UTILIZATION OF LOCAL FEED RESOURCES FOR IMPROVED SMALL RUMINANT PRODUCTION IN ADAMAWA STATE

BY

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DECLARATION

I declare that this work was carried out in its original form by HALILU NYAKO DANEYEL of the Department of Animal Science and Range Management Federal University of Technology, Yola, Nigeria.

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APPROVAL PAGE

This thesis titled **"UTILIZATION OF LOCAL FEED RESOURCES FOR IMPROVED SMALL RUMINANT PRODUCTION IN ADAMAWA STATE"** by HALILU DANEYEL NYAKO meet the regulations governing the award of Degree of Ph.D. ANIMAL PRODUCTION AND MANAGEMENT of Federal University of Technology, Yola, and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

This work is dedicated to my late Father Alh. Nyako Daneyel, Mother, Hajiya Fadimatu (Nyanya), my wife Hajiya Lailah and my children.

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ABSTRACT

This research was conducted at the Department of Animal Science Teaching and Research Farm of Federal University of Technology, Yola, from 2002 to 2006. The study was conducted to identify local feed resources for feeding small ruminants in Adamawa state and to evaluate their potential as feedstuff for small ruminant production. The effect of the feed resources on dry matter intake, growth rate, microbial protein supply and feeding strategies for ruminants in the state were investigated. Four experiments were carried out. Experiment 1 was a field survey conducted using structured questionnaires. Feeds collected were analyzed for chemical composition and degradability values. Experiment 2, twenty four (24) Yankasa rams were allotted to eight treatment diets namely T1 = (cowpea husk only), T2= (cowpea husk + cotton seed cake), T3 = (cowpea husk brewers waste) or T4 = (cowpea husk maize bran);T5 (grass only), T6 = (grass + cotton seed cake), T7 =(grass + brewers waste),T8= (grass + maize bran) in a CRBD. In experiment 3, twenty four (24) Yankasa rams also allotted to 8 treatments diets T1 =(groundnut hay only), T2 = (groundnut hay + cotton seed cake), T3 = (groundnut hay + brewers waste) T4 (groundnut hay + maize bran); T5 =(cowpea hay only), T6 = (cowpea hay + cotton seed cake), T7 (cowpea hay + brewers waste) T8= (cowpea hay + maize bran) in CRBD. In experiment 4, sixteen yankasa rams were assigned to 8 treatments each consisting of basal diet of cowpea husk, grass, cowpea hay or groundnut hay with the same supplement as in experiment 3 to determine microbial protein supplies. Experiment 1 showed that feeds were ranked based on degradability ranked the highest feeds for feeding small ruminants in Adamawa. Experiment 2 shows dry matter intake was highest in T_2 (cowpea husk + cotton seed cake) (960.4g/d/animal), water intake 3.2lit/day. Daily growth rate recorded was 88.9g/d/aminal, DMD, ranged from 57.8 to 69.2. Experiment 3, the results showed that T_6 (cowpea hay plus cotton seed cake) gave the highest DMI (947.69 g/a/day) and water intake was 3.4litresd/animal. DMD ranged from 51.0 to 68.1% and growth rate was highest in T_6 with 115.3g/d/animal. Experiment 4, the microbial protein supply varied from 38.45 to 56.4gN/kgDOMI and Nitrogen Retention ranged from 6.9 to 10.7 g/a/d Rumen liquor ammonia concentration for animals fed cowpea husk or grass with different supplements varied from 51.8 to 94.6, VFA varied from 36.3 to 102.7 Mmol, pH varied from 6.60-6.72. Rams fed groundnut or cowpea hays with different supplements gave ammonia concentration of 59.1 to 106.2 total VFA, range from 65.7 to 107.7 and pH varied from 6.0 to 6.7 feed resources for feeding small ruminants are in abundance in Adamawa State and diets consisting of cowpea husk +cotton seed cake or cowpea hay + cotton seed cake or groundnut haulms + cotton seed cake produced the highest dry matter intake and growth rate in Yankasa rams.

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CHAPTER ONE

1.0 INTRODUCTION

Nigeria is the most populous country in Africa with a population estimate of about 140 million people (NPC, 2006). The country experiences one of the largest population growth rates in the world. According to Aboyade (2003), Nigeria's population had more than tripled from 33 million in 1950 to 112 million in 1995 and is projected at present growth rate to reach a figure of 339 million by 2050. The land area of about 910,000sq km makes Nigeria to be the 13^{th} largest country in Africa. Inadequate nutrition particularly protein is common in developing countries. These countries are mostly located within the warm humid tropical area where the level of animal protein intake represents about one tenth of the level of intake in developed countries (Esonu, 2001). Also, rate of population growth calls for intensification of domestic livestock production to meet the increasing demand for animal protein (Akosim *et al.*, 1999).

Devendra (1989) pointed out that there has been a growing trend in many regions throughout the World to identify potentially important feed sources among shrubs and tree leaves and to explore possibilities of including them in ruminants diets.

It is a fact that there is lack of sufficient quantities of animal protein in the average Nigerians diet. Shaib *et al.* (1997) reported that Nigerians consumed an average of 3.25g g/caput/day of animal protein which cannot be compared with North America's 70.7g, Oceania's 63.4 g, Europe's 48.5 g, and Central America 22.8 g. Shaib *et al.* (1997) have also projected that Nigerians will only consume a maximum of 5.3g of animal protein per person per day by 2010, which is still far below the recommended FAO value of 35 g.

The status of the Nigerian ruminant livestock population shows that Goats are 35,500,000, sheep 22,100,000 and cattle 13,900,000 (Bourn *et al*, 2008) which are mostly located in the Sahelian ecological zone. More than 75% of the rural village dwellers in the zone keep small ruminants with a herd size of two to five animals per household while goats are more commonly kept than sheep. In Adamawa state the total ruminant livestock production is estimated at 2.8 million cattle, 2.0 million sheep and 4.0 million goats (Tukur and Ardo, 1999). Farmers keep these animals as source of food (meat and milk), for personal interest, for prestige, as a tradition, for ceremonial activities and security against crop failures (Oni, 2002). Waste products such as faeces and urine obtained from these animals serve as manure for crop production.

The major problem facing animal production in Nigeria is inadequate nutrition, mostly caused by unavailability of feeds during the dry season coupled with high cost of conventional feedstuffs. Many conventional diets in the tropics for ruminants are poor quality roughages typified by high NDF, low nitrogen and slow fermentation rates. This poor dietary combination leads to decreased feed intake, weight loss, increased susceptability to health risks and reduced reproductive performance (Aganga and Tshwenyane, 2003). Accordingly, the basal diets of most ruminants in the dry season are based on crop residues, roadside grasses or grazing on boundaries between crops and browse plants. Most of the diets are deficient in nutritional value and varied according to seasons (Zemmelink, 1999).

At the beigning of the rainy season, the young succulent grasses have a very high concentration of essential nutrients and have the capacity to support animal growth (Simbaya, 1999). But as the rainy season advances, there is a drastic reduction in the content of proteins and other nutrients which are also accompanied with a rapid increase in fibre content. As the quality of natural pastures deteriorates, animals are forced to eat more, in an effort to meet their nutritional requirements. Normally, intake at this time of the year is limited by the rumen capacity of the animal. Levels of vitamins and minerals, which are high at the beginning of the rainy season, are almost non-existent towards the end of the dry season. This again tends to limit animal performance and unless the animals feeds are adequately supplemented they can not perform as expected. Under such feeding conditions the main source of protein supply to the animals is the microbial protein synthesized in the rumen. The production of microbial protein however, varies considerably about (15-60g) of fermentable microbial protein is produced in the rumen ARC, (1984).

The ability to manipulate the microbial protein production to achieve a maximum yield will have important implications in the feeding of ruminants. Increasing the supply of microbial protein is particularly important in areas experiencing large fluctuations in nutrients supply such as Nigeria.

A higher microbial protein production can be achieved by selective combination of the basal diets and supplements to meet the requirement for microbial growth. Since microbial protein can be produced from low quality cheap feedstuffs, a feasible approach to improve the supply of protein could be to acquire a maximum production of rumen microbial protein from the use of locally available feed resources. Studies in this area will lead to the effective utilization of the available feed resources for animal production.

For us to develop a sustainable ruminant production system there is a need to utilize locally available feed resources in our environments.

1.1 Statement of the Problem

The seasonal weight losses in livestock are responsible for their late maturity in livestock (Adegbola, 1988). As pasture forage matures, the protein contents declines, fibre increases and both forage intake and digestibility decline (NAP, 2002). The low digestibility of grass means that the amount taken up by the animal will be reduced due to the decreased rate of passage through the rumen. Consequently, intake of both energy and protein from pasture by the animal decrease considerably during the dry season. Zemmelink (1999) reported that the dry season native pastures in Northern Nigeria is of extreme low quality and animals' feeding on these pastures without supplementation becomes completely emaciated towards the end of the season. The available crop residues are equally low in protein and high in fibre. They are characterized by high content of fibre (above 40%), low content of nitrogen (0.3-1.0%) and low content of essential minerals such as Sodium, Phosphorus and Calcium.

1.2 Justification of the Research.

The concept of matching ruminants' livestock production with available feed resources has therefore intensified research efforts into more useful residues and agro-industrial by products in most countries in the tropics and subtropics (Mirzaei-Aghsaghali and Materi-Sis, 2008). The utilization of agro-industrial by products may be economically worthwhile, since conventional feedstuff is often expensive. Because of their rumen physiological adaptation, ruminants can utilize inexpensive by-product feedstuffs to meet their maintenance feed requirements, growth, reproduction and production of milk. Supplementation in form of conserved materials like silages, hay, crop residues and food processing by-products are inadequate. To this end, every effort should be made to exploit all feed resources particularly those which are regarded as unsuitable for human consumption and those parts of products which are highly under utilized or not used at all but could be used for fattening programmes (Lakpini, 2002). There is no published data available on the feeding value of several feed resources for ruminants in Adamawa State. Therefore, research work aimed at identification and evaluation of available and cheap feedstuff in Adamawa state will stimulate livestock farmers to boost productivity.

1.3 Objectives of the Research

The research was designed to achieve the following objectives:

i. To identify available and preferred feed resources (Basal and supplements) for feeding small ruminants in Adamawa State.

ii. To determine the chemical composition and rumen degradability of some commonly available feed resources in Adamawa state.

iii. To determine dry matter intake, dry matter digestibility and growth of sheep fed with local feed resources

iv. To determine the microbial protein supply from the rumen of sheep fed local feed resources.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.2 Feed Resources for Feeding Ruminant

The major resources available are natural pastures, browses, crop residues and byproducts. The availability and quality of these resources vary, but evidence is presented to show that when they are properly selected and combined according to their nutritional characteristics, adequate and productive diets could be provided all year round, for sustainable small-ruminants production and productivity (Smith, 1998).

2.1.1 Natural pastures

Natural pastures grow on uncultivated land to which animals have access for grazing. They are found along roadsides and on fallow lands in the coastal forest belt of humid West Africa. They assumed more important proportions in the open derived savannah. Natural pastures consist of a mixture of grasses such as *Imperata cylindrical*, *Andropogon gayanus*, *Pennisetum* spp and *Hyparrhrenia* spp. These grasses grow rapidly during the wet season, becoming fibrous and coarse, and are under grazed 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 (Smith, 1998).

