FEED INTAKE, WEIGHT GAIN AND NUTRIENT DIGESTIBILITY IN RED SOKOTO GOATS FED WOOLLY FINGER GRASS *(DIGITARIA SMUTSII)* WITH PROTEIN SUPPLEMENTS

BY

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A THESIS SUBMITTED TO THE POSTGRADUATE SCHOOL, ABUBAKAR TAFAWA BALEWA UNIVERSITY, BAUCHI, IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF SCIENCE IN ANIMAL PRODUCTION AND HEALTH.

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AUGUST, 2005

DECLARATION

I hereby declare that this thesis was written by me and it is a record of my own research work. It has not been presented in any previous application for a higher degree. References made to published literature have been duly acknowledged.

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CERTIFICATION

This thesis entitled "Feed intake, weight gain and nutrient digestibility in Red Sokoto Goats fed Woolly Finger Grass (*Digitaria smutsii*) with protein supplements" by GOSKA, DAUDA YUSUFU meets the regulations governing the award of the degree of Master of Science of Abubakar Tafawa Balewa University, Bauchi and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

This thesis is dedicate to my late Father Pastor Dauda Biyang Goska and my Mother Dariya Dauda for their moral and spiritual support to me from childhood.

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ABSTRACT

Twenty Red Sokoto Goats (aged between 10 and 19 months and weighing an average of 12.00kg), were randomly assigned to five dietary treatments in a conpletely randomized design, to determine the effect of two types of protein supplements (cotton seed cake and blood meal) and their various combination on feed intake, growth and nutrient utilization by goats fed basal diet of fresh wooly finger grass (Digitaria smutsii). The dietary treatment groups were cotton seed cake (CC) only blood meal (BM) only and combination ratios of cotton seed cake and bloods meal (CB) 1:1, 2:1 and 1:2. The growth trial which lasted 91 days showed that total dry matter intake (DMT) (g/hd), crude protein intake (CPI) (g/hd) and feed conversion ratio (FCR) were similar across treatments. Significant (P<o.05) difference in daily weight gain (g/hd) was only noticed between the goats fed ratio 1:2 and BM. The result of the metabolism trial showed that there were no significant (P>0.05) differences in the apparent digestibility of dry matter (DMD), organic matter (OMD), neutral detergent fibre (NDFD) and acid detergent fibre (ADFD). Crude protein digestibility (CPD) were significantly (P<0.05) higher in the goats fed CC only and BM only than in the goats fed the mixtures. Faecal nitrogen in the goats fed CB 2:1 was significantly (P<0.05) higher than in those fed BM only. There were significant (P<0.05) treatment effect on the values of volatile fatty acids (VFA), five hours after feeding and those of rumen pH. However no treatment effect (P>0.05) was noticed on rumen ammonia values. In conclusion, the results of the

studies indicate that feeding cotton seed cake and blood meal in concentrate in ratio 1:2 may enhance the growth performance of goats.

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ABBREVIATIONS

ADF	=	Acid Detergent Fibre
ADFD	=	Acid Detergent Fibre Digestibility
ADG	=	Average Daily Gain
CP	=	Crude Protein
CPD	=	Crude Protein Digestibility
CPI	=	Crude Protein Intake
d	=	Day
DCP	=	Digestible Crude Protein
DCPI	=	Digestible Crude Protein Intake
DM	=	Dry Matter
DMI	=	Dry Matter Intake
hd	=	Head
kg	=	kilogramme
kj	=	kilojoule
l	=	Litre
ME	=	Metabolizable Energy
MJ	=	Megajoule
N	=	Nitrogen
NDF	=	Neutral Detergent Fibre
NDFD	=	Neutral Detergent Fibre Digestibility
OM	=	Organic Matter
OMD	=	Organic Matter Digestibility
WK	=	Week

CHAPTER ONE: INTRODUCTION

1.1 Background Information

The goat is one of the domestic small ruminants kept by most households in Nigeria for meat, skin, milk and manure. Small ruminants also serve as flexible financial reserve for the rural population and also play important socio-cultural role in the customs and tradition of many Nigerian societies (Abubakar and Mohammed, 1992; Gefu *et al,* 1994). Goats are estimated to represent over 49% of the domestic ruminants in Nigeria (Lufadeju *et al.,* 1995, Lamorde, 1997). Small ruminants (sheep and goats) display a unique ability to adapt and survive in areas they are found, hence their wide geographical distribution (Gefu and Adu, 1984).

Goat rearing activity in Nigeria is mainly concentrated in the rural areas (Smith *et al*; 1987), where most of them are kept in confinement or tethered the year round or during cropping season due to their destructive nature to crops (Gefu *et al*; 1994, Chidebelu and Ngo Noljon, 1998). Adult sheep have been reported to have lost 22% of their body weight while average daily gain in lambs was 30% lower during the cropping season in northern Togo (Van Vlaenderen, 1985 as cited by Otchere, 1986). This observation is true in most heavily cropped areas and indicates that all is not well with the nutrition of small stock in these areas during the raining season, though undernutrition during the dry season had often been stressed as a limiting factor in ruminant production in tropical Africa. (ILCA, 1979; Meyn, 1980).

1.2 Statement of Problems

Inadequate nutrition is the major problem of the confined or tethered goat, which is fed on cut and carry forages, hence limiting its selection of what to eat. These animals are supplemented only with household waste such as peels of yam, cassava, plantain and kitchen and grain offals (Gefu *et al;* 1994).

The available forages are also unable to meet the nutrient needs of the animal, as forages with crude protein levels below 7% can not sustain liveweight in animals (Milford and Minson, 1966 Onifade and Agishi, 1990,).

It is therefore, necessary to find suitable combination of a gro-industrial by-products to supplement the confirmed or tethered goat.

1.3 Objective

The main objective of this study was to compare the value of cottonseed cake (CSC) a higher degradable protein source, blood meal (BM) a slowly degradable protein source and their combinations in ratios 1:1, 2:1 and 1:2 as protein supplement for the goat with the aim of providing adequate rumen ammonia for the microbes and also by pass N for intestinal absorption to enhance performance of the animal.

1.4 .Justification

Blood meal is a good and cheap protein source which is not readily accepted by the goat when fed alone. A suitable combination of blood meal with other agro— industrial by- products like maize offal and cotton seed cake my enhance its acceptability and provide adequate rumen ammonia for the microbes and also by-pass N for intestinal absorption to enhance performance of the animal.

CHAPTER TWO REVIEW OF LITERATURE

2.1.0 Potentials of Goats.

Goats are believed to have originated from eastern China, though there is inadequate factual information on which to develop any final opinion (French, 1970). Goats belong to the bovidae family of the hollowed horned ruminants, in the sub-order Ruminantia of the mammalian Artriodactyla and genera capra. They possess a complex stomach with four compartments, recticulum, rumen, omasum and abomasum with which they are able to digest cellulose materials (Hungare *et al;* 1964, Church, 1979). Goats have been kept by man since the beginning of his farming operation, but attention of planners, scholars and farmers alike have been drawn more to their destructive potentials than their useful contribution to many agricultural production systems all over the world.

However, in the recent past, awareness of goats' merits that include: adaptation to adverse climate, ability to survive extended periods of drought better than other livestock, its capability of using some pasture resources not available to other stock (Howe et al., 1988 and Dominique et al., 1991 as cited by Adeloye and Fasetan, 1997) and the advantage of small size but efficient producer of meat, milk and special fibre (Mackenzie, 1980). Goats play significant roles in producing food for human, particularly in the areas of the world where the climate is hot and dry. Thus the population of goats is concentrated in the tropical and sub-tropical areas in the developing countries of Africa and Asia and in the warmer temperate regions around the Mediterranean and Central America (Wilkinson and Barbare, 1987).

In Nigeria, Brinkman and Adu (1977) reported the contribution of goats to the total meat supply to stand at 20%. Lufadeju *et al.*, (1995) and Lamorde (1997) reported goats contribution to the total number of ruminants to be 49%.

These clearly show that goat's contribution to the supply of animal protein is quite significant. Other than the meat and milk supply, they also supply skin and manure. Goats serve as flexible financial reserves for the rural population and play important socio-cultural roles in the customs and tradition of many Nigerian societies (Abubakar and Mohammed, 1992, Gefu *et al,* 1994).

2.1.1 Limitation to Livestock Production in the Tropics.

High cost of conventional feed stuff and rapidly declining quality of forages (Oruwani *et al.*, 1995, Lufadeju, et al 1987) have been reported as being limiting factors to livestock production. Others include poor genetic make up of the tropical breeds, poor management and poor health (Oyedipe *et al.*, 1982), inadequate supply and poor quality feeds (Ademosun, 1994).

2.1.2 Feed Resources and Feeding.

Feed resources for ruminants in Nigeria are mostly forages obtained from the natural range (Adegbaola, 1982, Agishi, 1985) especially in the Sahel And Sudan Savanna zones where most of the domestic ruminants are found. Agishi (1985) defined forages as the browse and herbaceous plants eaten by animals. They include non leguminious trees and herbs, leguminious browse plants, herbaceous forage legumes, annuals and perenial grasses. They also include cereals grown as green crops (McDonald, et al 1992). Grasses form the most important component in the diet of herbivores and are adapted to wide range of environment. They include grasses such as: *Pennisetum purpereum, Chloris gayana, Andropogon gayanus, Panicum maximum, Cynodon nlemfuensis, Digitaria smutsii* (Umunna and Lufadeju, 1985, Agishi and Mzamane 1988) ,*Cenchrus* species and *Eragrostis* (Adegbola, 1982). Other feed resources include crop residues, agro-industrial by-products such as poultry waste, bone and meat meal and blood meal which are fed as energy or protein sources (Agishi, 1985, Alhasan, 1985; Miller *and Rains;* 1963).

