry Matter	crude Protein	NDF	ADF	Ether extract	Ash	Lignin	Ca ppm	Ng ppm
Cassava Foliage	91.25	18.55	31.41	29.2	6.67	12.93	14.14	462.91	363.72
Groundnut Haulms	87.05	12.87	35.89	31.49	-	11.41	6.38	484.46	350.52
Digitaria Hay	87.6	5.7	76.99	52.32	-	0.3	-	-	-

Table 3.0: Live-Weight gain DM intake and Nitrogen Balance.

Level of Supplement as % of body Weight	Control T1	CF 0.5% T2	GNH 0.5% T3	CF 1.0% T4	GNH 1.0% T5	CF&GNH 0.5% T6	CF&GNH 1.0% T7
Weight gain g/day	53.57a	53.57a	62.49ab	59.52a	93.23b	83.32ab	95.23b
DM intake g/day	786.4	789.66	894.91	863.95	912.98	807.3	792.55
Dry matter Digestibility %	67.8a	68.63a	77.64b	69.85a	78.3b	78.6b	81.06b
Nitrogen Metabolism							
N intake g/day	7.17	9.04	8.98	11.21	10.44	8.79	9.37
Faecal N g/day	3.98	4.44	4.51	5.72	3.11	2.63	2.65
Urinary N g/day	0.86	0.93	0.42	0.86	0.63	0.75	0.62
Total N Excreted g/day	4.84	5.37	4.93	6.58	3.74	3.38	3.27
N Retained g/day	2.33a	3.67ab	4.05bc	4.63bcd	6.70d	5.41bcd	6.30cd
% N Retained of N intake	32.50a	40.6a	45.10ab	41.3a	64.17bc	61.54bc	65.83c

Means on the same row bearing different superscripts are significantly different (P<0.05)

CF - Cassava Foliage

GNH - Groundnut Haulms

exhibited by rams fed cassava foliage supplements. Dellow et al, (1988) observed high concentration of plant nitrogen > 30g N/kg DM associated with alfa alfa resulting in production of excessive ruminant $\text{NH}_3\text{-N}$ which is absorbed into the blood stream and excreted as urinary urea-nitrogen. He showed that rumen infusions of fermentable carbohydrate increased the efficiency of alfa alfa utilization by sheep.

Thus the need to include readily fermentable sources of carbohydrate in cassava foliage diets can not be overemphasised. Practical sources of readily fermentable carbohydrate in the present Nigerian situation would include cassava peels, waste bananas, oil sludge, brans from processing cereals, residues from processing fruit crops i.e. citrus, pineapple, etc.

However, further investigation is required to determine adequate levels of energy required for optimal utilization of cassava foliage.

REFERENCES

- Abate, A and Kiflewahid, B (1991) Use of nylon-bag technique in determining the complementarity of feedstuff for dairy cattle rations. In the complementarity of feed resources for animal production in Africa Proceedings of the joint feed resources networks, workshop held in Garborone Botswana AFRN. 4th -8th March 1991 P. 225 - 231.
- Adegbola, A A (1977) Methionine as an additive to cassava based diets. In proceedings Cassava as Animal feed workshop Ed by B Nestel and Graham M held at University of Guelph 13th 20th. April 1977 Ontario Canada. IDRC. P 9-17.
- Adegbola, A. A (1982) Forage resources and beef production in Nigeria. In beef production in Nigeria Proceedings of the National Conference on beef production, Kaduna Nigeria. July 27-30 1982 Published by NAPRI/ABU Zaria. P. 137 - 165.
- Adu, I.F., Adamu A.M. (1982) The nutritive value and utilization of three tropical grasshays by sheep TROPICAL Grasslands 16:29-33.
- Adu, I.F., Ikhatva U.J. (1984) A comparative evaluation of the utilization of groundnut haulms and digitaria smutsii hay by red Sokoto goats in Journal of animal production Research Published by NAPRI/ABU Zaria Vol. 4 No. 2 July 1984. P. 145 - 152.
- Agishi, E.C (1985) Forage resources of Nigerian grass lands. Proceedings national conference on small ruminants Zaria Nigeria. P. 115-140
- Akin, D.E (1982) Forage cell wall degradation and P-Coumaric aric fierulic and sinapic acids. Agronomy Journal 74:424-428
- A.O.A.C (1975) Official methods of analysis. Association of official analytical chemist 13th edition.
- Asaolu, V.O. (1988a) Utilization of Cassava peels and Gliciridia Sepium in diet of West African dwarf sheep M. Phil Thesis, Obafemi Awolowo University Nigeria.
- Attah-Krah, A.N and Reynolds, L (1989) Utilization of pasture and fodder shrubs in nutrition of sheep and goats in the humid tropics of West Africa. In Timon V.M and Baker R.P ed Sheep and goat meat production in the humid tropics of West Africa Animal Production and health paper 70 FAO Rome Italy 92-113.