A review of published nutrient contents of these grasses shows that during the period of rapid growth (wet season) they contain, on average, about 25% dry matter, made up of 10% crude protein, 6% ash and a fibre content of 32%, crude fibre or 43% acid detergent fibre (ADF). As the dry season advances and conditions become harsh, their nutritional quality declined to the extent that crude protein could fall to as low as 2%. Ash values decline to about 3-4% as a result of translocation to the root system, while fibre content increases in response to the process of lignification, sometimes up to 50% crude fibre or 60% ADF (Smith, 1998).

Grasses

Grasses tends to be high in nutrients in the rainy season, and begin to decline as the growing season progresses. By the time rainy season sets in, rangeland grasses such as guinea grass, elephant grass will have relatively high TDN levels and protein composition of 5 percent (Rinhart, 2008).

The most abundant grasses found in southern Guinea savannah zone of Adamawa state are *Andropogon*, *Hyparrhenia*, *Panicum* and *Ctenium species*. (Akosim *et al*., 1999) The following grass species; *Andropogon*, *Hyparrhenia*, *Bracharia* and *Aristida* were also reported by similar authors to be available in northern guinea savanna zone of the state. In the Sudan Savannah Zone of Adamawa state, Akosim *et al*. (1999) revealed the presence of the following species of grass: *Aristida longiflora*, *Cenchrus bi florus*, *Pennisetum pedicellatum* and *Eragrostis species*.

Legumes

Legumes are members of the Leguminosae family. The family has three subdivisions which include Papilionaceae, Caesalpinoiceae and Mimosoidae. Each of these separate families has specific characteristics peculiar to them. In general, however they are herbaceous plants or shrubs whose leaves are mostly pilate and stipinate. In some instances the leaves or its part may be modified into climbing tendrils. A common feature is pulvinus at the base of the leaflets and petioles. Almost all legumes produce nodules on their roots in which bacterial colonies live in symbiosis with plants. These bacterial are able to fix nitrogen from the atmosphere into the soil thus maintaining soil fertility.

Legumes are generally palatable and have very high nutritive value especially in crude protein and minerals. Legumes especially the annuals mature early as a result of this they tend to loose their leaves. Bundling of leaves for livestock is supposed to be done early to avoid loosing the leaves (NAS, 1979).

Most legumes are flowering plants and so their mode of propagation is by seedling. Land preparation is therefore required before they are planted especially the annuals. Some legumes especially the tree legumes are highly palatable; therefore animals graze on them all the time. In an attempt to survive the grazing pressure some of them have devised means of survival like thorns, poison production like tannins and saponins and hard seeds. Before animals feed on them they have to be sun dried to reduce their toxicity on animals.

Most of the members of the Papilionaceae family are annuals and highly nutritive to humans too; like Beans, groundnuts, Soyabeans and Bambara nuts.

Legumes generally grow even in poor soils but not water logged fertilization is done. If however, there is need, then only superphosphate fertilizer is applied.

All legumes are characteristically known to have fruits, flowers and pods and almost all are palatable to animals. Most legumes seeds are spread by animals, wind or water.

It was reported by Anonymous (2009a) that the tropical legumes developed in Australia include Townsville stylo (*Stylosanthes humilis*), Perennial stylo (*S. guyanensis*), sirato (*Macroptilium atropurpureum*), centro (*Centrosema pubesceus*), Greenleaf desmodium (*Desmodium intortum*), Glycine (*Glycine *wighti*), Puero (*Pueraria phasedloides*), and the tree leucaena (*Leucaena leucocephale*). A number of these cultivars can be used as tropical legume grass mixtures in order to overcome deficiencies (Anonymous, 2009b).

2.1.2 Browse

Browse plants are considered important and palatable and have been found to offer considerable potential while being productive. Traditional herdsmen and other pastoral groups habitually cut down branches from various trees species (*Acacia*, *Adasonia*, *Ficus*, etc) making them available to livestock during the dry season when no other forage is available (Yahaya *et al.,* 2000).

Trees and shrubs must have both desirable agronomic characteristics and high nutrient value to be useful as forages. The use of naturally occurring browse is a vital component in livestock production systems in many regions of the world, particularly in the arid and semi-arid lands where the dry season becomes unbearably longer than necessary. The nutrients value of a feed is determined by its ability to provide the nutrient required by an animal for its maintenance, growth and reproduction. Browse has been mostly used as feed for ruminants. While the leaves, stems and fruits may be used as complete feed as a suppleemnt to other feeds, anti-nutrients factors in some species are limitations (Gutteridge and Shelton, 1994).

Browse is the tender shoots, twigs and leaves of shrubs and trees (Devendra, 1989). They form an important component of the diet of especially goats, sheep and camels to a much lesser extent, Buffaloes and cattle. Atta-Krah (1989) stated that the importance of browse as being universal throughout the tropics, where it serves as a major feed resource, especially in the drier regions and during the dry season.

Some browse plants for feeding ruminants were reported by Akosim *et al.* (1999): *Daniella oliveri, Parkia biglobosa, Vitex doniana, Piliostigma thorningii*. The browse plants are located in the southern Guinea savannah zone of Adamawa state. Similarly, in the northern Guinea savanna zone of Adamawa state; *Afzelia africana, Vitellaria paradoxa, Terminalia laxiflora, Terminalia glancesscens, Prosopis africana, Albizia zygia, Ficus exasperrata Anogeissus leiocarpus, Balanite aegyptica, Tamarindus indica, Khaya senegalensis, Ficus sycomorus, Ziziphus spina-christ* etc were found to be more abundant (Akosim, et al 1999) . Some dominant browse plants in the sudan savannah zone of Adamawa state as *Acacia senegalensis, Acacia nitotica, Adonsonia digitaria, Ziziphus spin-christ, Terminalia avicerninoides* were reported (Akosim *et al*., 1999).

Karbo *et al*. (1993) fed browse forage to sheep and goats and obtained intakes of 0.5kg DM/head when *Cajanus* plus *Leucaena* plus *Gliricidia*. However intake declined to 0.2 kg/head with *Gliricidia* was offered alone. That indicates that feed combination tend to increase intake of animals than single feed resources.

Shrubs are very good to have on native range because they are high in protein for a greater part of the year. Many livestock and wildlife find these plants important for getting them through the rainy season. Shrubs generally have more than seven percent protein content through the rainy season combined with other dormant forages, these plants can often supply, an animal with its maintenance needs for protein if there are enough plants (Rinhart, 2008).

2.1.3 Forbs

Anonymous (2009c) documented that forbs are young herbaceous flowering plants that are not graninoids (grases, sedges and rushes). They are often broad-leaves. They have higher protein and energy content than ordinary pastures. Forbs usually constitute part of the primary and most economical source of nutrients for sheep and goats. They have high palatability and high digestibility. Susan (2003) reported that during the early part of the grazing season, forbs (weeds) tend to be higher in protein and energy than ordinary pasture.

Forbs, or non-woody broadleaf plants, are generally higher in protein than grasses. Many forbs are considered weeds, but most are often palatable and nutritious when immature (Rinhart, 2008).

2.1.6 Crop Residues

Crop residues can be defined as plant materials left after harvesting the vegetative or reproductive parts, that is, after extracting the primary product. A less desirable but often used term for crop residues is farm waste (Bogoro, 1997). The role of crop residues as ruminants' animal feedstuff during the period of dry season is well accepted by herdsmen (Alhassan *et al*., 1986).

Smith (2001) revealed that, from a nutritional standpoint, the plant material is made up of two fractions-the cell contents and the cell wall. Cell contents, which are usually highly digestible, constitute only a small fraction of the dry matter of crop residues, and hence make only a minor contribution to the feed value of crop residues. The cell walls which constitute the major fraction of crop residues may be highly or poorly digestible, depending on the relative proportions of its component parts lignin, cellulose, hemicellulose, silica, and how they are complexed with each other. Little (1985) reported that cereal stovers and straws have low crude protein (<60g per kg DM), readily fermentable energy, metabolizable energy and available nutrients.

The potential value of crop residues as nutrients sources for goats and sheep vary from as low as 2 percent crude protein for maize stover to as high as 27 percent for cassava tops. The wide ranges observed within particular crop residues for specific nutrients are attributable to factors such as variety, age of residues or stage of harvest, physical composition, i.e the proportion of stems and leaves, length of storage, cultural and harvesting practices. Considerable caution needs to be exercised therefore when using mean values to formulate diets or predict animal performance (Smith, 2001).

In general, crop residues have fairly high cell wall contents, low fermentable carbohydrates and except for leguminous residues, low protein content. As indicated earlier, such materials cannot sustain an efficient rumen ecosystem, and are therefore poorly fermented in the rumen. The very high values of most of the residues confirm their poor degradability in the rumen. Such slow rates of degradability mean slow movement of the materials in the rumen, and therefore low intake, and low total digestibilities (Smith, 2001). If diets based on crop residues are to be productive, the residues must be upgraded to improve the nutritive value.

According to Devendra (1985) the characteristics of a maintenance feed for adult ruminants are: a crude protein level of 6-7 percent, a dry matter digestibility of 50-55 percent and a dry matter intake of about 1.7 percent of body weight.

Crop residues are generally characterized by low levels of one or more nutrients which limit their utilization by livestock. However, the value of crop residues varies according to species, varieties, environmental conditions, stage of maturity and method of harvest, storage and feeding among other factors (Sibanda and Said, 1993).

The mean voluntary intake of maize, millet and sorghum stalks were observed to be 1.2 and 1.1% of body weight of sheep and goats respectively and 1.4% of body weight of cattle on maize and sorghum stalks. The dry matter digestibility (DMD) was reported to be about 47.60% for sheep on sorghum stalks and 51.6% and 56.9% for goats on sorghum and millet stalks respectively. The values for cattle were 48.0% and 66.7% for sorghum and maize stalk respectively. In vitro organic matter digestibility coefficients for maize stover (51.7%) wheat straw (48.0%) and rice straw 44.9%) were reported by Kiangi *et al.* (1981).

In the semi-arid region, goats resort to crop residues or dry standing hay and browse for survival (Ojo *et al.*, 2001). These residues include rice straw, bagasse, cowpea haulms, sorghum Stover, and groundnut. Most of the residues are also deficient in fermentable energy, reflected by the relatively low organic matter digestibility. Crop residues are characteristically low in metabolizable energy and nitrogen contents and thus intake is low. The residues are characterized by high lignocelluloses compounds, low protein digestibility and voluntary intake. That unless the animals have access to supplementary feeds they would lose weight.

Lamidi *et al.*, (1996) reported that the nutritive value of crop residue is characterized by low nitrogen contents and high fiber contents. Crop residues also have lignified cell wall material which often constitute up to 80% of the dry matter. Readily available carbohydrates and proteins are present in much lower amounts. The protein contents is usually not more then 7- 8% in most tropical roughages, where as, most other forages and agricultural products have higher level of protein.

When crop residues are fed to ruminants their intake is low and their utilization is limited by the slow rate of and total degradability and the rate at which particles break down to a critical size small enough to leave the rumen. There is a low proportionate fermentation in the rumen and negligible levels of fermantable Nitrogen, pre-formed branced chain fatty acids, some amino acids, peptides and by-pass protein (Preston and Leng, 1987). In addition, diets based on cereal crop residues are likely to have low and imbalanced minerals content, particularly sodium (Na), phosphorus (P) and copper (Cu) (Little, 1985). However, leguminous crop residues are nutritionally better and may be used as complementary forages if quantities permit.