2.2.0 Factors Affecting Feeding Quality of Tropical Forages

Among factors that affect forage utilisation are the maximum an animal can consume on dry matter basis, the level of soil fertility, the rate of digestion of the material and how long it remains in the rumen. Others are the stage of maturity of the plant, species or variety to which it belongs, the crude protein content and the presence of toxic substances (Campling and Balch, 1961, Milford and Minson, 1962, Agishi, 1985).

Tropical grasses are known to contain crude protein of between 8 to 9% at the early stage of growth. This can meet the requirement of most classes of ruminants, but they decline rapidly in their protein and soluble carbohydrate content, the crude protein content falling to about 1.5 to 2.5% during the dry season while the soluble carbohydrate is replaced by increased levels of lignin and hemicellulose (Hagger, 1972, Agishi, 1985, Lufadeju, et al, 1987). This would indicate a need to supplement the tethered or confined animal fed cut and carry forages during the later part of the wet and into the dry season.

2.3 Methods of Improving the Utilization of Forages

To improve utilization of forages, various methods have been employed that include: timely harvest, physical processing, chemical treatment and supplementation with legumes, browses and concentrate feed:

2.3.1 Timely Harvest

Harvesting forages at a good time to strike a balance between nutritional quality and yield is of significance to the ruminant. Thomas *et al.*, (1980) reported that increasing the digestability of grass silage by harvesting harbage at an earlier stage of growth increased intake and performance of beef cattle.

2.3.2 Physical Processing

Chopping of poor quality forages enhances intake, digestability of nutrients and reduces waste (Marrison, 1959; Anderson, 1978; Apolant and Chestnut, 1985 and Adu and Lakpini, 1983).

2.3.3 Pelleting or Grinding

Pelleting or grinding of roughage will usually increase microbial activity, hence improve forage utilization (Church, 1979).

2.3.4 Chemical Treatment

Treatment of roughages especially dried, with sodium hydroxide (Homb *et al.*, 1976) urea (Lufadeju *et al.*, 1987, Iwanyawu *et al.*, 1990a, 1990b) has been reported to dissolve the lignocellulose bond and hence microbial break down of cellulose.

Ammonia solution has been used to improve the nutritive value of poor quality roughages by improving intake and apparent organic matter digestibility (Tuah and Ørskov, 1989).

Ammoniation is also reported to significantly ($P< 0.05$) improve the crude protein and decrease NDF of crop residue. It also significantly ($P<0.05$) improves the ADF degradability of crop residue (*Taiwo et al.,* 1992). Adebowale (1985) reported marked increase in digestibility of maize straw treated with local alkali. The author also reported higher weight gain (32.2g/day) of goats fed treated maize straw than those fed untreated straw (14.3g/day).

2.4.0 Agro-industrial by-products as Feed Resources.

Residues from farms and food processing industries have been used as feed or feed supplements in livestock production. They are either used as energy or protein sources, depending on their nutrient composition. This has been reviewed by several workers (Umoh, 1982, Alhasan, 1985) who recommended that careful selection and combination of available concentrate and by-products can form very good ration supplements, with low cost but high economic returns to farmers. Similarly in a review by Alawa and Umunna (1993), it was stated that increased feed intake results from the inclusion of most agro-industrial by-products due to their low energy content. Consequently it was recommended that the apparent digestibility of by-products be determined and should generally not be substituted for conventional energy sources above 25 to 30%. However when used as maintenance ration for ruminants, these levels may be exceeded. Table1 shows some agro-industrial by-products used in livestock feed and their proximate composition.

2.4.1 Crop Based by-products

The most important crop based by-products include cereals residues, sugar industry by-products, root crop by products and oil seed by-products.

2.4.1.1 Cereals Residues

Maize offal

Maize offal is a left over of milling process of maize grain. Its chemical composition as reported by Alawa and Umunna (1993) and Ojewola and Longe(2000) is 89.4 - 91.98% DM 12.1-12.28% CP, 6.7 - 9.96% CF, 1.48 - 9% EE, 68.1-71.62%NFE, 4.2-4.66% Ash. Ojewola and Longe (2000) in their studies on layers reported that inclusion of maize offal at 30% in layers diet improved egg size significantly (P<005). This makes maize offal a potentially useful ingredient in livestock feed.

Stovers

Stovers of maize and sorghum consist of the leaves and stalks after harvest, which are highly fibrus (Alawa and Umunna, 1993). It is mostly used as roughage for cattle sheep, goats and horses that can digest in excess of 60% of the crude fibre content (Alhassan *et al;* 1984). Mean voluntary intake of supplemented sorghum stover has been found to be about 1.1% of the body weight for intensively fed goats and cattle and 1.4% for sheep. Alhassan *et al:* (1984) and Alhassan, (1985) suggested that goats and sheep fed sorghum stover should be supplemented with a minimum of 50g/head/day and 60g/head/day of cotton seed cake respectively to minimize weight losses.

Table 1: Proximate Composition (%) of various by-product Feed Stuffs.

		Dry matter	Crude protein	Crude fibre	Ether Extract	N.Free Extract	Ash	Gross Energy (MJ/Kg)	Phosphorus	Calcium	Source
1	Sorghum										
	Straw	94.8	4.80	36.9	1.70	56.6	9.2	n.a.	n.a.	0.05	Alawa,and Amadi,1991
	Treshed penicles	96.5	3.5	n.a.	n.a.	n.a.	n.a.	n.a.	0.09	n.a.	Alhassan et al, 1983
	Beer residue	91.0	22.0	8.4	4.6	n.a.	8.6	n.a.	0.16	0.11	Dogari, 1985
2	Maize										
	Straw	85.0	5.9	46.1	1.8	40.6	5.6	18.1	n.a.	n.a.	MAFF, 1984
	Offal	89.4	12.1	6.7	9.0	68.1	4.2	n.a.	0.58	0.06	Fadugba 1990
	Bran	89.0	10.0	9.0	6.3	60.9	2.7	17.1	0.23	0.03	Bourdon et al: 1987
	Husk	92.6	2.6	31.6	0.97	60.9	3.9	n.a.	n.a.	n.a.	Ekpenyong,1986
	Cob	90.0	2.9	31.6	0.8	3.1	1.7	16.7	0.06	0.11	Bourdon et al;1987
3	Rice										
	Straw	n.a.	4.5	35.1	n.a.	n.a.	16.6	n.a.	0.08	0.21	Bath et al: 1986
	Offal	91.8	6.3	417	2.3	n.a.	15.8	3.5	4.92	1.06	Attah, 1986
	Bran	90.0	12.8	11.6	13.8	41.1	10.7	17.2	1.40	0.07	Bourdon et al;1987
	Husk	90.0	4.2	42.1	1.6	36.4	15.7	16.1	n.a.	n.a.	MAFF, 1984
4	Sugar cane										
	Tope	25.6	6.3	35.0	2.2	50.2	n.a.	n.a.	n.a.	n.a.	Aletor, 1986
	Molasses (fresh)	73.1	5.6	n.a.	0.12	n.a.	n.a.	n.a.	n.a.	n.a.	Iwanyanwu, 1987
	Molasses (dried)	96.0	10.3	5.0	1.0	71.7	8.0	n.a.	0.08	0.89	Aletor, 1986
	Bagasse	87.8	1.7	45.1	1.5	49.2	2.5	n.a.	0.01	0.39	Aletor, 1986
5	Groundnut										
	Groundnut cake (Decorticated)	90.3	51.4	4.6	10.2	28.3	5.5	n.a.	n.a.	n.a.	Oyenuga, 1986
	Groundnut haulms	93.1	19.3	16.2	3.8	-	9.4	n.a.	n.a.	n.a.	Ojabo, 1985
6	Cotton										
	Cotton seed cake	95.0	23.9	25.4	4.73	40.3	5.2	n.a.	1.13	0.17	Alawa, 1991

na = not available

Adopted from Alawa and Umunna (1993).

2.4.2 Sugar Industries by-Products

Sugar cane molasses.

Molasses is a by-product of sugar manufacturing industry. It is known to be rich in fermentable carbohydrate, but low in nitrogen. Molasses is usually used to improve energy supply of poor energy feed and improve palatability of poorly accepted feed (Gampawar and Kakde, 1986). It is also used as a binder in pelleted feed and as carrier of urea or ammonia in semi-solid or solid blocks (Rafique *et al.*, 1985, Sansoucy, 1986). Su et *al.*, (1984) suggested that a daily allowance of molasses and urea at 1.06 - 1.45 and 0.1-0.2% of body weight respectively was suitable for cattle.

2.4.3 Root Crop by-products.

Root crop by-products in increasing use in livestock feed include peels and leaves. Smith (1993) reported cassava, yam and sweet potato peels as fermentable energy sources that might be used in place of molasses or maize bran. The use of cassava peels in sheep and goats feed has been reported by Adegbola et al; (1988, 1989). However the use of peels and leaves may be limited by availability in different ecological zones, as well as the presence of some toxic substances like hydrocyanide in cassava peels. Hydrocyanide in cassava peels have been reported to be reduced by 60-83% by sun drying and by ensiling for 14 days (after sundrying for 2 days to 40% DM) (Adegbola *et al;* 1989).

2.4.4 Oil Seed by-products.

Oil seed cakes/meals

Oil seed cakes and meals are by-products of vegetable oil industries that are in much use in the livestock industry. They include groundnut cake, soyabean cake/meal and cotton seed cake.