- Beerver, E.E, Thomson, D.J., and Cammell, S.B. (1976) Journal of Agric Science Camb 86.443. (Abstract)
- Campling, R.C and Balch, C.C (1962) Factors affecting Voluntary intake of food by Cows I Preliminary observation on effect of voluntary intake of hay and change in amount of the reticulorumen contents. British Journal of nutrition Vol. 16:115-124.
- Chalupa, W (1976) Journal Animal Science 43,828-834
- Chalupa, W. (1984). Manipulation of rumen fermentation in recent Advances in animal nutrition 1984 Ed Haresign W & Cole D.J.W Butterworths London P 143 - 160.
- Cheek, P.R, Patton, N.M; Lukefahr, S.D and McNitt, J.I. (1987) Rabbit Production. The interstate printers and publishers Illinois U.S.A.
- Cheng, K.J. and Wallance, R.J (1979). The mechanism of passage of endogenous urea through the rumen wall and the role of ureolytic epithelial bacteria in the urea flux. British Journal of Nutrition 42: 553-557.
- Church, D.C and Santos, A. (1981) Effect of graded levels of Soyabean Meal and a non-protein nitrogen molasses supplement on consumption and digestibility of wheat straw. Journal of animal science 53:1609-1615
- Coombe, J.B.(1985) Rape and Sunflower Seedmeal as supplements for sheep fed on oat straw. Australian Journal of agricultural research 36:717-728.
- Cotta, M.A and Russel, J.B (1982) Effect of peptides and amino acids on efficiency of rumen bacterial protein synthesis in continous culture. Journal of diary science 65:226-234.
- Czerkawski, J.W (1986). An introduction to rumen studies pergomon Press Oxford.
- Dellow, D. Obara, D.Y., Kelly, K.E and Sindair R.R. (1988) Improving the efficiency of Utilization of pasture by sheep. Proceedings New Zealand SOCIETY OF Annual Production Vol 48 253.
- Devendra, C (1977) Cassava as a feed source for ruminants. In Cassava as animal feed. Proceeding of workshop Ed by Nestel B and Graham M. University of Guelph IDRC Ottawa Canada 18th-20th April, 1977 p 107 - 119.

- Dixon, R.M and Egan, AR (1987) Strategies for Optimizing use of fibrous crop residues as animal feed in ruminant feeding systems utilizing fibrous agricultural residues. International development programme of Australian Universities and colleges.
- Eggum, B.O (1970). The protein quality of Cassava leaves British Journal of nutrition. Vol. 24. 761.
- Ekpechi, O.L. (1973) Endemic goitre and high cassava diets in Eastern Nigeria. In chronic cassava toxicity Ed Nestel B and McIntyre R. Proceedings of Interdisciplinary workshop (IDRC-010e) 153 Ottawa Canada P 65-73.
- Ellis, W.S (1978) Determinants of grazed forage intake and digestibility Journal dairy Science 61:1828. (Abstract)
- Enriquez, F.O and Ross, E. (1972) Cassava root meal in grower and layer diets Poultry Science 51:223-234
- F.A.O., (1986) Production year book (FAO Rome)
- Ferguson, K.A. Hemsley, J.A and Reis, P.J. (1967). Australian Journal of Agric Science 30:215
- Fereror, O., Owens, F.N and Lusby KS (1980) Evaluation of slow release urea for Winter Supplementation of lactating range cows Journal of animal Science 50:532-538.
- Fernandez, A. Macleod, N.A and Preston TR (1977) Cassava forage as a combined Source of Protein and roughage for cattle fed on molasses/urea. Tropical animal production 2:195-199.
- Floukes D and Preston TR (1978) Cassava or Sweet potato forage as combined sources. Effect of Supplementation with soyabean meal. Tropical animal production 3:186-192.
- Fomunyan RT and Meffeja (1987b) Cassava by products in rabbits and sheep diets. In proceedings workshop on utilization of agricultural by products as livestock feed in Africa. Ed. by little D.A and Said AN. African research network for agricultural by products ARNAB SEPT 16 Blantyre Malawi ILCA Addis Ababa Ethiopia. P 103-107
- Ganer, G. Orskov, E.R., Smart R. (1979) The effect of roughage or concentrate feeding and rumen retention time on total degradation of protein in the rumen. Journal of Agric Sci (Camb) 93 651-656.