There appears to be no toxic substances in straw and stovers, except when they are mouldy (Preston and Leng, 1987). However, phenolics and other aromatic compounds may reduce digestibility in some sorghum and millet varieties (Reed *et al.,* 1988).

Legumes like groundnut haulms have high CP content and are also rich in materials required for growth, development in pregnancy and lactation (Lakpini *et al*., 2002). Groundnut haulms and cowpea hay play very important roles in small ruminant production. They are often fed as supplements to grass basal feeds. Feeding them as basal feed for small ruminants has been proven to be cost effective (Lakpini *et al.,* 2002). Devendra and Mcleory (1992) reported the chemical composition of groundnut haulms as follows: DM 85.1%, CP 13.45%, CF 21% EE 9% Ash 10%, Ca 1.5% P 0.2% and M.E 8.12%.

Yahaya *et al.* (2001) evaluated the performance and cost effectiveness of Yankasa rams fed groundnut hay and cowpea vines as supplements with maize bran as the major source of energy. Groundnut hay however proved to be more nutritious and more useful in enhancing growth. Yahaya *et al.*(2001) reported chemical composition of groundnut hay as CP 9.9%, CF 21.1%, EE 2.4%, NFE 57.3%, Ash 7.3%, Ca 1.4%, P 0.0% and Dm 94.5%. Ground nut hay is also palatable and has high NDF content. The cell wall (NDF) of legumes is more fragile than that of grasses.

2.1.7 Agro-industrial by products

Agro-industrial by-products, on the other hand, are produced mainly after processing of crops for the production of a main product that may be radically different from the starting crop. They may be rich in nitrogen (oil seed cakes, brewery and flour milling by-products) and may be low or high in fibre (sugar cane bagasse, palm press fibre). Since they are produced at factory sites, they are less widespread geographically. With a few exceptions, they are mainly used as supplements. A list of major crop residues and by-product produced in the humid zone of West Africa is shown in Table 2.1.

Cassava peels has been used by many farmers as an energy supplement and in the fermented form it was used to substitute maize levels of 0, 20, 40 and 60% over a 6 months feeding trial. It was concluded that fermented cassava peel should not constitute more than 20 percent of a concentrate diet in order to avoid a reduction in performance (Adebowale, 1981).

The south west zone of Adamawa state produces some root and tuber crops namely; yam, cassava and potatoe. Among the cereals; maize, rice and sorghum are produced according to Sajo and Kadams (1999). The central zone produced cowpea, groundnut and rice. Some cash crops namely; sugar cane and cotton seed are obtained in the south west zone of Adamawa state (Sajo and Kadams, 1999).

Table 2.1: Major crop residues and agro-industrial by-product produced in West Africa.

Crop	Residue	By-product
Maize	Stover cob	Bran
Rice	Stubble straw	Bran, husk, rice meal
Sorghum	Stover	Bran
Wheat (imported)	-	Bran, offals
Barley (imported)	-	Spent grains
Groundnut	Haulms husks	Groundnut cake
Cowpea	Vines	-
-Cocoa	Pod	-
Coconut	Husk	Copra cake
Oil palm	Empty fruit bunch	Palm pressed fibre palm kernel cake
Rubber	-	Rubber seed meal
Banana/plantain	Leaves Pseudostems peels and rejects	-
Sugar cane	Tops	Molasses Bagasse Cane juice
Cassava	Tops Peels and rejects	-
Sweet potatoes	Vines and peels	-
Pineapple and citrus fruits	-	Pulps

Source: Smith (2001)

The products and by-products of tubers root crops and cereals are used in feeding ruminants in the state.

Cowpea husk are remains or by-product of cowpea after the seeds have been harvested and they are usually given to ruminant animals mostly during dry season when there is shortage of their conventional feed (forages, grasses etc) that are available during the rainy seasons. Cowpea husk are regarded primarily as a good source of protein and makes a significant contribution to the energy economy of the animal, having a metabolizable energy content of 135m9kg DM for ruminants and a crude protein of 14%, lignin content of 5.6 ND 749 and dry matter content of 982% (Alhassan *et al.,* 1986).

The nutritive value of cowpea certainly depends on the method of handling, processing and storage. They are fed to animals (ruminants) as supplements and in some cases sole depending on its availability. Because of their thick and fibrous stems, they are poorly utilized by ruminant unless they are processed adequately.

Brewers' grain, barley (P)

This is the residue, comprising of mixture of barley, maize and brewers' yeast from which starch and sugars have been extracted. The product therefore have only an intermediate energy value and usually 22% to 26% crude protein on a dry matter basis, about half of which is "bypass protein" palatability is not usually a problem and the product is safe even when fed in a pure form.

Brewers' grain sorghum (P)

This is a by-product of sorghum beer brewing, consisting of sorghum residue from which a large proportion of the starch and sugars have been extracted. It is palatable and safe to feed at any level. However, inclusion levels exceeding 25% of the ration dry matter are not recommended in dairy rations.

Citrus pulp (E)

This is the residue of citrus after the extraction of the juice. Low protein, intermediate to relatively high energy. It is palatable.

Corn and cob (E)

This has an energy level intermediate between maize grain and "snapped corn". It is a useful energy supplement for medium to lower-yielding cows and growing animals. Although highly palatable it may cause acidosis at high levels (Evans and Johnson, 2005).

Cotton seed, whole (P+E)

A good protein and energy supplement for lactating cows when fed whole. It should not be fed at more than 3kg per cow day. The presence of cotton fluff on the seed makes it difficult to handle the mixtures and this, combined with lightness, makes it almost impossible to mill. Its bulkiness makes for high transport costs as documented by Evans and Johnson (2005).

Cotton seed oilcake meal (P)

This is the residue of the dehulled cotton seed after the oil has been extracted. It is a reasonably good source of "bypass protein" periodically palatability problems have been experienced. It contains toxin called gossypol which may be detrimental to animals, especially to young stock. Normally it is not advisable to feed cotton seed oilcake meal to calves less than 6 months of age. Older cattle seem to be little affected by gossypol.

Groundnuts (P+E)

Groundnuts have high oil content (over 40% in the dehulled product) and therefore must be used within a day or two of milling. Diarrhoea, lowered butterfat and milk protein percentages may occur depending on the levels of inclusion in the diet. If the hulls are to be sand clinging to them. This sand can be abrasive on milling equipment, and cause problems in the animal if significant amount are ingested.

Groundnuts oilcake meal (P)

This is the residue after the hulls have been removed and the oil have been extracted. Typically, the protein contents are above 45% with less than 2% oil. The "bypass protein" content is low. Palatability is not normally a problem, but there is a high risk of aflatoxins, a toxins produced by moulds as reported by Evans and Johnson (2005). Some common supplements were reported by Adeloye, (1993) as cassava peels, yam peels, sweet potato peels, banana and even orange peels.

2.1.6 Hay

Hay is a generic term for grass or legumes that have been cut, dried, and stored for use as animal feed, particularly for grazing animals like cattle, horses, goats, and sheep. Hay can also be fed to pets such as guinea pigs and rabbits, though they consume much smaller quantities. Pigs may be fed hay, but they do not digest it very efficiently.

Hay is fed when or where there is no enough pasture or rangeland on which to graze an animal, when grazing is unavailable due to weather such as during the winter, or when lush pasture by itself is too rich for the health of the animal. It is also fed during times when an animal is unable to access pasture, such as when animals are kept in a stable or barn (Anonymous, 2008).

The aim of making hay is to produce a dry product of high quality. Hay making can be particularly important in semi-arid and arid region (Jackia, 2007).

Hay supplies for the dry season feed, accounts for the majority of dry feed for cattle, goats, and sheep and yet varies in nutritional content among feed-stuffs. An average goat or sheep will require 49Ibs of hay over 90 days feeding period. Knowledge of the quality of hay is an important management tool in developing proper nutritional programmes that delivers adequate nutrition for the desired levels of production at the least possible cost. According to Jackia (2007) the most important factors affecting hay quality in livestock feeding are stage of matority, level of fertilization, presence of weeds, environmental conditions during forage growth, harvest conditions, storage conditions and presences of non-nutritive factors.

2.1.7 Silage: Green forage preserved by fermentation in silo for use as succulent fodder during scarcity is called silage (Prasad, 2000). According to Prasad, (2000) the objectives of ensiling is to obtain enough acid contents in ensiled fodder for inhibiting the microbial fermentation for presentation of green fodder.

Some of the advantages of silage for feeding ruminants ensure getting succulent fodder during scarcity of green with less loss of nutrients and silages can be made in all seasons. It helps in control of weeds because crops along with grasses are harvested at bloom stage. Silage requires less floor area for storage than hay. Early harvest of green fodders for ensiling makes field available for crops and helps to control insects and pests as these are not able to complete life cycle. Silage is palatable and laxative feed (Prasad, 2000).

2.2 Problems of Livestock Production in Nigeria

FAO (2002) reported that the problems of livestock production in Nigeria include nutrition, animal health, breeding, management skills and socio-economic factors. Some of the constraints affecting livestock production especially small ruminants were reported by Ajala *et al* (2004). These include lack of credit facilities, high incidence of disease and parasites, housing condition, difficulty in procuring feeds, lack of deliberate and consistent government policy to boost livestock production in the country.

2.2.1 Nutrition.

Inadequate nutrition is a major constraint to production. The grazing areas are declining due to expanding arable cropping which forces farmers to adopt a cut-and-carry system which is labour-intensive. However, there are opportunities for increasing forage production through the use of improved varieties, agronomic practices and introduction of browse (multi-purpose trees). Further, opportunities exist to improve the availability of feeds throughout the year and efficiency of utilisation of feeds through conservation of forages and crop residues. The development of appropriate feed packages based on locally available forages, browse, crop residues and processing by-products will also go a long way in improving the efficiency of utilisation (FAO, 2002).

2.2.2 Animal health.

Livestock diseases are a major constraint to the development and improvement of the livestock industry in the region. Vector-borne diseases, particularly trypanosomiasis (transmitted by tsetse flies) and tick-borne diseases (especially theileriosis and heartwater) seriously limit livestock production in the region. East Coast fever (ECF), a form of theileriosis caused by the parasite Theileria parva and heartwater were singled out as the most important diseases for eastern and southern Africa, respectively.

Several papers highlighted the limitations and the unsustainability of the current control methods based on the use of acaricides and other chemicals and they reported encouraging research developments in the use of vaccines for the control of ECF and heartwater (FAO, 2002). High incidence of diseases and parasites especially during rainy season affect livestock production (Ajala *et al.*, 2004). Mortality rates tend to be high as recorded in small ruminants.

2.2.3 Genotype

The attributes and weaknesses of the indigenous animals, purebred exotics and crossbreds were reported in the case studies. In order to enable the purebred exotics to exhibit this genetic potential they need an optimum environment (feeding, management, health and climatic conditions) which cannot be attained on small farms. Crossbreeding improves milk production and many countries in the region have embarked on this. Crossbreds are suitable for smallholders. However, farmers face difficulties in adopting breeding plans for F1 or F2 crosses due to the anticipated segregation. Ajala *et al.* (2004) reported that lack of adequate information on improved small ruminant management practices is another constraint to livestock production.

It was also felt that inadequate characterisation of indigenous breeds for disease resistance and suitability to their respective environment has not been fully documented and there exist lost opportunities.