Groundnut cake

Groundnut cake has been in use as protein supplement for different types and classes of livestock. It has a crude protein content of over 45% which is highly degradable. Its rumen degradability is reported to be 0.71 - 0.90 (ARC 1980). Inspite of its very good palatability and high degradability, it is uneconomical for use in ruminants due to its high cost (FAEC,1974).

Groundnut cake has been proved to be highly perishable. A toxic factor (aflatoxin) a metabolite of the fungus *Aspergilus flavus* may develop in poorly stored groundnut cake hence contaminating it. Considerable animal species differences in susceptibility to aflatoxin has been reported. McDonald, et al., (1992) reported turkey poults and ducklings as being highly susceptible, calves and pigs are susceptible while mice and sheep are termed resistant.

Soyabean meal

Soyabean meal is known to contain all the essential amino acid except for sub-optimal amounts of cystine and methionine. It is also a poor source of vitamin B which has to be supplemented when in use in monogastric feeding. Soyabean contains some toxic stimulatory and inhibitory, goistrogenic and anti-coagulant factors (Alawa and Umunna, 1993). The inhibitory substances can be inactivated by toasting (McDonald *et al;* 1992).

Cotton seed cake/meal

Cotton seed cake (CSC) or cotton seed meal (CSM) is a by-product of the textile and vegetable oil industries which is obtained after the extraction of oil from cotton seed either by hydraulic or solvent extraction method (Morrison, 1959). It has a crude protein content of between 25-41% (Morrison, 1959: Ibrahim, 1998) and high levels of phosphorus (P). Cotton seed cake supplies protein of satisfactory quantity for cattle, sheep or horses, but less so for swine or poultry if fed as sole protein source because of its low lysine content. It could be used in combination with supplements as tankage, meat scrap, fish meal, milk by-products or soya bean meal. This does not only provide protein of better quality, but will also prevent the injury of monogastrics from gossypols (Morrison, 1959).

Several reports of higher feed intake in sheep, goats and cattle fed low quality roughages supplemented with cotton seed cake abound (McCollum and Galyean, 1985, Fomunyam and Mbomi, 1989, Adamu *et al;* 1996). Ngwa and Tawa (1992) observed increase in average daily gain by over 100% when CSC was supplemented to basal diets of rice straw in sheep. Similarly Adeloye and Fasetan (1997) reported increased DMI, weight gain, nitrigen intake and feed digestibility with CSC supplementation for goats on sorghum glume.

An anti-nutritional factor gossypol (a polyphenolic aldehyde), which is an anti-oxidant and a polymerisation inhibitor, occurs naturally in cotton seed. It is toxic to simple stomach animals, with general symptoms of depressed appetite, loss of weight and death usually resulting from circulatory failure. Ruminant animals do not show ill-effect even when they consume large quantities (McDonald et al.,1992). This is demonstrated in the report of Velasquez-Pereira *et al;* (2002) that supplements based on cotton seed meal that provided 43.5g total gossypol/d had no adverse effect on superovulation response or embryo development of beef cattle.

Groundnut haulms

Groundnut haulms is used extensively as feeding input of ruminants especially during the dry season, to fatten or reduce weight losses in the Sudan, Sahel and Guinea Savannah zones of Northern Nigeria (Ojabo, 1985). Its chemical composition is reported to be 93.1% DM, 19.3% CP, 16.2%CF, 3.8%EE, 9.4% Ash. Live weight gains of 90.2g/d were also reported for Yankasa sheep fed groundnut haulms (Adu and Lakpini, 1983).

2.5 Animal by-products

By-products of meat and fish processing industries like meat and bone meal, visceral offal, blood meal as well as manure of pigs, poultry and ruminants are valuable dietary supplement for ruminants and non-ruminants.

Fish meal

Fish meal is known to be a very good source of protein, but its high cost in the developing countries has made it not economical for use in ruminants feed. Its protein content vary from 500g/kg (50%) to 750g/kg (75%), with biological values of 0.36 to 0.82 to the rat (Mc Donald, et al.,1992). Fish meal protein has a high content of lysine, methionine and tryptophan and therefore a valuable supplement to cereal based diets. In addition, it has high mineral content, especially calcium (80g/kg) and phosphorus (35g/kg) and a number of trace minerals (Mc Donald, et al.,1992). Fish meal is of greater economic value to no-ruminants that do not synthesis all the protein they require. However its slow rumen degradability (when subjected to high heat treatment during processing) makes it serve as a good by-pass protein source to ruminants (Mc Donald, et al.,1992)

Poultry manure

Poultry manure in ruminants feed have been receiving increased attention due to the high cost of conventional protein sources which are rather used in non-ruminants ration. Dried poultry waste contains approximately 28% protein and 26 to 30% ash (Bhattacharya and Taylor, 1975 cited by Jordon *et al;* 2002). Approximately 50% of the N in poultry dropping is in the form of uric acid N (Jordon *et al;* 2002). Oltjen *et al,* (1968), cited by Jordon *et al;* (2002) found that uric acid is degraded to ammonia by rumen micro-organisms more slowly than urea. They suggested that the slower degradation might lead to a more favourable rumen ammonia pattern for efficient N utilization in high forage diets.

Lamidi *et al.* (2001) reported increase of about 22.07% of live weight of bulls from their initial weight, and 27.34% reduction in feed cost when bulls were fattened on concentrate diet containing 50% sun dried layer manure. Jordon *et al;* (2002) also reported that feeding supplement containing dried poultry waste to beef cows resulted in performance similar to that when more conventional supplement containing soyabean meal was fed.

Blood meal

Blood meal is a dry chocolate coloured powder or granular product, obtained by cooking and drying whole blood to a moisture content of 5-8%. Its proximate chemical composition have been reported to be 90.5% DM, 79.9%CP, 1.6%EE, 0.8%CF, 5.6%Ash, 0.28%Ca and 0.22%P (FAO, 1982).

Blood meal is one of the richest sources of arginine, methionine, cystine and leucine, but very poor in isoleucine contain less glycine than either fish, meat or meat and bone meal (Mc Donald, et al., 1992). Though blood meal has high crude protein content it has been reported to be degraded rather slowly in the rumen (Mosimanyana and Mowat, 1991), with a rumen degradablity of about .20 (Mc Donald, et al., 1992). The low rumen degradability is an advantage that it leads to minimum ammonia losses thereby increasing nitrogen utilization in the rumen and providing by-pass protein for digestion and absorption at the intestinal level (Mosimanyana and Mowat, 1991).

Stock *et al.*, (1981) reported greater conversion of protein to gain for lambs given blood meal than those given soya bean meal. Sibanda *et al.*, (1992a) reported 18% increased dry matter intake of veld hay offered to steers supplemented with a combination of blood meal, and meat and bone meal. Blood meal has also been used extensively in monogastric animals rations, a few examples include the works of King and Compbell (1978), Nwokoro (1993) and Hassan and Bryant (1986).

2.6 Supplementation

Supplementation of grazing ruminants is necessary when nutrients are not provided by basal forages in adequate quantity and quality to meet the animals requirement for performance expected (Stafford *et al*; 1996; Caton and Dhuyvetter, 1997). Understanding the rumen ecosystem makes it easy to make a choice on the type of energy and protein supplement to provide, for efficient utilization of both basal diets and supplement.

Based on previous studies by some workers reviewed by ARC (1980) on the nature of digestion in the rumen, the roles played by the rumen microbes and their nutrient requirement, ARC (1980) proposed a new system of protein supplementation to provide nitrogen for microbes body synthesis and amino acid requirement of the host animal for production.

NRC (1985b), NRC(1996) cited by Bohnert *et al.*, (2002) indicated that crude protein consumed is divided into degradable intake protein (DIP) and undegradable intake protein (UIP). Rumen microbes utilize degradable protein intake for their body synthesis. This is more efficiently done in the presence of energy supplied by fermentation of organic matter (ARC, 1980).

Microbial cellulolytic activities in the rumen are often influenced by the amount of DIP. This was demonstrated by Hafley *et al,* (1993) that ruminally degraded protein tended to increase gains of growing cattle grazing warm season grass, compared with the energy control group. Alawa *et al.*, (1987) reported variation in straw intake of cattle fed supplements that provided different amount of rumen degradable protein. They established that straw dry matter intake (DMI) and metabolizable energy (ME) obtained from straw were significantly linearly related to rumen degradable protein intake. Similar reports are also given by Koster *et al,* (1996), Bandyk et al., (2001) for beef cows and steers respectively.

Supplementation with argro-industrial by-products either as energy or protein sources to increase animal performance has been extensively documented (Alhassan, 1985, Givens *et al.*, 1992).

Supplementing browses fed to goats and sheep (Awah and Manigui, 1996, Umoh and Halilu, 1992), with concentrate, was reported to influence the digestibility and feed efficiency of forages.

Voluntary intakes of tropical grasses by ruminant animals have been increased by supplementation with oil seed cakes and other industrial by products during dry season, and this has resulted in improved animal performance (Kandylis *et al.*, 1992). Studies have shown blood meal to be a good source of rumen undegradable protein (Mosimanyana and Mowat, 1991), it is also known to support high livestock productivity (Harvey and Speers, 1989).

2.7.0 Rumen Microbial Requirement and Feed Utilization

Microbial fermentation of feeds in the rumen is of special significance (McDonald, et al; 1992). Rumen pH, rumen ammonia concentration, fermentable energy supply and type of microbial population are key factors that influence feed utilization.