- Gomez, GM, Valdiviesco, D., Dela Avesta and Salcedo TS (1984) Effect of variety and plant age on cyanide content of whole root cassava chips and its reduction by sun drying. *Animal feed science and Technology* 11:143-152.
- Gondwe, A.T.D (1974) Studies on the hydrocyanic acid content of some varieties of cassava (Manihot esculenta) and some traditional cassava food products. *East African Agric and forestry Journal* Vol. 40 161 - 170.
- Gulati, SK, Ashes, J.R, Gordon, G.L.R and Phillips MW (1985) possible contribution of rumen fungi to Fibre digestion in sheep. *Proceedings nutrition Society Australian* 10:96-106.
- Hagemeister, H., Luppig, W., Kaufman, W. (1981) Microbial protein synthesis and digestion in the high yielding dairy cow In recent advances in ruminant nutrition 1981 Ed by Haresign W and Cole DJA P. 31-48 Butterworths London.
- Hagger, R.J (1970) Seasonal production of Andropogon gayanus I seasonal changes in yield components on chemical composition *J. Agric Sci (Camb)* 74:487-494.
- Hahn, S.K. (1988) Cassava as Livestock feed in Africa Proceedings of the IITA/ILCA/University of Ibadan Workshop on the potential Utilization of Cassava as livestock feed in Africa 14-18th November 1988 p. 16 - 38.
- Hamid, K and Jalaludin, S (1972) Responce of laying hens to low and high levels of tapioca meal making *Agricultural research* 2:47-51.
- Henhold N., Petit: H and Halliwell R.W. (1989) Body condition Scoring System for goats *Tropical Animal Health and Production*. 21:121-127.
- Hibbit, K.G. (1984) Effect of protein on health of dairy cows recent advances in *Animal nuturition* 1984 Ed by Haresign W. and Cole D.J.A. Butterworths London P. 189 - 200.
- Hulman, B and Preston TR (1981) Leucaena Leucocephala as a Source of protein for growing animals fed whole sugarcane and Urea. *Tropical Animal Production* 6:318-321.

Hutagalung, R.I. (1977) Additives other than methonine in Cassava diets in Cassava as animal feed Ed Nestel B and Graham M. Proceedings of workshop University of Guelph. IDRC - 095e B Ottawa Canada. P 18-32

Ibrahim, M.N.M and Schieve, J.B (1985) Factors affecting Urea -ammonia treatment. In relevance of crop residues as animal feed in developing countries P. 175-185 ed M Wanapat and C Devendra Funny Press Bangkok Thailand.

Ifut, O.J. (1989) The potential of Cassava peel for feeding goats in Nigeria. In Cassava as Livestock feed in Africa. Proceedings of the IITA/ILCA/University of Ibadan Workshop on the potential Utilization of cassava as livestock feed in Africa P. 72 - 81.

Iyayi, E.A and Tewe, O.O. (1988) Effect of protein deficiency on Utilization of cassava peel by growing pigs in Cassava as livestock feed in Africa. Proceedings of the IITA/ILCA/ University of Ibadan Workshop on the potential utilization of cassava as livestock feed in Africa P. 54 - 57.