Insufficient foundation and replacement stock is a major constraint to the development and expansion of the smallholder dairy. Low reproductive rates (low calving rates and long calving intervals) in the sector is caused by missed heat detection, poor or non-existent artificial insemination (AI) delivery services and brucellosis where bull centres are used. High mortality rates of calves also retard the raising of replacement stock (FAO, 2002).

2.2.4 Management Skills.

While the exotic breeds have a high potential for milk production, they are susceptible to endemic diseases in the tropics and they need large quantities of feeds on a continuous basis to sustain high milk yields. Therefore farmers need to be trained in disease control, management, feed production and utilisation.

2.2.5 Socio-economic.

A number of issues perceived to be hampering the development of the smallholder dairy industry in the region were raised under this section. These include unfavourable pricing policies, lack of alternative market opportunities, lack of capital, poor infrastructure, lack of output processing technologies, weak institutional research extension-farmer linkages and inadequate training at all levels. These issues act as disincentives to farmers. The lack of an interdisciplinary holistic approach to livestock development programmes and projects in the region was also noted. The following are important areas for the future.

Ogri (2009) reported some environmental problems associated with livestock production in tropical Africa as cost of concentrates and feeds, free grazing, poor breeding etc. He also revealed that prevalence of disease increased herding and agriculture have caused excessive removal of vegetation, lowering of the water table and dessication of the land, with a resultant gradual change in climate and vegetation.

2.2.6 Physical envrionmemt

Climate

According to Leng (2000) heat stress in ruminant, which is indicated by excessive respiration rates in general reduce feed intake. Animals that are in a hot climate can therefore be expected to have a lower intake of an unbalanced diet than animals in cool/cold climate. In general, on a poor quality roughage diet if the rumen of an animal in a hot humid environment is deficient in fermentable N, sulphur and phosphorus then this will: (a) reduce digestibility by as much as 5 to 10 units (b) reduce efficiency of microbial cell growth per unit of organic matter digested and therefore lower P/E ratio in the nutrients absorbed (c) reduce feed intake both because of the lower digestibility and also because of the extra heat from the rumen and the animal (Leng, 2000).

Finance

In most tropical countries, the rate of interest on loans is high and capital is scarce for farming developments, because so much other public and industrial growth is proceeding simultaneously (Loosli *et al*., 1999).

Infrastructure:

According to Loosli *et al*; (1999) there are inadequate housing facilities for different classes of animals in the country. Different housing designs to suit environmental circumstances and convinience of the different producers of animals is lacking. Similarly, poor network to facilitate the delivery of liquid milk to centres of consumption from distant places. Milk hygiene and quality control are virtually non-existent. There is organized cleaning of equipment and the equipment in most cases is any container that is handy (Loosli *et al*., 1999). There are no facilities for the filtration, cooling, pasteurization, sterilization and product packaging in most cases.

2.3 Improvement of the nutritive value of crop residues

Three alternatives are available for improving the intake and digestibility of fibrous residues. These are (i) treatment of the residues to improve biodegradation, (ii) appropriate supplementation with additional nitrogen, readily available energy and minerals, and (iii) a combination of treatment and supplementation (Smith, 2001).

Many of the treatments for crop residues are unsuitable for use in small scale farming systems found in humid West Africa. The various treatment methods are briefly discussed below in terms of their mechanism of action, effectiveness and suitability.

2.3.1 Physical treatments:

Physical processing of straw by chopping or soaking improves the intake but has no influence on the nutritive value; chopping on the other hand was reported to facilitate the urea treatment of coarse stovers (maize or sorghum) (Sansoucy, 1990).

Physical treatments for enhancing crop residue use by ruminants are grinding and pelleting. Grinding, or fine chopping, decreases particle size, increases surface area and bulk density of both leaf and stem fractions, and hence raises rumen microbial accessibility or feed intake. The increase due to grinding is generally higher with low quality than with quality residues, and with small and young animals rather than with older and larger animals (Quigxiang, 2001).

2.3.2 High Pressure Steaming

Steam treatments were reported by Walker (1984) that roughages' hemicelluloses fraction can be destroyed by high pressure treatments leading to production of acetic and other acids. Also, Quigxiang (2001) opined that high pressure steaming improves the nutritive value of low quality feeds. High pressure steaming markedly decreases straw CF and therefore increases the invitro DM digestibility. Results from an insitu study showed that NDF digestibility of treated wheat straw was increased by 68 percent in rumen-fistulated sheep and by 233 percent with caecum-fistulated pigs. Rumen VFA concentration was also increased 9.9 percent in sheep fed diets based on the high pressure steamed wheat straw, compared to untreated straw. In lamb feeding trials, animals were fed equal amounts of mixed concentrates and wheat straws. Lambs fed high pressure steamed straw ate more of it and gained faster than lambs with untreated straw (Quigxiang, 2001).

2.3.3 Irradiation

Irradiation treatment of lignocellulosic materials to improve the utilization of cell wall polysaccharides was reviewed by Quigxiang (2001). He found that when basswood was irradiated with high velocity electrons, rumen bacteria fermentation was increased. Electron irradiation of straw can also increase polysaccharide digestibility by ruminal micro-organisms. When straw was ground through a 6 mm screen an optimal animal performance in terms of diet digestibility, intake and growth rate were obtained as compared to straw ground through 3, 10 or 13 mm screen in a beef fattening trial using diets containing 30% ground barley straw as documented by Greenhalgh and Wainman (1972).

2.3.4 Chemical treatment

Since the beginning of the 19th century, attempts have been made to improve the digestibility and nutritive value of crop residues. A major breakthrough was chemical treatment to remove encrusting substances (cellulose, hemicellulose and lignin). Many chemicals have been screened in laboratory experiments for their potential to enhance digestibility. However, only three are being routinely used in animal research: Sodium hydroxide (NaOH), Ammonia (NH_3), and Calcium hydroxide (CaOH) (Quigxiang, 2001). The use of any chemical depends on its effectiveness in improving digestibility and / or intake, cost of treatment, availability and freedom from chemical residues.

Sodium Hydroxide Treatment

Adebowale (1987) reported that sodium hydroxide (Caustic Soda) was used in treating maize stover which gave the best improvement in animal performance as compared to Cocopod husk and palm bunch ash. Sodium hydroxide treatment of crop residues has been investigated and used in some areas of the country since the late 1970s. The procedure basically followed the "dry method", where NaOH is applied at 3-5 %percent at a moisture content of 20-30 percent of DM. Alkali treatment may saponify the ester bonds between lignin and carbohydrates or the phenolic acid-carbohydrate complexes in plant cell wall. Through these effects, structural carbohydrates in both lignified and unlignified plant tissues become more digestible, with consequent increases in rate and digestibility.

Alkali treatment

Chemical treatment using urea/ammonia received much attention in most developing countries (Sansoucy, 1990). The use of ammonium hydroxide (NH_4OH) was reported to have generated considerable interest because of its additional advantage of incorporating non-protein nitrogen in the feed (Parra and Escobar, 1985).

The major problem in adopting any of these methods is cost implication; for example, the cost of processing crop residues using chemicals may hinder farmers from adopting it (Alhassan *et al*., 1986).

Ammonia treatment (Ammoniation)

Sandstol and Coxworth (1984) reported on the use of ammonia on roughages for ruminant feeding. The ammonia supplies nitrogen to and delignifies the treated materials. However, Lufadeju *et al.* (1992) reported that use of ammonia is not very common in Nigeria because of its unavailability, and even if they are available, the high cost of transportation of gaseous ammonia in special gas tankers, and the highly technical personnel required to handle this potentially hazardous material do not make it economically feasible.

2.3.5 Biological treatments:

Ibrahim and Pearce (1980) used species of fungi (*Pleurotus spp, Volvariella rolvacae, Strophania rugosa annulata*) to convert crop residues into human and animal foods. Treatments of sorghum stover with *Trichoderma harzanium* improved the CP content of substrate while the CF was reduced

Attempts at the improvement of straw quality with biological treatments were reported by Hunter (1991). However, this approach is unlikely to yield practical results, mainly due to practical difficulties of fermentation, organic matter loss, chances of toxicity and lack of biotechnological improvement. Proper microorganism focuses mainly on the manipulation of rumen micro flora or on the use of enzymes on straws. Of all the available biological methods, ensiling appears to be the only feasible and valuable methods for our target users.

2.3.6 Supplementation

The effect of supplementation of energy on digestibility was also revealed by Hossain *et al*., (2003). The digestibility of crude protein (CP), nitrogen free extract (NFE) and ether extract (EE) was similar in sheep ($p>0.05$) for all dietary energy regimes. However, the digestibility of dry matter (DM), organic matter (OM) and crude fibre (CF) increased significantly ($p<0.05$) as the level of dietary energy supplementation was increased. The authors concluded that, increased levels of dietary energy supplementation along with other nutrients from the concentrate mixture might increase the availability and proper balance of nutrients to the host animal.

Adebowale (2004) reported in one feeding trial, 20 white Fulani steers were fed *adlibitum* on treated and untreated maize cobs (chopped) with fresh Siam weed. Live weight improved from 320g when animals were fed untreated maize cob to a daily gain of about 480g when cobs were treated and supplemented with Siam weed. In another trial, maize husk and bran supplemented with Leucaena foliage were fed to West African Djallonke goats for 12 weeks. Animals reacted better to maize bran than to maize husks i.e the maize bran is better degraded in the rumen than maize husk.

The effect of protein supplementation on intake and growth performance of goats and sheep were reported by Kabir *et al*. (2004). They stated that feeding of goats with high protein diets significantly ($p<0.01$) increased crude protein intake (73.14 vs 59.91 g/d) compared with low protein diet. However, no significant ($p>0.05$) difference was observed between the high protein and low protein diet for the values of DM intake and live weight gain, although there was a tendency to increase live weight gain in goats given the high protein diets. It was concluded that the effect of supplementing high protein on intake and live weight gain was higher in sheep than goats.

Ngawa and Tawah (2002) reported that supplementation with energy and/or protein increased the efficiency of utilization of rice straw. Supplementation with groundnut haulms, cowpea vines and cottonseed cake produced positive effects on growth rate. They concluded that by giving small quantities (up to 30% of total DM intake) of a legume crop residue will substantially increase the total DM intake and improve the digestibility of rice straw above that which can be obtained by use of non-protein-nitrogen supplements. Judicious amounts of legume crop residues, which are generally available in abundance during the harvest season, could be fed in combination with rice straw and rice bran to small ruminants in the hot dry season to ensure minimal weight loss, mortality and weakness due to malnutrition. The authors reported 20.0g of daily weight loss when rice straw was fed alone as basal diet. However, the daily weight gain increased to 48.93, 52.14 and 49.29g when basal diet was supplemented with groundnut haulms, cottonseed cake and chopped cowpea vines.

Butterworth and Mosi (2009) revealed that supplementing diets with legume hay is a more appropriate and cost-effective way of increasing animal production from cereal crop residues in Africa than is the use of strong alkali.

Okello *et al.* (2005) in an experiment to find the effect of feed supplements on weight gains of Mubende goats in Uganda found that oats fed with maize bran as supplement virtually maintained weight. That is, the goats received only adequate energy and protein for maintenance.