The pH of a medium is known to have marked effect on enzymatic activity. Orskov, (1983), Mould, et al. (1983) and Orstov, (1992) indicated that ruminal pH below 6.0-6.2 would reduce the activity of cellulolytic bacteria and could reduce force fibre digestibility. A recent report by Thomas *et al;* (1994) indicated that optimal ruminal pH for fibre digestion or cellulolytic activity is between 6.7 and 7.1

Rumen ammonia concentration required for maximum digestion are not constant but are a function of fermentability of the diet (Erdman *et al.*, 1987). Minimum levels of 50mg NH_3/l of rumen fluid have been recommended for efficient utilization of fermentable carbohydrates (Satter and Slyter, 1974, Roffler *et al.*, 1976). Mehrez *et al;* (1977) recorded maximum rate of fermentation at slightly above 200mg NH_3/l of rumen fluid for starch-based diets. For optimum degradation and increase intake of roughage with low CP, rumen ammonia concentration exceeding 150 mg/l has been recommended (Sibanda and Said, 1991). Dixon (1986) reported that a deficiency of NH_3-N substrate for rumen micro-organisms will reduce rumen microbial digestion of low-N roughages. The author also suggested that micro-organism digesting high N-forages could obtain much of their N substrates directly from the forages and will be less dependent of the rumen fluid NH_3 pool.

Microbes do not only depend on quantity of rumen degradable protein intake, but also the amount of readily fermentable energy supplied and ingested (Hagemeister *et al.*, 1981). Reports by Smith *et al.*,(1980) and Smith *et al;*(1983) showed that diet with high energy concentration (eg maize or barley) are most suitable for highly degradable nitrogen sources (eg urea), while for slowly degradable protein sources (eg fish meal) low energy diet is most appropriate for efficient degradation in the rumen.

The ecosystem of the rumen is not constant, because it depends on the nature and type of feed. Adaptation of the rumen ecosystem towards presence of cellulytic bacteria influences the digestion of forages. The bacteria have the biochemical ability to produce enzymes which can hydrolyze cellulose and hemicellulose (Hong *et al;* 1988; Nocek and Kohn, 1988 cited by Bowman and Firkin, 1993).

2.7.1 Supplement Combination for Efficient Utilization of Fibrous Feeds.

Improvement of feed utilization by ruminant can be achieved by provision of adequate protein and energy sources in a correct manner (Ørskov 1987). Many experiments indicate that relative or absolute deficiency of protein results in marked reduction of digestible energy and reduce feed intake (Church, 1979). On the other hand, Lewis and Mc Donald (1958) cited by Church (1979) found that the greatest utilization of protein in the rumen occurred when a carbohydrate was present that could be fermented at comparable rate to the protein.

Examples of suitable combination of protein and energy sources are the reports of Smith *et al.*, (1980) and Smith *et al.*, (1983) that showed that diet with high energy concentration (e.g maize or barley) are most suitable for highly degradable nitrogen sources (eg urea), while for slowly degradable protein sources (eg fish meal), low energy diet is most appropriate.

A suitable combination of protein sources is also beneficial. A report of a growth trial with cattle by Stock *et al.*, (1981) indicate that supplements containing a combination of either blood meal, meat meal or corn gluten meal with urea gave significantly ($p<0.05$) superior weight gains to those obtained with urea. Understanding the rumen degradation characteristics of dietary protein sources and the fermentability of available energy sources, makes the combination of protein supplements as well as protein and energy supplement for efficient utilisation of fibrous feed easy.

2.8 Conclusion

Supplementing grazing ruminants on tropical forages during late wet season, and into the dry season with protein supplements is of significance due to the rapid decline in the nutritive qualities of the forages as reported by Hagger, (1972); Agishi, (1985) and Lufadeju et al, (1987).

Energy and protein supplementation are used to maintain targeted production levels or to minimize weight losses of grazing livestock (Clanton, 1982 and Caton and Dhuyvetter, 1997 cited by Loy *et al:*, 2002). Appropriate combination of protein supplements give significantly ($p<0.05$) superior body weight than a single source as exemplified by the report of Stock *et al:* (1981) for cattle and sheep.

CHAPTER THREE: MATERIALS AND METHODS

3.1 Site of Study

The study was conducted between September and December 2002 at the Experimental Unit of the Small Ruminant Research Programme of the National Animal Production Research Institute, Ahmadu Bello University, Shika, Zaria, situated at latitude 11^0 15'N, longitude 7^o 32'E and at altitude of 610 M above sea level. The area is in the northern guinea savannah vegetation zone which receives an annual rainfall of approximately 1100m, with mean maximum temperature range from 27-35,^{0}C depending on season.

3.2 Feeding Trial

3.2.1 Animals Management.

Twenty Red Sokoto Goats comprising of 10 intact bucks and 10 maiden does obtained from the breeding flock of Small Ruminants Research Programme, of the Institute were used. Their mean body weight was 12kg and their ages were between 10 and 19 months

Four days before the experiment commenced, all the animals were dewormed using albendazole (Eagle chemical co. LTD) and dipped using steladone 300EC (Novartis inc.) against endo–and ecto– parasites. The experiment was of completely randomised design in which the twenty goats were distributed into five groups of four animals (2 males 2 femles) per group.

3.2.2 Experimental Diets

Freshly cut Woolly Finger Grass (*Digitaria smutsii*) was fed as basal diet supplemented with five concentrates consisting of maize offal (MO) and either cotton seed cake (CC), blood meal (BM), or the mixture of cotton seed cake and blood meal CB (1:1), CB (2:1) and CB (1:2) as shown in table 2. The concentrates were isonitrogenous with an average CP of 18.64 %. The chemical composition of the dietary ingredients and concentrates are present in Table 3.

Table 2. Percent Composition of Concentrates Supplements.

	Diets				
Ingredient (%)	CC	BM	CB (1:1	CB(2:1)	CB(1:2)
Maize offal	80	91.4	88	86	89.4
Cotton seed cake	20	-	6	9.3	3.53
Blood meal	-	8.6	6	4.7	7.07
Total	100	100	100	100	100

Table 3 Chemical Compositions of the Dietary Ingredients and Concentrates (DM Basis)

	INGREDIENTS[1]			
Chemical composition (%)	D.S	MO	CC	BM
Average dry matter (as fed)	31.8	-	-	-
Dry matter (residual)	94.68	95.10	95.65	92.91
Crude protein	6.84	12.63	29.72	87.12
Neutral detergent fibre	78.90	40.48	49.70	1.80
Acid detergent fibre	48.08	10.12	39.35	0.70
Ether extract	7.01	1.50	13.93	2.40
Ash	10.60	7.21	4.39	4.60

	CONCENTRATES[2]				
	CC	BM	CB (1:1)	CB (2:1)	CB (1:2)
Dry matte (residual)	89.26	91.29	85.79	90.08	90.60
Crude protein	20.65	18.04	19.56	17.65	17.32
Neutral detergent fibre	42.33	37.10	33.96	40.45	38.03
Acid detergent fibre	18.01	12.15	14.16	16.63	13.23
Ether extract	4.10	2.10	2.40	3.09	2.34
Ash	7.04	7.10	6.88	4.84	6.82

[1]DS = *Digitaria Smutsii*; MO = Maize offal; CC = Cotton seed cake; BM = Blood meal

[2]CC = Cotton seed cake; BM = Blood meal; CB (1:1) = Cotton seed cake-Blood meal (1:1); CB (2:1) = Cotton seed cake-Blood meal (2:1); CB (1:2) = Cotton seed cake-Blood meal (1:2).

3.2.3 Experimental Procedure

Animals were assigned to each of the dietary treatment groups such that each group consisted of two males and two females and balanced for weight. Basal diet of Woolly Finger Grass was fed at 3% body weight of individual animals on dry matter basis, while the concentrates were fed at 2% body weight. Concentrated diets were fed first.

Animals were housed in individual feeding pens and fed their treatment diets. They were allowed an adjustment period of 14 days to adjust to the feed and pens. Animals were weighed weekly and feeds adjusted accordingly.

3.2.4 Data collection

The data was collected for a period of three months (early September to early December). At the end of the trial, rumen liquor was collected from each animal using a stomach sunction pump, before feeding, 2 hours and 5 hours after feeding. The pH of each sample collected was recorded before the addition of 10mls of 0.0 5 N sulphuric acid. The samples were stored in a refrigerator for analysis of rumen ammonia and total volatile fatty acids.

3.3 Metabolism Trial

3.3.1 Animals Management

Animals from the feeding trial were transferred into metabolic cages equipped for faecal and urine collection. They were maintained on their respective treatment diets, and allowed a 14 days adjustment period to the cages before faecal and urine collection was done for a period of 7 days.

For each animal, total daily urine out put was collected into plastic containers to which 10mls of 0.05N sulphuric acid had been added to prevent ammonia loss from the urine. Total urine collected was measured and 20% of each day's collection was taken and stored in a refrigerator. Each animal's urine sample was bulked at the end of collection period and stored until it was required for nitrogen analysis.

Total faecal out put from each animal was collected and weighed fresh, and 20% of each day's collection was taken and dried in the oven for 48 hours at 70^{oc} and its weight recorded before storing for proximate analysis.

3.3.2 Chemical Analysis

The proximate composition of feeds, and faecal samples was determined by standard methods (Association of official Analytic chemist (1980). Total N was determine by standard micro kjeldal technique. The neutral detergent fibre (NDF) and acid detergent fibre (ADF) determination was carried out by the method of Goring and Van soest (1970). Total volatile fatty acid and ammonia concentration in ruminal fluid was assessed by distilation involving titration with 0.01N NaOh according to AOAC (1975) methods. The pH of the ruminal liquor was measured with a pH meter.

3.3.3 Statistical Analysis

The General Linear Model (GLM) procedure of Statistical Analysis Systems (SAS 1995) was used for analysis of variance of all statistical components in a completely randomised design. Treatment means were separated by Duncan Multiple

Range Test.(Duncan 1955) Metabolizable energy (ME) MJ/Kg DM and daily metabolizable energy intake, MEI MJ/hd/day were calculated according to MAFF(1975) method

ME = 0.15 x DOMD where,

ME = Metabolizable energy in MJ/Kg DM.