Job, T.A (1975) Utilization and protein supplementation of cassava for animal feeding and the effect of sulphur sources on cyanide detoxification Ph.D thesis University of Ibadan Ibadan.

Karue, C.N. (1973) Metabolism of dietary urea with cassava when used to supplement dry season roughage in Kenya III ed World Conference Animal production. Vol. 1: 5C 44-45.

Kay, R.B.N. (1960) The rate of flow and compstion of various salivary scretation in sheep and calves Journal of Physiology 150:515-537.

Kempton, T.J., Nolan, J.V., Leng R.A (1977) Principles for the use of non protein nitrogen and by-pass protein in diets for ruminants. World Animal review 22:2.-5

Kennedy, P.M. and Milligan, L.P. (1978). Transfer of urea from blood to the rumen Biritsh Journal of Nutrition 40: 149-154

Kennedy, P.M. and Milligan, L.P. (1980). The degradation and utilization of endogenous urea in the gestro intestinal tract of ruminants. A review Can Journal of Animal Science 60: 205-201

- Kennedy, P.M. and Milligan L.P 1988. The degradation and utilization of endogenous urea in the gastrointestinal tract of ruminants. A review *Can Journal of Animal Science* 60: 205-221.
- Khajarern, S., Hutanuwat, N. Khajarern, J. Kitpanit, N. Phalaraksh, K and Terapuntuwat, S (1978). The improvement of the nutritive and economic value of cassava root products *Ann. Rep Cassava nutrition project (Khon Kean University Thailand)*.
- Khajarern, S. Khajarern, J.M., Phalaraksh, K., Kitpanit N. and Terapuntuwat, S. (1980) Cassava: A potential concentrate for animal nutrition in the tropics *Australian development assistance bureau*. P 133 - 156.
- Krebs, G and Heng R.A (1984) The effect of supplementation with molasses/urea blocks on ruminant digestion *proceedings of the Australian society of Animal production* 15:704.
- Larsen, R.E and Amaning-Kwarteng K. (1976) Cassava peels with urea and molasses as dry season supplementary feed for cattle. *Ghana Journal of Agric Sci*. 43-47.
- Lee, K.C and Hutagalung R.I (1972) Nutritional Value of Tapioca Leaf (Manihot Utilissima) for swine *Journal of nutrition* 40:587. (Abstract)
- Lemma, G and Alemu, T. (1991) Effects of feeding hydrated Teff straw and protein sources on Teff straw voluntary intake and growth of young homo sheep grazing native pasture during the dry season. In complementarity of feed resources for animal production in Africa. *Proceedings of joint feed resources networks workshops held in Gaborone Botswana 4th-8th March 1991* P. 147 - 148.
- Leng, R.A and Nolan, J.V (1984) Nitrogen metabolism in the rumen *Journal of dairy Science* : 67:1072-1089.
- Lufadeju, E.A (1988) Evaluation of methods of improving Utilization of mature Andropogon gayanus hay by friesian-Bunaji Heifers Ph.D thesis submitted to post graduate School ABU Zaria.
- Maner, J. (1973) Cassava in Swine feeding in Centro interm de Agriculture Tropical Cali Colombia *Bull. RR-1*