Very few studies have been carried out in which changes in the rumen environment have been measured when concentrates are fed with poor quality basal diets. It is known that poor quality roughage provide insufficient degradable nitrogen and fermentable energy to sustain optimum digestion of fiber. The ideal N concentration in the rumen for efficient digestion has been variously estimated at 50 – 70/litre (Satter and Slyter, 1974) and at 150 – 200mg/liter (Krebs and Leng, 1984). However, Ndlovu (1991) reported that these levels are not easy to maintain in a stall fed animal over 24 hours particularly if the feed is a mature grass and it is fed in insufficient quantities. He further stated that concentrates are relatively good source of degradable nitrogen and fermentable energy, so their inclusion in the diet is likely to increase the rumen population of cellulolytic microbes.

Increase in food intake and digestibility of the basal diet arising from supplementation with concentrates should lead to a significant increase in animal performance. Mc Meniman *et al*. (1988) fed rice straw supplemented with mung bean, cowpea, pigeon pea, peanut or Lucerne. Energy intake was increased through the combined effect of increasing the dry matter digestibility of the supplemented deits and increase in the total daily dry matter intake of the diets. The improved intakes resulted in significant increase and some reduction in the extent of weight loss.

Supplementation of low quality roughage is done by feeding limiting nutrients in the form of concentrates (energy and protein), minerals, non-protein nitrogenous (NPN) substances (urea, biuret, poultry litter) or green forages. Bailey and Sim (1998) reported OMI of sheep supplemnted with cottonseed meal (27.7g/kg BW) was higher ($p<0.01$) than lambs fed only hay (20.g/kgBW), i.e control. Total tract digestibility of OM differed ($p<0.01$) among supplement treatments i.e hay supplemented with gamagrass grain (61.8%) and hay supplemented with cottonseed meal (58.6%) and control (54.9%) treatments. They revealed that differences in digestibility may be the result of addition of protein and carbohydrate supplemnts rather than an increase in digestibility of the hay.

Adams *et al.* (1995) observed that intake of sorghum stover by sheep was improved by urea-ammoniation, but not significantly. Increasing the level of supplementation with CSC improved stover intake by sheep fed the unammoniated stover, but resulted in decreased intake of ammoniated stover by sheep. Liveweight gains were improved by amoniation and supplemnttaion. The interaction between urea-ammoniation of stover and CSC supplementation resulted in better livewieght gains in sheep. However, ammoniation and supplementation did not affect DM, NDF and ADF digestibilities, but resulted in increase in cellulose and hemicellulose digestion. Ammoniation and supplementation resulted in higher N-balance in the sheep. Ammoniation resulted in marked increases in rumen ammonia concentration, but increasing level of supplementation did not apparently affect rumen ammonia concentrations. It was concluded from these results that ammoniation of sorghum stover and CSC supplementation improved the nutritional quality of sorghum stover fed to sheep. The effect of supplementation on intake and digestibility was more marked at lower levels of supplementation than at the higher levels. At higher levels of supplementation, ammoniation had no advantage probably because the ruminal ammonia concentration required for maximum microbial biomass production has been met by the degradation of the supplement. It may be that at this high level of ammonia concentration energy will be a limiting factor. It was also concluded that supplementation with CSC at the 1% of the sheep body weight with ammoniated, but not with unammoniated SS, will maintain sheep liveweight. Higher levels with either straw can result in marginal gains while lower levels will lead to liveweight losses.

Barley and Sim (1998) revealed that nitrogen balance was more favourable for lambs supplemented (+5.7 gN/day) than for unsuppelemnted lambs (+1.7 gN/day). They opined that lamb supplemented with gamagrass grain (+6.3 gN/day) retained more nitrogen than lambs supplemented with cottonseed meal (+5.0 gN/day) even though nitrogen intake was similar. The difference in the nitrogen retention between the supplement treatments was the result of higher urinary nitrogen excreation from the CSM as compared to gamagrass grain treatment, while fecal nitrogen excretion was similar for both supplement treatments.

Increase in food intake and digestibility of the basal diet arising from supplementation with concentrates should lead to a significant increase in animal performance. Mc Meniman *et al*. (1988) fed rice straw supplemented with mung bean, cowpea, pigeon pea, peanut or Lucerne. Energy intake was increased through the combined effect of increasing the dry matter digestibility of the supplemented diets and increase in the total daily dry matter intake of the diets. The improved intakes resulted in significant increase and some reduction in the extent of weight loss.

2.4 Methods of measuring the Nutritive value of feed stuffs

2.4.1 Proximate system

McDonald *et al.* (1998) reported on the analysis of the following nutrients moisture, ash, crude protein, ether extract, crude fibre and nitrogen free extractives.

The system consists of the following steps;

a. Dry Matter (DM) at 100^0C

b. Ether extraction of the dry residue for estimation of lipids.

c. Reflux of the fat-extracted residue for 30 minutes with 1.25% H_2SO_4 followed by 30 minute with 1.25% NaOH. The insoluble residue is dried, weighed and ashed and the insoluble organic matter reported as crude fibre.

d. Determination of nitrogen and ash on separate portions of sample.

e. The calculation of nitrogen free extract (NFE) as the DM not accounted for by the sum of EE, CF, Ash and CP (Nitrogen x 6.25).

The system is the basis on which total digestible nutrient (TDN) is calculated, using the following assumptions.

i. Ether extract recovers lipids and fats which contains2.25 times the energy of carbohydrate.

ii. All nitrogen is in protein which contains 16% nitrogen.

iii. Crude fibre recovers the least digestible fibrous and structural matter of the feed.

iv. The NFE represent highly digestible carbohydrates.

None of these assumptions are true, and the degree of error varies considerably. Ether extract includes waxes and pigments of little value, and does not recover soaps in faeces, which are the main form in which undigesible fatty acids are excreted. Forages contain no triglycerides and leaf galactolipids contain less energy than the factor 2.25 would imply. The error involved with ether extract is a relatively minor one unless lipid is a large component of the DM. Ether extract can be ignored in the analysis of most forage and many other ruminant feeds.

Plant tissue contains a variety of nitrogenous constituents that may be divided into proteins, nucleic acids, water soluble NPN and very insoluble factions associated with the crude lignin. Nitrogen content of plant proteins varies from 15 to 16%. True protein, however accounts for only about 70% of the forage nitrogen and little or none of the faecal nitrogen so that the application of the 6.25 factor to all feed nitrogen constitutes an error that is reflected mainly in the NFE calculation (Van Soest, 1988).

The NFE contains the cumulative errors of all the other determinations. The largest of these errors is due to the solubilization and loss of much lignin and hemicellulose in the preparation of crude fibre. Even cellulose is not wholly recovered, and the behaviour of different plant materials is quite variable.

The disadvantges of this method is that the proximate system of analysis is the division of the carbohydrate into crude fibre and NFE. The unequal recovery of lignin, cellulose and hemicllulose in the crude fibre leads to a variable relationship between crude fibre and plant cell wall.

2.4.2 The detergent system

According to Van Soest (1988) the NDE analytical method, which was originally devised for forages, can also be used for starch-containing foods provided an amylase treatment is also included in the procedure. The acid-detergent fibre (ADF) is the residue after reflexing with 0.5m sulphuric acid and cetyltrimethyl-ammonium bromide, and represents essentially the crude lignin and cellulose fractions of plant materials but also includes silica.

The ADF was used in determining forages which give the true picture of feed digested. In the UK the ADF method has been modified slightly, the duration of boiling and acid strength being increased. The term modified acid-detergent fibre (MADF) is used to describe this determination (Orskov and McDonald, 1979).

2.4.5 In vitro method

Van Soest (1987) reported that digestibility can be estimated by digestion process. The method has advantages in the sense that microorganism and enzymes are sensitive to undetermined factors that influence rate and extent of digestion. The rumen *in vitro* system depends on the degree to which it affects rumen events and the sequential processes of the ruminant's digestive tract. Similarly, the other advnatge of this method over that of any purely chemical analysis rests on the accuracy of its biological response. The medium is usually a buffer solution simulating ruminant saliva. The time of batch fermentation is commonly 48 hours for digestibility estimation, although other time periods have been used to estimated rate of fermentation etc (Van Soest, 1987). Various end point procedures are used. These include measurement of gas production, VFA production, cellulose disappearance, residual dry mater, the residue after pepsin digestion and the neutral-detergent residue. These end points are not of equal value, and their respective utility depends on the purpose to which they are being applied (Van Soest, 1987).

2.4.6 In-situ (In-Sacco) Rumen Digestion

The nylon bag technique is simple and requires only nylon bags, rumen cannulated animal and an oven. The method measures protein degradability in terms of the amount of nitrogen in the bag. It involves the suspension of the bag in the rumen. The bag is withdrawn after a desired period of time and the percentage residual nitrogen is calculated. The percentage of nitrogen which disappeared from the bag (or the rumen degraded nitrogen RDN) is expressed as

100 minus the percentage residual nitrogen. The method was used by Vankeuren and Heinemann (1962). Frigold *et al*. (1975), Crawford *et al*. (1978), Nocek *et al*. (1979), Ganev *et al*. (1979) and Quin *et al*. (1938) used the fibre bag technique to investigate the digestion of feeds in the rumen of cannulated sheep. They used cylindrical bags composed of a very fine natural silk. Subsequent authors have used artificial fibres for the bags (Erwin and Ellison, 1959; Johnson, 1966 and Rodriguez, 1968). The artificial fibre bag (dacron bag, nylon bag, rumen bag) technique provides a powerful tool for the initial evaluation of feedstuffs and for improving our understanding of the processes of degradation. The new schemes of evaluating protein for ruminant nutrition (Burroughs *et al*., 1974; Satter and Roffers, 1974 and Roy *et al*., 1977) recognised two fractions from the degradation of dietary protein in the rumen, namely: rumen degradable protein (RDP) and undegraded dietary protein (UDP). On this basis, the nitrogen needs of the ruminant animals has been partitioned into two distinct and separate requirements; namely; the nitrogen requirement of the rumen microbes and the amino acid requirement of the host animal in small intestine (ARC, 1984). However, the adoption of this scheme requires adequate estimate of the proportion of dietary protein in the rumen.

Digestion of feedstuffs occurring in the rumen, as distinct from that in the entire GIT, has also been utilized to evaluate feedstuffs (Oddoye *et al*., 2005 and Bogoro *et al*., 2006). For individual feedstuffs this is usually accomplished by suspending the feed in a permeable bag of non-digestible material, such as nylon bag, in a rumen of fistulated animal.

A method for describing the time curve of degradability for an individual sample was adopted by Orksov and McDonald (1979). Their method involved carrying out a time series of rumen incubations. Dry matter loses were then plotted against time and non-linear model fitted according to the equation below.

$$P = a + b\ (1\text{-}exp^{-ct})$$

Where:

P = potential degradability
t = incubation time
a = Y axis intercept at time O. Represents soluble and completely degradable substrate that is rapidly washed out of the bag

b = the difference between the intercept (a) and the asymptote. Represents the insoluble but potentially degradable substrate which is degraded by microorganism according to first order kinetics.

c = rate constant of b function

1-(a+b) = the undegradable portion of a sample; a, b, and c are constant fitted by an interactive least square procedure.

From this model, an estimate of the potential degradability of a feed can be made; however, the effect of rumen outflow on loss of small particles from the rumen has not been appraised.

Incorporation of ruminal outflow rate and the curve constant derived from the equation above results in an estimation of effective ruminal degradability and can be calculated according to Orksov and McDonald (1979).

Effective degradability = a+((b x c)/(c + k))

Where:

a, b and c are as defined in the Orskov and McDonals (1979) equation.

k = rumen small particle outflow rate.