DOMD = Digestibility of organic matter in DM as a percentage

DOMD = (Organic matter in food – organic matter in faeces/dry matter in food) x 100

$$\text{DMEI} = \frac{\text{Daily DMI}}{1000} \times \text{ME/kg DM.}$$

CHAPTER FOUR RESULTS

4.1 Growth Trial

4.1.1 Voluntary Intake

Mean daily dry matter intake (DMI) and crude protein intake (CPI) are presented in Table 4. The DMI values in the growth trial were similar across dietary treatments and ranged from 383.46g daily for the goats fed BM to 426.83g daily for those fed CB (1:2). On kilogramme metabolic liveweight basis, DMI ranged from 60.6g/kg $W^{0.75}$ for the goats fed CB (1:1) to 66.69g/kg $W^{0.75}$ for those fed CB (1:2). No significant ($P>0.05$) differences were observed in DMI (kg $W^{0.75}$) across the treatments.

4.1.2 Crude Protein Intake

Total daily crude protein intake (CPI) are shown in Table 4. CPI were similar across diets and ranged from 47.92g/daily for the goats on CB (2:1) to 54.35g daily for those on CC.

4.1.3 Liveweight Gains

Daily live weight gains and feed conversion ratio are presented in Table 5. Final weights did not differ significantly ($P>0.05$). Daily weight gains ranged from 20.51g daily for the goats fed BM to 31.87g daily for those fed CB (1:2). The daily weight gain values recorded for the goats fed CC, CB (1:1) and CB(2:1) were comparable but CB (1:2) gave significantly ($P< 0.05$) higher gains than BM . Feed conversion ratio ranged from 13.72 for the goats fed CC to 20.02 for the goats fed BM.

Table 4. Mean Daily Dry Matter (DM) and Crude Protein (CP) Intakes of Red Sokoto Goats Fed Woolly Finger Grass with Protein Supplements in Feeding Trial.

	Diets[1]					
Variables	CC	BM	CB (1:1)	CB (2:1)	CB (1:2)	SEM
Concentrate	194.94	194.68	192.11	189.00	223.78	21.43
Woolly Finger Grass	207.73	188.78	199.92	213.97	203.05	14.73
Total	402.67	383.46	392.03	402.97	426.83	28.64
DMI (% of body weight)	3.35	3.48	3.23	3.43	3.56	
Dry matter intake (g/kg $W^{0.75}$)						
Concentrate	30.10	32.10	29.73	29.19	35.07	2.46
Woolly Finger Grass	32.44	31.75	30.70	33.96	31.62	2.18
Total	62.54	63.85	60.43	63.15	66.69	2.63
Crude protein intake (g/hd)						
Concentrate	40.25	40.20	37.50	33.39	38.66	0.31
Woolly Finger Grass	14.10	12.81	13.57	14.53	13.78	0.14
Total	54.35	53.01	51.07	47.92	52.44	0.29

[1]CC = cotton seed cake., BM = Blood meal., CB (1:1) = cotton seed cake – Blood meal (1:1); CB (2:1) =cotton seed cake – Blood meal (2:1); CB (1:2) = cotton seed cake – Blood meal (1:2).

Table 5. Mean Daily Dry Matter Intake, Live Weight Gain and Feed Conversion Ratio of Red Sokoto Goats Fed Woolly Finger Grass with Protein Supplements

	Diets [1,2,3]					
Variables	CC	BM	CB (1:1)	CB (2:1)	CB (1:2)	SEM
Dry matter intake (g/hd)	402.67	383.45	392.04	402.04	426.84	28.64
Initial weight (kg)	12.00	11.00	12.12	11.75	12.00	0.95
Final weight (kg)	14.70	13.20	14.65	14.70	14.90	0.96
Weight gain (g)	2700	2200	2525	2450	2900	0.34
Daily weight gain (g/hd)[2]	29.67^{ab}	20.51^{b}	27.74^{ab}	26.92^{ab}	31.87^{a}	3.11
Feed conversion ratio[3]	13.72	20.02	14.54	15.35	13.84	2.13

[1]CC = cotton seed cake., BM = Blood meal., CB (1:1) = cotton seed cake – Blood meal (1:1); CB (2:1) = cotton seed cake – Blood meal (2:1); CB(1:2) = cotton seed cake – Blood meal (1:2).

[2]Means within the same row bearing different superscript letters differ significantly ($P<0.05$)

[3]Feed conversion expressed in g feed consumed/g gain

4.2 Metabolism Trial

4.2.1 Dry Matter (DM) and Digestible Crude Protein (DCP) Intakes.

The daily intakes of DM, DCP and metabolizable energy (ME) are presented in Table 6. Forage and concentrate DMI in absolute terms did not differ significantly ($P>0.05$) among diets. Forage DMI ranged from 216.99g/hd/day for the goats on BM to 295.74g/hd/day for those on CC. Concentrate DMI ranged from 183.91g/hd/day for the animals on CB (1:1) to 242.08g/hd/day for those on CB (1:2)

The DMI on metabolic liveweight basis ranged from 65.39g/kg $W^{0.75}$ for the animals on CB (1:1) to 74.83g/kg $W^{0.75}$ for those on CB (1:2). There were no significant differences in DMI on metabolic live weight basis among diets.

The metabolizable energy (ME) content of diets (MJ/kg/DM) range 11.53 for CB (2:1) to 12.36 for BM. The daily metabolizable energy in take (MEI) and intake per kilogramme metabolic live weight did not differ significantly among diets and ranged from 5.00 for the animals on BM to 6.14 for those on CB (1:2) and 0.76 for the animals on BM and CB (1:1) to 0.89 for those on CB (1:2)

Table 6. Mean Daily Dry Matter (DM), Metabolazable Energy (ME) and Digestible Crude Protein Intakes of Red Sokoto Goats Fed Woolly Finger Grass with Protein Supplements in Metabolism Tial.

	Diets [1,2]					
Variables	CC	BM	CB (1:1)	CB (2:1)	CB (1:2)	SEM
Concentrate (g/hd)	201.76	118.01	183.91	227.77	242.08	24.43
Digiteria smutsii (g/hd)	295.74	216.99	254.34	269.33	262.12	29.62
Total DMI (g/hd)	497.50	335.00	438.25	497.10	504.20	34.87
DMI (g/kg·$W^{0.75}$)	72.61	65.74	65.39	74.42	74.83	3.45
TDMI (as % body weight)	3.82	3.58	3.46	3.96	3.96	0.19
ME of diets ME (MJ/ kg DM)[2]	11.56	12.36	11.84	11.53	12.18	
Daily ME intake (MJ/hd)	5.75	5.00	5.19	5.73	6.14	0.40
Daily ME intake (MJ/hd $W^{0.75}$)	0.81	0.76	0.76	0.79	0.89	0.03
Digestible CP intake (g/hd)	46.11	41.50	35.25	36.93	39.91	4.01

[1]CC = Cotton seed cake; BM = Blood meal; CB (1:1) = cotton seed cake Blood meal (1:1)., CB (2:1) = Cotton seed cake – Blood meal (2:1)., CB (1:2) = Cotton seed cake – Blood meal (1:2)
[2]Calculated as ME = 0.15 X DOMD (MAFF 1975).

Where:

ME = Metabolizable energy in MJ/kg DM

DOMD = Digestibility of organic matter in the dry matter as a percentage

The mean daily digestible crude protein intake (DCPI) ranged from 35.25g/hd/day for the goats on CB (1:1) to 46.11g/hd/day for those on CC, but there were no significant differences among diets.

4.2.2 Digestibility of Nutrients

The mean values for the digestibility of nutrients are presented in Table 7. The values for dry matter digestibility (DMD) ranged from 75.06% for the goats on CB (2:1) to 81.14% for those on BM. Organic matter digestibility (OMD) ranged from 76.84% for the animals on CB (2:1) to 82.43% for those on BM. No significant($P>0.05$) differences in DMD and OMD were observed among the diets.

Crude protein digestibility (CPD) was highest for the goats fed BM and lowest for those fed CB (1:1). The CPD for the goats fed BM and CC were similar but significantly higher ($P< 0.05$) than in goats fed CB(1:1), CB (2:1) and CB (1:2) which were also similar to one another.

The mean values for digestibility of neutral detergent fibre (NDFD) and acid detergent fibre (ADFD) were highest for the animals fed BM (83.59% and 82.43% respectively). The lowest value for NDFD was recorded for the goats fed CB (1:1) (74.27%).while the lowest value for ADFD was recorded for those fed CB (2:1) (76.84%). No significant ($P>0.05$) differences were however observed in NDFD and ADFD among the diets.

Table 7. Mean Apparent Digestibility of Nutrients by Red Sokoto goats Fed Daily Dry Woolly Finger grass with Protein Supplements.

	Diets [1,2]					
Variables	CC	BM	CB (1:1)	CB (2:1)	CB (1:2)	SEM
Dry matter	76.88	81.14	77.14	75.06	79.22	2.38
Organic matter	77.08	82.43	78.79	76.84	81.22	2.31
Crude protein	74.68[a]	77.88[a]	66.26[b]	62.98[b]	66.79[b]	1.51
Neutral detergent fibre	80.35	83.59	74.27	77.57	81.80	2.69
Acid detergent fibre	77.08	82.43	78.79	76.84	81.22	3.57

[1]CC = cotton seed cake., BM = Blood meal., CB (1:1) = cotton seed cake Blood meal (1:1); CB (2:1) = cotton seed cake – Blood meal (2:1); CB (1:2) = cotton seed cake – Blood meal (1:2).