- Maner, J.H. and Gomez, G (1973) Implications of cycuide toxification in animal feeding studies using high cassava rations in chronic cassava toxicity Ed Nestel B and McIntyre R Proceedings of inter-disciplinary workshop DRC - 010e Ottawa P 113 - 120.
- McCullon, F.T And Galyean. M.L. (1985) Influence of Cotton seed meal supplementation on voluntary intake of rumen fermentation and rate of passage of prairie hay in beef steers J. Animal Science 60:570-577.
- McMeniman, N.P, Elliot R and Ash, A.J. (1988) Supplementation of rice straw with crop by products I legume straw supplementation. Animal Feed Science Technology 19: 43-53.
- Meggison D.A. Mcmeniman W.P. Armstrong D.G (1979), Efficiency of utilization of non protein nitrogen in cattle. Proceedings Nutrition Society 38: 147. (Abstract)
- Mehrez, A.Z., Orskov, E.R (1977) A study of the artificial fibre bag technique for determining the digestibility of feed in the rumen Journal of Agric Science (Camb) 88: 645-650.
- Meyrelles, L., macleod N.A and Preston, T.R (1977) Cassava foliage as protein source in Sugarcane diets for cattle. Effect on rumen fermentation of different levels of cassava foliage and urea. Tropica Animal production 2: 300-305.
- Miller, T.B. (1961) Recent advances in studies of the chemical composition and digestibility of herbage Herbage abstract 31: 1-9.
- Minson, D.J. (1980) Nutritional differences between tropical and temperate pastures. In grazing animals (FHW Morley ed) Elsevier Asmsterdam. P. 103-157.
- Moor, C.F. (1976) The utilization of cassava forage in ruminant feeding international seminar on tropical livestock products 8th 12th March 1976 Acapulco Mexico P. 21 - 27.
- Montaldo, A (1977) Whole plant Utilization of Cassava for animal feed. In Cassava as animal fed Ed Nestel B and Graham M. Proceedings of Workshop held at University of Guelph IDRC - 095e Ottawa Canada P. 95 - 106.

- Montilla, J.J (1977) Nutrition of Broilers. In Cassava as an animal feed. Nestel B and Graham M Ed. Proceedings of a workshop held at University of Guelph April 1977 P. 25 - 38.
- Mosi, A.K and Butterworth, M.H (1983).The Voluntary intake and digestibility of combination of cereal crop residues and legume hay for sheep. *Animal feed science and Technolgy* 12:241-251.
- Moran, J.B., Satoto, K.B and Dawson J.E (1983). The utilization of rice straw fed to Zebu cattle and swamp Buffalo as influenced by alkali treatment and teucaena supplementation *Austrian Journal of Agricultural research* 34: 73-84.
- Muinga, R.W., Thorpe, W, Topps, J.H. and Mureithi, J.G (1991) responce to a Pennisetum Purpureum hapier grass) basal diet harvested at 2 different heights and fed with three levels of leucaena forge to crossbred dairy cows in sub humid tropics. In complementarily of feed resources for animal production in Africa. proceedings of the joint feed resources networks workshop held in Gaborone Botswana 4th-8th March 1991 Ed by John stores said AN and Jackson A.K. P. 75-84.
- Muller, Z: Chou, K.C and Nah, K.C (1974) Cassava as a total substitute for cereals in livestock and poultry rations. *World Animal review* Vol. 12:19.
- Muller, Z (1977) Improving the quality of cassava root and leaf products technology. In cassava as a animal feed Ed Nestel B and Graham M. Proceedings of a workshop held at University of Guelph IDRC-095e 121 Ottawa Canada P. 120 - 126.
- Murillo, O.E. (1952) Valor de la harina de hojasy tallos deshidratados de yuca en la production de teche Turrialba 2: 166-169 as cited by Smith, O.B (1988) A review of ruminant responses to cassava based diets. In Cassava as livestock feed in Africa a proceedings of the IITA/ILCA/ University of Ibadan, Ibadan workshoip on potential utilization of cassava as livestock feed in Africa Ed Hahusk REYNOLDS L and Egbunike G.N. P. 39 - 53.
- Ndlovu, L.R and Maryame Z (1987) Hydration as a means of improving utilization of maize stover fed to steers. In over coming constraints to efficient utilization of agricultural by products as animal fed. Proceedings of 4th annual workshop held at Animal Research Mankon station Bimenda Cameron 20-27th Oct. 1987. P. 334-353