The recommended procedure published by the Australia agricultural council subcommittee advise the use of polyester material with a welded (heat monofilamentous) rather than multifilamentous woven mesh with a pore size in the range of 35-50µm (Orksov and McDonald, 1979).

2.4.5 In-vivo techniques

This involves feeding of animals to obtain digestibility. The feed under investigation is given to the animal in known amounts and the output of faeces measured (McDonald *et al.*, 1998). More than one animal is used, firstly because animals, even of the same species, age and sex, differ slightly in their digestibility, and secondly because replication allows more opportunity for detecting errors of measurement. The animals are either confined in a crate or stall to facilitate collection and/or urine or faeces are collected with the aid of bags attached to the animal.

It is normal practice to accustom an animal to the ration (adaptation period) to be studied for a period of time to allow adaptation of the rumen microorganism and to adjust feed intake to a stable level below maximum consumptions. This enables the removal from the digestive tract all residues of previous feeds, and to establish a uniform rate of feed products and excretion of faeces.

The experimental period is usually 5-14 days long with long periods being desirable as they give greater accuracy (McDonald *et al.*, 1998). The trial is completed by analyzing samples of the feed used and the faeces and/or urine collected.

The general formula for calculating the in-vivo digestibility of feed is;

$$\text{Digestibility} = \frac{\text{Feed consumed} - \text{faecal output}}{\text{Feed consumed}}$$

2.4.6 Indicator method

The lack of suitable equipment or the particular nature of the trial in some circumstances may make it impracticable to measure directly either feed intake or faecal output, or both. For instance when animals are fed as a group it is impossible to measure the intake of each individual. Digestibility can still be measured, however, if the feed contains some substances which are known to be completely indigestible. If the concentrations of this indicator substance in the feed and in small samples of the faeces of each animal are then determined, the ratio between these concentrations gives an estimate of digestibility (McDonald *et al.*, 1998).

The indicator may be either natural (or internal) or external. Natural or internal indicators are those found in plant material and include materials such as lignin, silica, plant, chromogens (pigments), and nitrogen. External (added materials) indicators that have been used include such materials as chromic sesquioxide (Cr_2O_3), dyes, polyethylene glycol, and iron. An ideal indicator should be insoluble in the GIT, be indigestible, pass through the tract at the same rate as ingested feed, have no undesirable pharmacological effect on the animal (such as diarrhoea), and be suitable for chemical analysis. The indicator most commonly added to feed is chromium in the form of chromic oxide (Cr_2O_3). Cr_2O_3 is very insoluble and hence indigestible; moreover, chromium is unlikely to be present as a major natural constituent of feed.

Indicator methods have also been used extensively to study changes in digesta that occur in the GIT, and to estimate the extent of digestion that occurs in various segments (partial digestion).

2.4.7 Determination of Rumen Ammonia Concentration

There are two methods of determination of rumen ammonia concentration are calorimetric method and the distillation method. The former was first used by Faucet and Scott (1960) and latter modified by Chaney and Marbach (1962). This method is based on the fact that any ammonia or urea (on hydrolysis) in the rumen fluid is absorbed by the color reagents and these color reagents are phenol sodium nitro oxidise solution and sodium hydroxide/sodium hypochlorite solution. The colour developed is read using a spectrophotometer.

The other method was by Nolan and Leng (1972) and involves the collection of ammonia from ruminal fluid samples into boric acid (2% w/v) containing a mixed indicator by steam distillation over 5mg MgO (which previously had been heated for 3 hours at 60^{o}c to decompose carbohydrate).

2.4.8 Determination of Microbial Protein Production in Ruminants

It was suggested by a lot of researchers that Allanton excretion in urine could be used as an indicator of microbial protein in the rumen. Allantoin is the major form of the purine degradation products excreted in urine by ruminants. The reason of using allantion as an index of microbial synthesis is based on the fact that most absorbed purines are degraded and excreted in urine as derivatives, the excretion of which is positively correlated with the purine uptake. Therefore if the quantitative relationship between the purine uptake and the derivative excretion is known, estimate of the microbial protein available to the animal from the urinary purring derivative could be made possible (ARC, 1984).

2.5.0 Factors regulating feed intake of ruminants.

Intake is critically important for acquisition of nutrients by ruminants. Intake is the ingestion of feedstuff by the animal, and is regulated by the following factors, which are all interrelated (Rinehart, 2008).

- Palatability
- Foraging behaviour
- Chemical characteristics of the feedstuff
- Forage quantity, density and availability
- Dietary energy and fiber content
- Physiological stage of the animal
- And temperature

2.5.1 Palatabilit*y* is the flavour and texture of the feedstuff. Ruminants seek sweetness in their feed, probably because sweet is an indicator of soluble carbohydrates, the most critical dietary element for the animal after water. Ruminants will in turn avoid feedstuffs that are bitter, as these often are associated with toxic secondary chemicals.

2.5.2 Foraging behaviour describes how an animal goes about the grazing process and animal grazing behaviour involves understanding:

- Food habits and habitat preferences, and
- The effects of nutrients and toxins on preference

2.5.3 Forage quantity, *density and availability* directly influence forage intake and intake is directly related to the density of the pasture sward. Ruminants can take only a limited number of bites per minutes while grazing, and cattle in particular will only graze for about 8 hours per day. It is important then to ensure that each bite taken by the grazing animals is the largest bite she can get. A cow grazes by wrapping her tongue around and ripping up forage; sheep and goats use their lips and teeth to select highly nutritious plant parts. Large bites of forage are therefore ensured by maintaining dense pastures.

2.5.4 **Dietary energy and fiber content.** As has been mentioned, livestock eat to the point of satiety. Another good definition of satiety is gastrointestinal satisfaction. Ruminants possess nutritional wisdom and will select diets high in digestible organic matter, because the most critical nutrients selected by ruminants are soluble carbohydrates. What an animal actually eats from a pasture is often of higher nutritional quality than the average of the pasture overall. Forages with a dry matter digestibility (DMD) of 60 to 69 percent are considered high quality forages from an energy perspective. Dietary fiber is also a forage quality indicator.

Fiber is necessary for proper rumen function, and is a source of energy as well. However, high levels of fiber in the diet decrease intake. Less digestible forages tend to stay in the animal's digestible system longer (slowing the rate of passage) so the animal remains "full" longer and subsequently doesn't eat as much. However, the younger a plant is the more soluble carbohydrates it contains, and the less fiber (cell wall components) it contains as well. Younger plants therefore are generally more digestible than mature plants.

2.5.5 **Physiological stage** refers to the stage of life the animal is in, and what level and type of production are being supported. The key physiological stages in the life of ruminant animals are:

- Growth (i.e young lambs, kids, and calves, including feeder animals)
- Late pregnancy (very important in sheep and goats)
- Lactation (for dairy production or maintenance of offspring)
- and maintenance (such as the cow's dry period)

2.5.6 Temperature affects the amount of feed and animal needs to maintain its body functions. An animal's metabolic rate increases as the temperature drops below the animal's comfort zone. As temperature drops, more energy is needed to maintain internal heat, so intake increases accordingly. Subsequently, animals typically will not graze as much during hot and humid weather (Rinehart, 2008).

The productivity of ruminants is determined by many factors, but two of the most important are what and how much they eat (Preston and Leng, 1987), this implies that ruminants consume a wide variety of feeds, some of which initially may be quite unpalatable; they are highly selective and appear to enjoy some feeds more than others. According to Preston and Leng (1987), animals usually eat green pastures or cereal grains with apparent relish, consuming other feeds only relatively slowly and without apparent interest. They further reported that ruminant recognise both unpleasant and pleasant sensations associated with feed either prior to or during eating.

2.6 Water Requirement of Ruminants

Water makes up the fifth essential nutrients. Adequate clean water should always be available. Ruminants require large amounts of water daily to keep the contents of their rumens in a liquid phase. Otherwise, the bacteria cannot optimally mix with the feed. As a mater of fact, when water is restricted, ruminants will restrict the amount of dry mater they take in. thus feed efficiency and gain will be markedly affected. Lack of water also encourages the formation of bladder stones in the male.

Sheep and goats required one gallon of water per day for dry ewes, 1.5 gallons per day for lactating ewes, and 0.5 gallons per day for finishing lambs.

Water consumption will increase during the heat period and when the animals are grazing or browsing plants with high concentrations of secondary, toxic chemicals.

Cattle require from 3 to 30 gallons of water per day. Factors that affect water intake include age, physiological status, and temperature and body size. Water should be clean and fresh, as dirty water decreases water intake. It is good to remember that all other nutrient metabolism in the body are dependent on the availability of water, and if an animal stops drinking, nutrient metabolism (which results in growth and lactation) will decrease (Rinehart, 2008).

Water as an essential nutrient is second only to oxygen in importance to sustain life and optimize growth, lactation and reproduction of diary cattle (Beede, 2005). Factors typically considered in water quality evaluation include odour and taste (organoleptic properties), physical and chemical properties, presence of toxic compounds, concentrations of macro and micro mineral elements and microbial contamination. Excess concentrations of some of these factors may have direct effects on the acceptability (palatability) of drinking water; whereas others may affect the animal's digestive and physiological functions, once consumed and absorbed (Beede, 2005)

Water intake differed significantly between sheep and goats as well as among the various breeds. The total body water contents of individual sheep ranged between 52.37 and 71.51 percent live weight, while values for goats were between 48.16 and 74.69 percent live weight (Aganga, 2008). That is, water turnover rates per day per animal were 2.52, 2.63, 0.86 and 1.09 (litres) for Uda sheep, Yankasa sheep, Sahel goats and Maradi goats, respectively. Aganga (2008) further reported that water requirements varied with types of feed, indicating that an amount of water was adequate at one time for a particular diet could be insufficient for another; also water intake of Nigerian sheep and goats is influenced by diet types, combinations and processing methods.

The effects of age on the requirements of sheep and goats showed significant differences ($p<0.01$) with regard to water intake. Generally, sheep drink more water per metabolic size than goats, while the older animals drank more than the young ones. The older animals were bigger in body size and, consequently, they required more water for proper digestion and utilization of the feed they consumed. With regard to gender, female goats drank more free water than male goats; however, the differences were not statistically significant (Aganga, 2008).

Observation of water intake of ewes under various physiological states shows that lactating ewes drank more water than pregnant and non-pregnant ewes. Water intake of the pregnant ewes was slightly higher than that of the pregnant non-pregnant ewes, but it was significantly lower than that of the lactating ewes (Aganga, 2008).

Water requirement for any class of ruminants is not easily estimated because numerous dietary and environment factors affect water absorption and excretion. Khalifa *et al*. (1975) reported on food intake and water metabolism of Kenana heifers at different seasons of the year and observed that water intake decreased gradually in dry summer, wet summer and winter; the differences between summer and winter values being significant. Adegbola and Obioha (1984) revealed that West African dwarf sheep require less water than other breeds of sheep of both temperate and tropical origin and much less than that of cattle. They further observed that factors such as size, surface area of the animals, and intensity of solar radiation, humidity ambient temperature and type of feed affect the free and total water intake by animals.

Provision of clean water (*Adlib*) is important for maximum performance of farm animals. According to Halengi *et al.* (1996) water intake is positively correlated with dry matter intake and also increases with roughages level. Adegbola and Obioha (1984) revealed that young West African sheep consumed 1.5 – 2.l/day.