[2]Means within the same row bearing different superscript letters differ significantly ($P<0.05$)

4.2.3 Nitrogen Balance

The daily nitrogen intake and out put are presented on Table 8. The mean values for nitrogen intake were similar across dietary treatments and ranged from 8.45g/hd/day for the goats fed CB (1:1) to 9.87g/hd/day for those fed CC. Urinary nitrogen values were also similar and ranged from 0.31g/hd/day for the goats fed CB (1:1) to 1.79g/hd/day for those fed CB (1:2). Faecal nitrogen values ranged from 1.81g/hd/day for goats fed BM to 3.44g/hd/day for those fed CB (2:1). Faecal nitrogen values for CB (2:1), CB (1:2) and CB (1:1) were comparable, while goats fed CB (2:1) had significantly ($P< 0.05$) higher faecal nitrogen values than those fed BM. The value for the goats fed CC was comparable to those fed BM, CB (1:1) and CB (1:2). Total nitrogen out put were similar across dietary treatments and ranged from 2.39g/hd/day for the goats fed BM to 4.94g/hd/day for those fed CB (1:2).

Nitrogen balance ranged form 4.59g/hd/day for the goats fed CB (1:2). to 6.06g/hd/day for those fed BM. No significant (P>0.05) difference was observed among dietary treatments. Nitrogen retained as percent of nitrogen intake was highest in the goats fed BM (71.71%) and lowest in the goats fed CB (1:2) (48.16%). No significant (P>0.05) difference was also observed among dietary treatments.

Table 8. Mean Daily Nitrogen Intakes and Balance of Red Sokoto Goats Fed Woolly Finger Grass with Protein Supplements.

	Diets [1,2]					
Variables	CC	BM	CB (1:1)	CB (2:1)	CB (1:2)	SEM
Urine/Faecal excretion						
Urine (ml/hd)	123.72	61.81	62.04	125.07	127.19	26.87
Faeces (Fresh g/hd)	165.44	143.10	150.77	185.17	162.51	24.04
Nitrogen balance (g/hd)						
Nitrogen intake	9.87	8.45	8.53	9.35	9.53	0.83
Urinary nitrogen	1.70	0.58	0.31	0.99	1.79	0.53
Faecal nitrogen	2.50[bc]	1.81[c]	2.89[ab]	3.44[a]	3.15[ab]	0.26
Total nitrogen out put	4.20	2.39	3.20	4.43	4.94	0.59
Nitrogen retained	5.69	6.06	5.32	4.91	4.59	0.82
Nitrogen retained as % of nitrogen intake	57.64	71.71	62.36	52.51	48.16	5.66

[1]CC= cotton seed cake., BM = Blood meal., CB (1:1) = cotton seed cake – Blood meal (1:1)., CB (2:1) = cotton seed cake – Blood meal (2:1)., CB (1:2) = cotton seed cake – Blood meal (1:2).

[2]Means within the same row bearing different superscript letters are significantly different (P<0.05)

4.2.4 Rumen pH, Volatile Fatty Acid and Ammonia Values

Table 9 shows the rumen fluid pH, volatile fatty acids (VFA), and ammonia-N ($NH_3 - N$) values. The pH value before feeding ranged from 6.60 for CC to 7.18 for CB (1:2). The values recorded for CC and BM were similar but significantly ($P < 0.05$) lower than for CB (1:2). Values for CC, BM and CB (1:1) were comparable. The pH values 2 hours after feeding ranged from 5.74 for CB (1:1)to 6.29 for CB (1:2). The pH on CB (1:2) was significantly ($P< 0.05$) higher than for CB (1:1). The pH values 5 hours after feeding ranged from 5.14 in CB (1:1)to 5. 96 in CB (1:2). CB (1:2)gave significantly ($P< 0.05$) higher pH value than CB (1:1). Volatile fatty acid (mmol/100mls of rumen liquor) before feeding ranged from 47.33 in BM to 62.00 in CB (2:1) and CB (1:2). The VFA values increased 2 hours after feeding and ranged from 129.75 to 155.25 mmol/100 mls. The values were similar across diets. The VFA values dropped 5 hours after feeding and ranged from 87.50 Mmol/100 mls in CB (1:2) to 142.33 mmol/100 mls in BM. The values for BM and CB (1:1) were similar but significantly ($P< 0.05$) higher than that of CB (1:2).

The rumen ammonia values were similar across dietary treatments before feeding and ranged from 18.86 mg/100 mls of rumen liquor for the goats fed BM to 30.43 mg/100 mls of rumen liquor for those fed CB (1:1). Rumen ammonia values, 2 hours after feeding ranged from 19.02mg/100mls for the goats fed BM to 41.94 mg/100 mils for those fed CB (1:2). The ammonia values 5 hours after feeding ranged from 22.07 mg/100 mls for the goats fed BM to 23.44 mg/100 mls for those fed CB (1:1). No significant ($P>0.05$) differences were observed among dietary treatment, 2 and 5 hours after feeding. It was observed that there was inconsistency in the pattern of rumen ammonia values in relation to time of collection of the rumen liquor.

Table 9. The pH, Volatile Fatty Acid and Ammonia – N of Rumen Liquor of Red Sokoto Goats Woolly Finger Grass with Protein Supplements

	Diets [1,2]					
Period	CC	BM	CB(1:1)	CB (2:1)	CB (1:2)	SEM
pH Before feeding	6.60[c]	6.70[c]	6.82[bc]	7.05[ab]	7.18[a]	0.09
2 hours after feeding	5.97[ab]	5.96[ab]	5.74[b]	6.06[ab]	6.29[a]	0.10
5 hours after feeding	5.59[ab]	5.63[ab]	5.14[b]	5.60[ab]	5.96[a]	0.22
VFA (Mmol/100ml)						
Before feeding	56.75	47.33	61.25	62.00	62.00	9.40
2 hours after feeding	150.75	153.331	147.25	155.25	129.00	10.41
5 hours after feeding	108.75[ab]	42.33[a]	134.75[a]	109.75[ab]	87.50[b]	14.21
NH_3-N (mg/100ml)						
Before feeding	19.94	18.86	30.43	26.84	28.04	4.83
2 hours after feeding	23.87.	19.02	23.63	21.94	41.94	9.31
5 hours after feeding	22.13	22.07	23.44	23.07	23.38	3.12

[1]CC = cotton seed cake., BM = Blood meal., CB (1:1) = cotton seed cake – Blood meal (1:1)., CB (2:1) = cotton seed cake – Blood meal (2:1)., CB (1:2) = cotton seed cake – Blood meal (1:2)

[2]Means within the same row bearing different superscript letters differ significantly ($P<0.05$)

CHAPTER FIVE DISCUSSION

5.1 Feeding Trial

5.1.1 Dry Matter Intake

Forage dry matter intake was slightly higher on CC, CB (2:1) and CB (1:2) than on BM and CB (1:1) but no significant difference was observed among treatments. This is consistent with the report of Sugimoto *et al.*, (2003) that forage DMI did not differ due to CP source of supplement when grazing steer calves were fed soyabean meal and corn gluten meal. Forage DMI in this study appears to be low. This could be attributed to substitution effect of concentrate feeding before the forage. Similar report of reduced forage DMI due to concentrate feeding was given by Adegbola *et al.*, (1977) when West African Dwarf sheep were fed hay or hay plus concentrate of varying protein contents.

Total dry matter intake (TDMI) did not differ among treatments. This agrees with the report for lambs (Stock *et al.*, 1981), calves (Gardner, 1968, Andrighetto and Bailoni 1993, Sugimoto *et al.*, 2003,) that TDMI did not differ due to source of crude protein supplement.

5.1.2 Crude Protein Intake

Crude protein intakes (CPI) which ranged from 47.92 to 54.35g daily were similar across treatments. This could be due to the similarity in CP content and total dry matter intake of the diets. These values were high enough to meet the maintenance requirement of the animals (4.625g CP or 0.74g N/mg $W^{0.75}$ for Red Sokoto Goats; (Mba *et al.*, 1975). Based on the maintenance requirement for Red

Sokoto Goats (Mba *et al.*, 1975) and the average live weight of 12.0kg for the animals in this study, the daily CPI for maintenance was estimated to be 29.81g. The lowest amount of CP consumed in this study daily was 47.92g and this value is 18.11g (60.75%) more than that required for maintenance. It is apparent that CPI across treatments supplied more than enough protein for maintenance and for some growth.

5.1.3 Liveweight Gains

The liveweight measurements during the experimental period indicated loss of weight by all the animals up to the sixth week. This is consistent with the report of Mba *et al.*, (1982) that West African Dwarf kids (4 – 6 month old) fed basal diets of *Gliricidia* and supplemented with concentrate lost body weight for the first seven weeks and there after gained weight up to the thirteenth week. Sibanda *et al.*, (1992 b) reported loss of weight of 56g/day in the first six weeks of confinement by does previously managed under traditional system, when they were stall-fed. The loss of weight could be due to stress of confinement (Smith *et al.*, 1988) that results in initial reduction in feed intake (Siban *da et al.*, 1992 b). The animals used in this study were obtained from a flock that was grazed in an open range land and only herded together at night within a fence. The animals all gained weight after the sixth week, but there were no significant differences in final weights. The gain in weight after the sixth week was probably due to adaptation to confinement.