- Ndlovu, L.R (1992) Complementarity of forages in ruminant digestion. Theoretical considerations. In the complementarity of feed resources for animal production in Africa. Proceedings of the joint feed resources network workshop held in Garborome Botswana. P 17-24.
- Ngwa, A.T and Tawah, C.L (1992) Effect of Legume crop residues and concentrate supplementation on voluntary intake and performance of Kirdi sheep fed basal diet of rice straw. In the complementarity of feed resources for animal production in Africa. Proceedings of the joint feed resources network workshop held in Garbon Botswana. Ed John Es Stoves Said AN and Jackson A.K. P. 239-248.
- Nolan, J.V., Norton, B.W., and Leng, R.A. (1973) Nitrogen recycling in sheep. Proceeding Nutrition Society 32. 93-98.
- Oguntimein, G.B (1988) Processing Cassava for animal feed. In Cassava as livestock feed in Africa proceedings of the IITA/ILCA/University of Ibadan Workshop on potential utilization of cassava as livestock feed in Africa. Ed Hahn S.K. Renoldsh and Egbunike G.N. P.103-111.
- Oke, O.L. (1973) The mode of cyanide detoxification. In chronic cassava toxicity Ed Nestel B Mclutyre R. Proceedings interdisciplinary workshop London. IDRC 010e 97 Ottawa Canada P. 40 - 47.
- Okeke, G.C. and Oji, U. (1988). The nutritive value of grass ensilled with cassava peel and poultry excreta for goats. Proceedings workshop on goat production in humid tropics Ed smith B and Bosman H.G. 20-24th July 1988. Obafemi Awolowo University Ile Ife Nigeria. P 101-106.
- Olaloku, E.A., Egbuiwe, A.M and Oyenuga, V.A (1971). The influence of Cassava in production ration on the yield and composition of white fulani cattle. Nigerian Agric. Journal 8: 36 - 43.
- Oldham, J.D. (1981) Amino acid requirements for lactation in high yielding dairy cows. In recent advances in ruminant nutritions (1981) Ed. Haresign, W. and Cole D.J.A. P. 49-81 Butterworths London.
- Omole, T. A (1977) Cassava in the nutrition of layers. In Cassava as animal fed Ed Nestel B and Graham M. Proceedings of Worksho at University of Guelph IDRC- 095e 51 ottawa P. 51 - 55.

- Orskov E.R and McDonald I. (1979). The estimation of protein degradation in the rumen from incubation measurements weighed according to rate of passage Journal of Agric Science (Camb) Vol. 92:499-503.
- Osuji, P.O., Sibanda, S and Nsahlai (1993) Feed evaluation ILCA manual 1993 P. 9
- Osuntokun, B. O. (1973) Ataxic neuropathy associated with high cassava diets in West Africa. In chronic Cassava toxicity ed Nestel B and Mclutre R. Proceedings of inter disciplinary workshop London IDRC - 010e 127 Ottawa P. 127 - 136.
- Oyenuga V.A. (1961) Nutrition Value of cereal and cassava diets for growing and fattening pigs in Nigeria. British Journal nutrition 15:327 - 335.
- Perdock, H.B., Thamotharam M., Blom, J.J., Van De Born. H and Van Velum, C. (1982) Practical experiences with urea-ensiled straw in srihauka. In Maximum livestock production from minimum land. P. 123-134 Ed Preston TR etal. 3rd Seminar Baughladesh Agric research Institute Jogdebpur.
- Preston T.R and Willis M. B (1974) Intensive Beef Production 2nd Ed Pergamon Press Oxford.
- Preston, T.R and Leng, R.A (1984) Supplementation of diets based on fibrous residues and by-products as Feed. Ed F Sundstol and E Owen Elevier Press.
- Preston T.R. and Leng R.A (1987) Matching ruminant production systems with available resources in the tropics and Subtropics. Technical Center for agriculture and rural cooperation Published by Penembol Books Aramidale P. 126.
- Rajah, S.K. (1980) Animal nutrition in the tropics P.207 -208 Vikas Publishing House PUT Ltd India. P. 207 -208.
- Rogers, D.J. (1963) Studies of Mahihot esculenta and related species Bull Terrey Botary Club 90, 143. (Abstract)
- Ross, E and Enriguez F.O (1969). The nutritive value of Cassava leaf meal poultry Science 48:846. (Abstract)