Small ruminants should have *ad libitum* access to clean, fresh water at all times (Susan, 2002). Accordingly, a mature animal will consume ¾ to ½ gallons of water per day. Water requirements increases substantially when environmental temperature rise above 35^{o}C and declines with very cold environmental temperatures. The author further reported that animals' nutrients requirements will increase if it has to consume cold water during cold weather. Rain and dew may dramatically decrease free water intake. Inadequate water intake can cause health problems. In addition, water and feed intake are positively correlated (Susan, 2002).

Sheep obtain water by drinking metabolic water from oxidation of nutrients in feed (NAP, 2002). NAP, (2002) revealed that the exact amount of water required by sheep is not known and varies considerably depending on body metabolism, ambient temperature, stage of production, size, wool covering, and amount of feed consumed and feed composition.

NAP, (2002) revealed that adequate intake of good – quality water is essential for sheep to excrete excess toxic substances such as oxalate ammonia and mineral salts (Phosphates that cause urinary calculi).

The effect of water temperature on rumen temperature, digestion and rumen fermentation in sheep was studied by National Academy Press (2002). They reported that rumen temperature was affected by temperature of water consumed with 0^0C water depressing rumen temperature. Water temperature had no significant effect on nitrogen balance or on DM, protein or crude fiber digestibility, although digestion coefficient tended to be lowers at 0^0c water. Water temperature had no significant effect on rumen pH, but water at all temperature depresses fatty acids (VFA) and ammonia-nitrogen concentrations increase 1 to 4 hours post feeding.

It was further revealed that 0^0c water suppresses rumen microbial activity as evidenced by elevated pH at 4 hours post feeding for 0^0c water compared with pH values for 10^0, 20^0, and 30^0c water and by depressed concentrations of VFA and ammonia-nitrogen and lower digestibility values compared with the other water-temperature treatments.

CHAPTER THREE

4.0 MATERIALS AND METHODS

3.1 Location of the Study Area

The study was conducted at Federal University of Technology, Yola in Adamawa State, located at the North Eastern part of Nigeria. It lies between latitude 7^0 11^1 North of the equator and longitude 11^0 14^1 East. Adamawa State is within the Sudan and Guinea Savannah Zones of West Africa and is characterized by relatively short period of rainy season. Rainy season commences in April and ends in late October while dry season commences in late October and ends in April. The mean annual rainfall ranged between 700mm to 1,600mm, mean minimum temperature of 15.2^0C and maximum temperature of 39^0C (Adebayo, 1999).

3.4 Vegetation and Landforms of Adamawa State

The major vegetation formations in the state are the Southern Guinea Savannah, the Northern Guinea and the Sudan Savannah (Akosim *et al.*, 1999). Within each formation is an interspersion of forest trees e.g *Daniela oliveri, Vitex doniana, Terminalia laxifilora, Ziziphus spina-christ,* which are found in the state. Some grass species of *Andropogon, Panicum, Bracharia, Aristida longiflora,* are found in the state (Akosim *et al*., 1999). The trees do shed their leaves during the dry season and the grasses are annual by nature, they are either overgrazed by activities of transhumance or destroyed by fire.

Landform types in Adamawa state is generally grouped into valleys and trough, upland plains, lowlands, hills, and mountain ranges. The major valley, the Benue, running east to west bisects the state almost into two equal havles having landform of stricking similarity in outlook and percentage coverage (Tukur, 1999).

The state covers a land area of about 38,741km^2 with a population of 2,102,053 people (NPC, 2006).

3.5 Experiment I

3.3.1 Survey of available and preferred feed resources for feeding small ruminants in Adamawa State.

3.3.2 Introduction

It is of immense importance for farmers to know the types, quantity and quality of feed resources used for feeding small ruminants in the state. Different types of feeds resource for feeding small ruminants in Adamawa state were sampled. The essence of obtaining these feeds was to come up with a package of different feed resources for feeding particularly small ruminants in the state. The feed resources were evaluated based on their availability, quality which may give the picture of their potentials for small ruminant feeding. The feed resources were ranked according to availability, nutritive value and selectivity by ruminants.

3.3.5 Objectives

1. To identify the commonly available feeds resources used for small ruminants feeding in Adamawa State.
2. To rank the feeds based on their availability, chemical composition and degradability value.

Study procedure:

Field survey was conducted and some commonly available feed samples in Adamawa State were identified. To achieve the objective (1) above the state was divided into four (4) zones according to Adamawa Agricultural Development Programme (1996). The zones are zone 1 Mubi, zone 2 Yola, zone 3 Mayo and zone 4 Guyuk.

3.3.6 Identification of Feeds

In each location a pilot survey was conducted to identify the feeds by both questionnaires and oral interviews. A simple random sampling technique was used in each location within each zone. In each location 50 quetsionnaires were distributed to 50 small ruminants' household farmers to obtain information on the available feed resources in their various localities. Responses from the questionnaires and oral interviews on browse plants, grasses, agricultural by-products and crop residues were considered. Based on percentage availability in each location samples/species and their percentage availabilities were calculated. From each of these categorised feeds, samples were collected in four replications and labeled using both local and scientific names.

3.3.5. Proximate Analysis

The identified and selected feed samples were oven-dried at 70^{o}c to constant weight. The samples were ground using a hammer mill preserved in sealed bottles. Their proximate analysis (crude protein (CP), crude fibre (CF), Ether extract (EE) and Ash) was carried out according to A.O.A.C. (2004).

3.3.6. Rumen Degradability test

3.3.6.1. Preparation of feed samples for rumen degradability test

Based on the result of proximate analysis feed with high CP and low CF were selected and used for degradability studies at Abubakar Tafawa Balewa University, Bauchi (ATBU).

3.3.6.2. The Nylon Bag

Three (3) grams of feeds were weighed in duplicate in to nylon bags as described by Orskov *et al.,* (1980). The nylon bags were obtained from the Rowett Research Institute Aberdeen, United kingdom. The bags have a mesh size of about

45μ and of 140 x 90mm size. To ease identification the nylon bags were numbered with an indelible marker. Bags were individually weighed. Bags were attached on the plastic tube of clear polyvinyl chloride (PVC) tubing; eight slits evenly spaced were marked on each plastic tube with one end having a string attached to a tile-like material for marking incubation time.

3.3.6.3. Management of the Cannulated Animal

A Bunaji (white Fulani) bull weighing 350 kg and aged 4 years was used for rumen degradability studies. The bull was fitted with rumen cannuala having a diameter of 90 mm. The study was conducted at the Animal production Farm, Abubakar Tafawa Balewa University of Technology (ATBU) Bauchi. The bull was housed under a roofed shade and had access to water and mineral lick. The bull was fed with feeds which comprised of 5 kg of grasses + cowpea hay and 500 g of maize bran daily in two allocations; at 8:00am and 3:00 pm.

3.3.6.4. Incubation time

Feed samples were incubated for 3, 6, 12, 24, 36 and 48 hours for supplements and 6, 12, 24, 48, 72 and 96 hours for fibrous feeds.

3.3.6.5. Withdrawal of Bags from the Rumen.

Nylon bags removed from the rumen were immediately taken to the laboratory and washed under running tap water till water running through the bags become very clear. Bags were hanged for 10 minutes for the remaining water to drip out of the bags. The bags were then dried in an oven at 70^0c for 48 hours to determine DM loss.

3.4. Experiment II

3.4.1. Dry Matter Intake and growth rate of Yankasa rams fed cowpea husk or grass hay supplemented with maize bran, cotton seed cake or brewers waste.

3.4.2. Introduction: There is need to improve the feeding and management systems of sheep by looking at ways of enhancing their intake. Based on the result of chemical analysis and degradability values in experiment 1, the following feeds, groundnut hay, cowpea hay, grass, cowpea husk were selected as roughages (basal diets) while maize bran, cotton seed cake and brewers wastes were selected as supplements.

3.4.3. Objectives

i. To evaluate the dry matter intake, digestion and growth rate of sheep fed different basal and supplement feeds combinations.

ii. To identify the best basal and supplement feed combinations for sheep production in Adamawa State.

3.4.4. Animals and their Management

Twenty four (24) Yankasa rams weighing between 15 and 20kg and aged, between 6 – 12 months were used. They were purchased from Girei, Ngurore and Yola Local markets of Adamawa State. Animals were fitted with neck bands for identification. The animals were quarantined for a period of two weeks during which they were dewormed with Banminth F.

3.4.5. Treatments and Experimental Design:

Animals were randomly allotted to 8 treatments diet with 3 animals per treatment in a randomized block design (RBD). The treatments diets were Treatment 1 cowpea husk only, Treatment 2 cowpea husk + cotton seed cake Treatment 3 cowpea husk + brewers waste Treatment 4 cowpea husk + maize bran Treatment 5 grass only Treatment 6 grass + cotton seed cake Treatment 7 grass + brewers waste Treatment 8 grass + maize bran.

3.4.6 Feeding and Housing

The animals were kept in pens with sufficient ventilation. Each animal was offered 300g of supplement daily in 2 allocations in the morning at 8:00am and at 3:00pm in the afternoon. The supplement was fed 30mins before the basal feed was given. The basal feed was fed *ad libitum*. The leftovers were collected the following morning and weighed before fresh feed was offered. This was to determine feed intake. Animals were provided with fresh drinking water in graduated plastic containers. Amount of water consumed by each animal daily was recorded. Salt lick was provided *ad libitum*. The experiment lasted for two (2) months after one week of adaptation period.

3.4.7. Live Weight Measurement

The animals were weighed at the beginning of the experiment and subsequently at weekly intervals. The difference between the previous week and the current week gave the changes in live weight.

3.4.8. Digestibility Study

The Digestibility study commenced after the end of the feeding trial. Eight (8) Rams were selected and confined in metabolism crates and fitted with collection bags to facilitate feacal collection, while the urine was collected separately. An improvised metabolism cage was consrtructed using zinc sheets at the bottom of measured timber wood. It was designed in such a way that the urine will flow in the slanted zinc which directed it into plastic containers. This was followed by 7 days adjustment and 5 days collection periods. Feed offered and leftovers were weighed daily. Total feacal output was collected daily, weighed and sub-sample taken for chemical analysis.

3.4.9. Chemical analysis

Feed sample collected were oven-dried at 70ºc to constant weight. The samples were ground using a hammer mill and which passed through a 1mm sieve. The samples were preserved in sealed bottles and kept in dessicator. Their chemical composition, crude protein (CP), crude fibre (CF), Ether extract (EE) and Ash was carried out according to A.O.A.C. (2004).

3.4.10 Statistical analysis

The data collected was analysed using anal;ysis of variance of a randomized block design and means separated using Duncan's Multiple Range Test (Duncan, 1955).

3.5. EXPERIMENT III:

3.5.1. The Effect of feeding various supplements on DMI and Growth rate of Yankasa Rams offered a basal diet of cowpea hay or groundnut haulms.

3.5.2 Introduction.

During the dry season grazing land is scarce and pastures are deficient in energy protein and minerals. This was worsened by inadequate alternative feed during this critical period (Okello *et al*., 2005). In Nigeria savannas, the basal diet of most ruminants in the dry season is based on crop residues, and dry season standing grasses. Most of the diets are imbalanced in nutritional value and variable according to season (Zemmelink, 1999).