Mean daily weight gain (ADG) of the animals in this study which ranged from 20.51 to 31.86g/hd/d. were lower than 26.67 to 63.34g/hd/d reported for West African Dwarf goats fed sorghum glume, supplemented with graded levels of CC

(Adeloye and Fasetan, 1996) or 53.0-69.0g/hd/d reported for growing sheep fed maize stover supplemented with molasses block containing either blood meal, cotton seed cake, wheat bran or CC+BM (Makun et al., 2001). The low daily gain compared to the reports of Adeloye and Fasetan, (1997) and Makun et al., (2001) could be attributed to dietary differences and species differences between sheep and goats. It could be due to the slow response to diets by goats in terms of growth rate especially during confinement as reported by Adegbola and Mecha, (1988) and Sibanda *et al.*, (1992 b). It could also be due to the poor feed efficiency of goats due to high maintenance energy requirement which causes higher heat loss (as percent of Metabolizable energy intake) (Hart *et al.*, 1992).

The goats on CC, BM, CB (1:1) and CB (2:1) had similar daily weight gains. Though there were no significant differences between gains on CC, BM, CB (1:1) and CB (2:1), CC, BM, CB (1:1) and CB (2:1)gave slightly higher gain than BM. However the goats on CB (1:2) had significantly higher daily gain than those on BM. This result suggests the supply of more rumen degradable protein to the rumen microbes from a mixture of CC and BM than from BM alone. The goats on CB (1:2) probably had the most balanced amino acid supply than other treatments. Similar findings have been reported by Urbaniak, (1995) and Tomlinson *et al.*, (1997) for cattle. These authors reported that a combination of protein sources supplied amino acids to the ruminants in optimal proportions than a single source. Feed conversion was highest on BM and lowest on CB (2:1), though there were no significant differences among treatments.

5.2 Metabolism Trial

5.2.1 Dry Matter and Digestible Crude Protein Intakes

The total dry matter intake (TDMI) were similar across treatments. This supports the reports of Adamu, (1985), Ha *et al.*, (1986) and Sugimoto *et al.*, (2003) that dry matter or feed consumption did not differ due to crude protein source. Dry matter intake was higher than the report for sheep by Makun *et al.*, (2001). This was probably due to the higher digestibility of fresh Woolly Finger Grass (Milford and Minson 1962, Agishi, 1985). Similar report of high DMI from fresh forage has been made by Donaldson *et al.*, (1991).

The estimated metabolizable energy levels (MAFF 1975) of the diets (11.52 to 12.36 MJ/kg DM) were similar to the energy levels of 2.7 to 3.0 Mcal/kg DM (11.34 to 12.66 MJ/kg DM) found adequate and recommended for maintenance and growth in indigenous small ruminants (Adu, 1985, Nuru 1985). The values are also comparable to 11.3 MJ/kg DM for growth in temperate breeds of goats (Sanz Sampelayo *et al.*, 1991).

5.2.2 Digestibility of Nutrients

The dry matter digestibility (DMD) and organic matter digestibility (OMD) were similar and generally high across the treatments (above 75). This is consistent with report of Urbaniak, (1995) that forage dry matter and organic matter digestibility were not affected by crude protein source. The high digestibility of all the nutrients (above 77%) for the animals fed BM could be attributed to the high amino acid profile of BM which is degraded slowly in the rumen (Mosimanyana and Mowat, 1991) and better digested at the lower gut. This is in agreement with the report of

Makun *et al.*, (2001) when blood meal was fed alone and in combination with cotton seed cake to sheep. However the digestibility of all the nutrients for the animals on BM in this study were higher than obtained by Makun *et al.*, (2001).

The digestibility of CP were higher when CC or BM were fed separately than when combined. This is in contrast to the report of Stock et al., (1981), that N-digestibility was not affected when meat meal, blood meal, corn gluten meal or their combination were fed with urea to lambs. However, Andrighetto and Bailoni, (1994) reported lower CP digestibility when they fed a mixture of feather meal and blood meal than when these were fed separately. The digestibility of CP appeared to decrease with increase in CC inclusion. The depression in CP digestibility was probably due to an interaction between CC and BM. The mean values for digestibility of neutral detergent fibre (NDFD) and acid detergent fibre (ADFD) were quite high, being above 74%. However there were no significant differences among treatments. This is in agreement with the reports of Hannah *et al.*, (1991) and Adegbola, (2002) that cellulose and Hemicellulose digestibility was not affected by protein supplementation.

5.2.3 Nitrogen Balance

There were no significant differences in nitrogen intake, out put and retention among treatments. This is due to similarity in CP content and intake of the diets. The values of urinary N ranged from 0.31 – 1.79g. Mba et al., (1982) reported values of 1.o9 to 2.5 for West African Dwarf kids fed *Gliricidia* – concentrate diets. The values obtained in the present report are lower than 3.3- 8.8g for Yankasa sheep fed graded levels of protein concentrate (Osuhor *et al.*, 1991) and 6.3 – 6.67g for lambs fed meat meal, blood meal, corn gluten or their mixtures and urea (Stock *et al.*, 1981). There were significant differences in faecal nitrogen that indicated that the goats on BM excreted lower faecal nitrogen than on other diets. This may suggest a higher overall digestibility and absorption of N from BM alone than from the other treatments. However faecal N values for BM were comparable with those on CC.

The values for nitrogen retained (range 4.59 – 6.06g) shows that all the animals were in positive nitrogen balance. The values of 1.23 - 20.40g have been reported for small ruminants on positive nitrogen balance, (Mba *et al.*, 1982; Gangadevi and Kunjikutty, 1985, Hassan and Bryant, 1986, Anugwa, 1990 and Pasha *et al.*, 1994). There were no differences in nitrogen retention due to diets. This supports the report of Stock *et al.*, (1981) that no differences were observed in N retention when soyabean meal, meat meal, blood meal, corn gluten meal and their mixtures were fed with urea to lambs. The similarity in nitrogen retention reflected the trend in total nitrogen intakes, out put and ME intakes. It has been reported that there is an increase in nitrogen retention with increase in ME intake (Hassan and Bryant, 1986). These authors suggested that the effect of ME and nitrogen intakes on nitrogen retention could be additive.

5.2.4 Rumen Fluid pH, Volatile Fatty Acid (VFA) and Ammonia

Rumen pH before feeding (range 6.60 – 7.18) was within the range reported to be suitable for fibre digestion (Thomas *et al.*, 1994) and optimum microbial protein synthesis (Ørskov, 1994). Differences in pH values indicate variation in ruminal fermentation and protein degradation resulting in VFA and ammonia production. The rate was probably higher on diets CC and BM leading to lower pH values. The pH values dropped across treatments 2 hours after feeding and further dropped 5 hours after feeding. The drop in pH values after feeding was as a result of increase in VFA and long chain fatty acids from fermentation. However pH values within the rumen fluid collection period were within values (6.5 and above) reported to be adequate for rapid absorption of ammonia (Hogan, 1961). There were significant differences in pH values due to diets and collection time. This agrees with the report of Urbaniak, (1995) and Adegbola, (2002).

The levels of total VFA were similar across treatment, before feeding suggesting similarity in carbohydrate fermentation. The VFA concentration from the goats fed BM was slightly lower than those fed other diets. This agrees with the report of Andrighetto and Bailoni (1994) when dairy goats were fed blood meal and feather meal, VFA were lower on the feather meal (the less degradable protein source). There was a general rise in VFA concentrations 2 hours after feeding. Diets had no effect on the level of VFA. The VFA concentration on CC in this study was higher than the value of 10.93 and 12.31 mmol/100 ml (before and after feeding) reported by Adegbola, (2002) for bulls fed cotton seed cake and rice straw. This was probably due to the higher digestibility of nutrients in this study than was obtained in the author's study.

Ruminal ammonia – N (mg/100ml) were similar across treatments. This was probably due to similarity in absorption rate due to pH value range. Ammonia – N values (range 18.86 – 30.43 mg/100 ml) before feeding were higher than 5mg/100ml reported by Satter and Slyter, (1974) and Roffler *et al.*, (1976) as recommended level for efficient utilization of fermentable carbohydrates and 8.5mg/100ml for optimum protein yield and rumen function (Satter and Roffler, 1975 and Leng *et al.*, 1977).Ammonia concentrations 5 hours after feeding is within the range of 19 – 25mg/100ml considered optimum for forage digestion (Mehrez *et al*, 1977). The result of this study indicates that ruminal CP degradation were adequate acro ss treatments for normal rumen function and forage digestion

CHAPTER SIX : SUMMARY, CONCLUSION AND RECOMMENDATION

6.1 SUMMARY

Inadequate nutrition is the major problem of the confined or tethered goat which is fed on cut and carry forages, and is supplemented only with house hold waste such as peels of tuber and root crops or grain offals. These supplements are unable to meet the animal's protein needs. Supplementation with protein supplements from oil seed and animal by products is necessary when nutrient are not provided by basal forages and cereals offals in adequate quantity and quality to meet the animals requirement for performance. In this study cut and carry Woolly finger grass was fed and supplemented with concentrates containing cotton seed cake or blood meal or their mixture.

In the growth trial, feed intake and feed conversion were not affected by source of protein supplement. Goats fed the ratio 1:2 ratio had higher daily gain than those fed blood meal only.

Result of the metabolism trial showed no differences in digestibility of dry matter organic matter, neutral detergent fibre and acid detergent fibre. However, crude protein digestibility was higher in the goats fed cotton seed cake or blood meal alone than the mixture.

There were similarities in nitrogen intake, urinary nitrogen, nitrogen out put and nitrogen retention. Faecal nitrogen value in the goats fed the ratio 2:1 mixture was higher than in those fed blood meal alone.

Rumen pH values before feeding were higher in the goats fed the mixture than in those fed cotton seed cake or blood meal only. Two and five hours after feeding, the pH value was higher in the goats fed the ratio 1:2 mixture than in those fed ratio 1:1 mixture. Volatile fatty acids values were similar before feeding and two hours after feeding. However, five hours after feeding, volatile fatty acids value was lover in the goats fed the ratio 1:2 mixture than in those fed blood need or ratio 1:1 mixture.