- Santana A and Havell, F.O., De B (1979) Rate of rumen digestion of dry matter of leaf petiole and stem of banana sweet potato and cassava foliage using invivo nylon bag technique with cattle fed sugar cane or molasses based diets. Tropical Animal Production P. 59 - 65.
- Satter, L.D. and Roffe, R.E (1981) Influence of nitrogen and carbohydrate inputs on rumen fermentation. In recent advances in ruminant nutrition. P. 115 Ed. Haresign, W. and Cole, D.J.A Butterworths London.
- Silva, A and Orskov. F.R. (1985) Effect of Unmolassed Sugar beet pulp on rate of straw degradation in the rumen of sheep given barely straw Proceeding of the nutrition society 44:50. (Abstract)
- Smith, O.B. (1988) A review of ruminant responses to cassava based diets. In cassava as livestock feed in Africa. P. 39-53 Proceedings of the IITA/ILCA/University of Ibadan Workshop on potential utilization of cassava as livestock feed in Africa. Ed by S.K. Hohn L. Reynolds and GN Egbunike P. 39-53.
- Smith, O.B, Idowu, A.O., Asaolu, V.O. Odunlamo, M.O (1988c) Comparative rumen degradability of forage browes, crop residues and by products. In African Small ruminants research and development ed by Wilson RT and Azeb M. ILCA Addis Ababa Ethiopia P. 204 - 208.
- Snedecor, G.W and Cockran, W.G (1980) Statistical methods (7th Ed) IDWA State University Press Ames. IDWA U.S.A.
- Steel, R.G.D and Torrie, J.H. (1980) Principles and procedures of statistics Abiometrical approach. 2nd Ed. McGraw Hill Press New York U.S.A.
- Tejada de Hernandez L. and Brambila S (1969) Investigacion acerca del valor nutritivo de la yuca para el pollito Tec Perumex 3:329 cited by Tewe OO and Egbunike G.N Utilization of Cassava in non ruminant livestock feeds. In Cassava as livestock feed in Africa proceedings of the IITA/ILCA/University of Ibadan. Ibadan Workshop on potential Utilization of cassava as livestock feed in Africa. Ed Hohn S.K. Regnolds L and Egbunike G.N. P. 28 - 38.
- Tewe, O.O. (1975) Implication of the Cyanogenic glycosides fraction of cassava in the growth and reproduction of rats and Pigs Ph.D thesis Dept. of Animal Science University of Ibadan Nigeria.

- Tewe O.O. (1984) Cyanogenic glucoside, Protein interreaction in Cassava peel based rations: Effect on some hematological parameters in growing pigs Nutrition reports international 30(2): 425-431.
- Tilley J.M.A and Terry R.A (1963) A two stage technique for invitro digestion of forage crops. Journal of British grassland Society England 18 104-111
- Thomes P.C and Rook J.A.F (1981) Manipulation of rumen fermentation. In Recent development in ruminant nutrition Butterworths London. Ed Heresign W and DJA Cole. P 157 - 183.
- Wanapat, M. (1985) Improving rice straw quality as ruminant feed by urea treatment in Thailand. In relevance of crop residues as animal feeds in developing countries P. 147-175 Ed M Wanapat and C Devendra Funny Press Bangkok Thailand.
- Warambwa, A.R and Ndlovu, R. (1992) Use of whole sunflower seeds and urea as supplements to crop residues based diets for animal production in Africa. Proceedings of the Joint feed resources net work workshop held in Gaborone Botswana 4th-8th March 1991 Ed John E Stanes said AN and Jackson A.K. P. 197 - 204.
- Whitehead, R.G.H. Cooke B.T. Chapman. (1967): Automation in Analytical Chemistry Technicom. Symposum Vol. 2 Page 377 Bassingstoke itants. Technicom Instrument Company Ltd.
- Yilala, K. (1987) Overcoming the constraints to nitrogen availability to improve crop residue utilization by ruminants in Burkina Faso. In Overcoming the constraints to efficient utilization of Agricultural by-products as animal feed page 80-104.
- Zimmerlink, K.G (1973) Utilization of poor quality roughages in the Northern Guinea Savanna Zone. In animal production in the tropics. Proceedings of the international symposium on animal production. Page 167-176 Ed by Loosli J.k Dyenuga V.A. and Babatunde G.M.