6.2 CONCLUSION

It is concluded from the results of these studies that feed intake and feed conversion were similar in all the treatments. All the animals gained weight, however the best response in growth was observed on the ratio 1:2 mixture ration.

The digestibility of nutrients in the goats were similar, except crude protein digestibility that was higher in the goats fed cotton seed cake or blood meal alone, than those fed the mixture. The values of nitrogen retention showed that all the animals were in positive nitrogen balance.

Rumen pH values before feeding were within values reported to be suitable for fibre digestion. While rumen ammonia values were within those required for rumen function, optimum protein yield and forage digestion.

6.3 RECOMMENDATION.

Base on the result of the studies, I wish to make the following recommendations:

1. That the tethered or confined goat be provided protein supplements of agro-industrial by-products to enhance it's growth performance.
2. That cotton seed cake and blood meal be fed in concentrate in the ratio 1:2 to enhance the growth of the goat.
3. That further studies be conducted using various combination ratios of cotton

seed cake and blood meal with a view to find an optimal combination ratio.

4. That the blood parameters of such supplemented goat be studied for treatment effect on health status.

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APPENDICES

APPENDIX I

Analysis of Variance for Dry Matter Intake of Red Sokoto Goats Fed Woolly Finger Grass with Protein Supplements.

VARIABLE: DMI

Source	DF	Sum of Squares	Mean Squares	F – value	p
Treatment	4	3273.68	818.42	0.28^{ns}	0.88
Error	13	37637.97	2895.22		
Corrected Total	17	40911.65			

ns = Not significant (P>0.05)
DF = Degree of freedom.

APPENDIX II

Analysis of Variance for Dry Matter Intake per kg Metabolic Live Weight of Red Sokoto Goats Fed Woolly Finger Grass with Protein Supplements

VARIABLE: DMI/kg $W^{0.75}$

Source	DF	Sum of Squares	Mean Squares	F – value	P
Treatment	4	69.94	17.48	0.71^{ns}	0.59
Error	13	319.25	24.55		
Corrected Total	17	389.19			

ns = Not significant (P>0.05)
DF = Degree of freedom.

APPENDIX III

Analysis of Variance for Crude Protein Intake of Red Sokoto Goats Fed Woolly Finger Grass with Protein Supplements

VARIABLE: CPI,

Source	DF	Sum of Squares	Mean Squares	F – value	P
Treatment	4	93.836	23.459	1.52[ns]	0.84
	13	882.173	67.859		
Corrected Total	17	976.010			

ns = Not significant (P>0.05)
DF = Degree of freedom.

APPENDIX IV

Analysis of Variance for Daily weight Gains of Red Sokoto Goats Fed Woolly Finger Grass with Protein Supplements

VARIABLE: ADG,

Source	DF	Sum of Squares	Mean Squares	F – value	P
Treatment	4	224.17	56.04	1.64*	0.22
Error	13	444.82	34.21		
Corrected Total	17	668.99			

* = Significant (P<0.05)
DF = Degree of freedom.

APPENDIX V

Analysis of Variance for Feed Conversion Ratio of Red Sokoto Goats Fed Woolly Finger Grass with Protein Supplements

VARIABLE: FCR

Source	DF	Sum of Squares	Mean Squares	F – value	P
Treatment	4	85.46	21.36	1.33ns	0.31
Error	13	208.89	16.06		
Corrected Total	17	294.36			

ns = Not significant (P>0.05)
DF = Degree of freedom

APPENDIX VI

Summary of ANOVA for Mean Daily Dry Matter (DM) Metabolizable Energy (ME) and Digestible Crude Protein Intakes of Red Sokoto Fed Woolly Finger Grass with Protein Supplements in Metabolism Trial.

	SOURCES OF VARIATION						
	TRT	ERR	CT	MEAN SQUARES		F-VALUE	P
VARIABLE	DF	DF	DF	TRT	ERR	TRT	
DMI	4	13	17	6545.37	4.292.9 0	1.52 ns	0.25
DMI (g/kgW$^{0.75}$)	4	13	17	76.94	42.04	1.83 ns	0.18
TDMI (as % BW)	4	13	17	0.181	0.131	1.38 ns	0.29
MEI (mj/hd)	4	13	17	0.691	0.586	1.18 ns	0.36
MEI(mj/kgW$^{0.75}$)	4	13	17	0.008	0.004	1.69 ns	0.21
Digestible CPI (g/hd)	4	13	17	70.84	56.96	1.24ns	0.34

ns = not significant (P>0.05)
DF = Degree of freedom
TRT= Treatment
ERR = Error
CT = Corrected total

APPENDIX VII

Summary of ANOVA for Digestibility of Nutrients by Red Sokoto Goats Fed Woolly Finger Grass with Protein Supplemented

	SURCE OF VARIATION						
VARIABLE	Treatment DF	Error DF	corrected DF	MEAN SQUARES Treatment	Error	F-VALUE Treatment	P
DMD	4	13	17	19.29	20.11	0.96 ns	0.46
OMD	4	13	17	20.94	18.96	1.10 ns	0.39
CPD	4	13	17	137.25	8.13	16.88*	0.001
NDFD	4	13	17	47.78	25.68	1.86 ns	0.17
ADFD	4	13	17	9.22	45.13	0.20 ns	0.93

* = Significant ($P<0.05$)
ns = not significant ($P>0.05$)
DF = Degree of freedom.

APPENDIX VIII

Summary of ANOVA for Dry Matter Intake (DMI), Dry Matter Intake per kg Metabolic liveweight (DMI/kg $W^{0.75}$) Urinary output, Urinary Nitrogen, Faecal out put, Faecal Nitrogen and Total Nitrogen output of Red Sokoto Goats Fed Woolly Finger Grass supplemented with Protein Supplements

	SURCE OF VARIATION						
VARIABLE	Treatment DF	Error DF	corrected DF	MEAN Treatment	SQUARES Error	F-VALUE Treatment	P
MDI	4	13	17	6545.37	4292.90	1.25 ns	0.25
DMI/kg $W^{0.75}$	4	13	17	0.0081	0.004	1.62 ns	0.18
Urinary output	4	13	17	4278.89	2549.45	1.68 ns	0.21
Urinary nitrogen	4	13	17	1.54	1.00	1.54 ns	0.24
Faecal output	4	13	17	942.24	2040.61	0.46 ns	0.76
Faecal nitrogen	4	13	17	1.33	0.25	5.31*	0.009
Total nitrogen output	4	13	17	3.36	1.25	2.69 ns	0.078

* = Significant ($P<0.05$)
ns = Not significant ($P>0.05$)
DF = Degree of freedom.

APPENDIX IX

Summary of ANOVA for Nitrogen Intake and Balance and Metabolizable Energy Intake of Red Sokoto Goats Fed Woolly Finger Grass with Protein Supplements

	SOURCE OF VARIATION						
	Treatment	Error	Corrected	MEAN SQUARES		F-VALUE	P
VARIABLE	DF	DF	DF	Treatment	Error	Treatment	
Nitrogen intake	4	13	17	1.42	2.4	0.58[ns]	0.68
Nitrogen Balance	4	13	17	1.11	2.41	0.46[ns]	0.76
Nitrogen retained as percent of nitrogen intake	4	13	17	235.91	113.17	2.08[ns]	0.14
Metabolizable Energy intake (MEI)	4	13	17	0.69	0.58	1.18[ns]	0.36
MEI per kg $W^{0.75}$	4	13	17	0.009	0.004	1.69[ns]	0.21

ns = Not significant (P>0.05)
DF = Degree of freedom.

APPENDIX X

Summary of ANOVA for Rumen pH of Red Sokoto Goats Fed Woolly Finger Grass with Protein Supplements

	SOURCES OF VARIATION						
	TRT	ERR	CT	MEAN SQUARES		F-VALUE	P
VARIABLE	DF	DF	DF	TRT	ERR	TRT	
pH0	4	13	17	0.2263	0.0312	7.25*	0.002
pH2	4	13	17	0.1576	0.0412	3.82*	0.026
pH5	4	13	17	0.3408	0.1816	1.88*	0.170

* = significant (P<0.05)
DF = Degree of freedom
TRT= Treatment
ERR = Error
CT = Corrected total

APPENDIX XI

Summary of ANOVA for Volatile Fatty Acid of Red Sokoto Goats Fed with Protein Supplements

	SOURCES OF VARIATION						
	TRT	ERR	CT	MEAN SQUARES		F-VALUE	P
VARIABLE	DF	DF	DF	TRT	ERR	TRT	
VFA0	4	13	17	128.61	298.58	0.43^{ns}	0.78
VFA2	4	13	17	409.82	406.97	0.01^{ns}	0.43
VFA5	4	13	17	1772.94	757.70	2.34*	0.10

ns = not significant (P>0.05)

* = *significant* (P<0.05)

DF = Degree of freedom

TRT= Treatment

ERR = Error

CT = Corrected total

APPENDIX XII

Summary of ANOVA of Rumen Ammonia NH_3 of Red Sokoto Goats Fed Woolly Finger Grass with Protein Supplements.

	SOURCE OF VARIATION						
	Treatment	Error	corrected	MEAN SQUARES		F-VALUE	P
VARIABLE	DF	DF	DF	Treatment	Error	Treatment	
NH 0	4	13	17	95.88	87.48	1.10^{ns}	0.39
NH 2	4	13	17	313.94	325.21	0.97^{ns}	0.45
NH 5	4	13	17	1.63	36.58	0.04^{ns}	0.99

ns = not significant (P> 0.05)
DF = Degree of freedom