In order to develop a sustainable ruminant's production system, efforts should be directed to making the best use of local feed resources by adjusting the production system according to local conditions. The use of appropriate supplements and basal diets is a fundamental component of the feeding strategy in order to balance nutrients at the level of rumen and the animal (Lakpini, 2002).

Crop residues such as cowpea and groundnut hays were used as basal diet. Little information is available on appropriate feed combination of a variety of basal diets and supplements to ruminants in the state.

3.5.3. Objectives

i. To determine the dry matter intake, digestion and growth rate of sheep fed different basal and supplement feeds combination.

ii. To recommend the best basal and supplement feed combination for sheep production in Adamawa State.

3.5.4. Animals and their Management

Twenty four (24) Yankasa rams weighing between 15 and 20 kg and aged, between 6 – 12 months were used. They were purchased from Girei, Ngurore and Yola Local markets of Adamawa State. Animals were fitted with neck bands for identification. Each animal was tethered to a peg with a short rope to its front leg which allowed easy rotation of animals. Separate feeding and watering troughs and blocks of minerals licks were provided to each animal.

The animals were quarantined for a period of two weeks during which they were dewormed with Banminth F against endoparasites.

3.5.5 Treatment and Experimental Design:

Animals of similar average weights were randomly allocated to 8 treatment combinations of 3animals/treatment arranged in a complete randomized block design (CRBD). Treament 1 groundnut hay only, Treatment 2 groudnnut hay + cotton seed cake, Treatment 3 groundnut hay + brewers wastes Treatment 4 groundnut hay + maize bran. Treatment 5 cowpea hay only, Treatment 6 cowpea hay plus cotton seed cake, Treatment 7 cowpea hay plus brewers wastes, Treatment 8 cowpea hay plus maize bran.

3.5.6 Feeding

Each animal was offered 300 g of supplement daily in 2 allocations in the morning at 8.00am and at 3.00pm in the afternoon. The supplement was fed 30 minutes before the basal feed was given. The basal feed was fed *ad libitum*; it comprised of cowpea hay and groundnut hulm. Feed refusals were collected the following morning and weighed before fresh feed was offered. Animals were provided with fresh drinking water in graduated plastic containers. Amount of water consumed by each animal daily was recorded. Salt lick was provided *ad libitum*. The experiment lasted for eight weeks.

3.5.7. Live Weight Measurement

The animals were weighed at the beginning of the experiment and subsequently at weekly intervals. The difference between the previous weeks and the current week gave the changes in live weight gain.

3.5.8. Digestibility Study

The Digestibility study commenced after the end of the feeding trial. Eight (8) Rams were selected and confined in metabolism crates and fitted with collection bags to facilitate feacal collection, while the urine collection was done using zinc sheets constructed under the metabolism crates which directed the urine into plastic containers. This was followed by 7 days adjustment and 5 days collection periods. Feed offered and refusals were weighed daily. Total feacal output was collected daily, weighed and sub-sample taken for chemical analysis.

3.5.9. Chemical analysis

Feed samples collected were oven dried at 70^0C to contant weight. The chemical composition for crude protein (CP), crude fibre (CF), Ether extract (EE) and Ash were carried out according to AOAC (2004).

3.5.10. Statistical analysis

Complete randomized block design (CRBD) was employed for data analysis and means separated using Duncan's Multiple Range Test (Duncan, 1955).

3.6. Experiment IV

3.6.1. Effects of feeding different basal feeds and supplements combination on microbial protein synthesis in the rumen of Yankasa Rams.

3.6.2. Introduction

Microbial protein synthesized in the rumen is the major source of protein for ruminant animals particularly in feeding conditions where high quality feeds are in short supply. The ability to manipulate the microbial protein production to achieve a maximum yield will have important implication in feeding of ruminants.

The level of rumen ammonia (NH_3) is critical for efficient microbial fermentation of feed. Rumen NH_3 concentration can therefore be used to diagnose the deficiency of fermentable (N) nitrogen in diets (Preston, 1986). The critical NH_3 level in the rumen for efficient microbial growth on different substrates is likely to vary according to the fermentability of the substrates. The level of total volatile fatty acids (VFA) is also indicative of total fermentation rate.

3.6.3 Objectives

The objectives of the experiment are:

i. to determine the DM intake and digestibility of different local feed resources fed to rams.

ii. to estimate rumen microbial protein supply to the animals fed different combination of basal and supplements diets

iii. to determine the effect of various feeds combination on rumen pH, NH_3 and VFA concentrations in rams fed different combinations of basal and supplements diets.

3.6.4 Digestibility Studies

For the digestibility studies rams were divided in to two (2) groups.

a. Cowpea husk or grass with differet suppelemnts were fed and

b. Cowpea hay or groundnut haulms with different suppelemnts were offered.

a. 8 rams, 1ram/treatments	b. 8rams, 1 ram/treatments
Treatment 1 cowpea husk only	T1 groudnut haulms only
Treatment 2 cowpea husk + CSC	T2 groudnut haulms + CSC
Treatment 3 cowpea husk + BW	T3 groudnut haulms + BW
Treatment 4 cowpea husk + MB	T4 groudnut haulms + MB
Treatment 5 grass only	T5 cowpea hay
Treatment 6 grass + CSC	T6 cowpea hay + CSC
Treatment 7 grass + BW	T7 cowpea hay + BW
Treatment 8 grass + MB	T8 cowpea hay + MB

Rams were given an adjustment period of 7 days to get used to the new environment before a 7- day collection period. The total daily faeces and urine voided for each animal was weighed and 25% of the sample taken for analysis. The faeces were oven dried at 105°c for 24 hours. The daily samples of test diets were bulked separately, they were ground using a hammer mill to pass through 1mm sieve and stored in air tight bottles until required for analysis.

3.6.5. Determination of rumen microbial protein supply

Rumen microbial protein supply was estimated by calculation as outlined by ARC (1984).

The calculation is as follows:

$$\text{Microbial N(gN/d)} = \frac{\text{X(nmol/d) x 70}}{0.116 \text{ x } 0.83 \text{ x } 1000} = 0.727X$$

MN = Microbial Nitrogen (Nitrogen released from the diet)

Where MN = 32g/kg DOMR (ARC, 1984)

DOMR = Feed intake x DM x DMD x OM x 0.65 (ARC 1984).

DOMR = Digestible organic matter in the rumen (organic matter obtained after digestion in the rumen)

Calculation of DOMR

DM = Dry matter (feed obtained after water is remove)

DMD = dry matter digestibility (feed after digestion expressed as percentage)

OM = organic matter (feed after removal of water and ash)

0.65 = DOMR (ARC, 1984).

The method of ARC (1984) for the calculation of microbial protein synthesis in the rumen was used in this study.

3.6.7 Proximate Analysis

Feed samples collected were oven dried at 70^0C to contant weight. The chemical composition for crude protein (CP), crude fibre (CF), Ether extract (EE) and Ash were carried out according to AOAC (2004). Also urine was analysed for Nitrogen as described by A.O.A.C. (2004).

3.6.8. Sampling of Rumen Liquor

3.6.8.1. Procedure

Sixteen (16) Rams were used. Eight (8) were fed cowpea husk or grass as basal diet with supplements (CSC, MB and BW) while the others were offered cowpea hay or groundnut hay as basal diet and supplements (CSC, MB and BW). Feeding trial lasted for 7 days, i.e adjustment period and one day collection period. Rumen liquor was collected from each ram using a trocar and canula. Thirty (30) ml of liquor was collected in bottles just before feeding, then 1 hour and 2 hours after feeding. The rumen liquor was obtained by straining the digest using cleaned white clothes. Immediately after collection, pH was determined using an AGB-75 laboratory pH meter. Particulate matter was removed by straining the rumen fluid through layers of surgical gauze before being acidified (pH 3.0 and 3.5), and taken to the laboratory for total volatile fatty acids (VFA) and ammonia (NH_3)-nitrogen (N) analysis. The rumen ammonia was determined by the method of Nolan and Leng (1972). Ammonia from ruminal fluid samples was collected into boric acid (2%w/v) containing a mixed indicator by steam distillation over 8ml Na0H (40%). The boric acid-ammonia solution was titrated with Hcl (0.046N) to obtain ammonia– nitrogen concentration in mg/100ml.

3.6.8.2 Statistical Analysis

One way analysis of variance was employed for data analysis and means separated using Duncan's Multiple Range Test (Duncan, 1955).

CHAPTER FOUR

4.0 RESULTS AND DISCUSSIONS

4.1 Experiment 1:

<u>Survey of available and preferred feed resources for feeding small ruminants in Adamawa State</u>

<u>Feed resources in zone I</u>

<u>Grasses</u>

Table 4.1 summarized the results of survey of feed resources and their percentage availability for feeding small ruminants in zone I. The results show Pangola grass, Northern and Southern Gamba grass Finger grass, Guinea grass and Elephant grass having the highest percentage occurrence above 70% while Giant star grass, Bermuda grass and love grass having the least availability respectively.

These grasses are the most abundant basal feeds for feeding small ruminants and livestock generally in this zone. Lakpini (2002) had reported that most of the grasses used in feeding small ruminants are either annuals or perennials. The onlisted grasses in this work are embedded in his report.

Table 4.1: Commonly available feed resources (Grasses) for feeding small ruminants in Zone 1, Adamawa state.

A	Botanical names	Common names	% frequency availability
1	*Digitaria decumbens*	Pangola	80%
2	*Andropogan gayanus*	Northern Gamba	76%
3	*Andropogan teetorum*	Southern Gamba	75%
4	*Digiteria smutsii*	Finger grass	75%
5	*Paricum maximum*	Guinea	75%
6	*Pennisetum purpureum*	Elephant	72%
7	*Pennisetum clarn destinua*	Kikuyu	65%
8	*Hypacechia rufa*	Jaragwa	65%
9	*Setanai pumilla*	Cartail	60%
10	*Melinis minufliflora*	Hyarrhenia	60%
11	*Chloris gayuna*	Cenchrus biflorus	55%
12	*Cenchtrus biflorus*	Hedge long	55%
13	*Dactyloctenium aegyptica*	Crowfoot	50%
14	*Gragrostis grass*	Eragrostis spp	48%
15	*Cynodon dactylon*	Bermuda grass	40%
16	*Cynodon pectostachyus*	Giant star	40%
17	*Axonopus compressus*	Carpet grass	40%
18	*Brachiaria brizantha*	Signal	40%
19	*Eragrostis ferruginea*	Love grass	35%

Feed resources in zone II

Grasses

Table 4.2 shows the percentages availability of pasture grasses in zone II as Pangola, guinea and carpet grass were the most frequently available while hyparrhenia, love and jaragwa appeared less frequently in the zone. These natural pastures are available along roadsides and fallow lands. These findings agree with Rinhart (2008), who reported that by the time rainy season sets in, rangeland grasses for feeding small ruminants are in abundance but as the rainy season begins to decline the qualities of grasses tend to gradually reduce.

Table 4.2: Commonly available feed resources (grasses) for feeding small ruminants in Zone II, Adamawa state.

	Botanical names	Common names	% frequency availability
1	Digitaria decumbens	Pangola	82%
2	Paricum maximum	Guinea	80%
3	Andropogon tectorum	Southern Gamb	75%
4	Pennisetum purpuerum	Elephant	74%
5	Digitaria smutsii	Finger	70%
6	Axonopus compressus	Carpet	70%
7	Imperatra cylindrical	Spear	68%
8	Cynodon plectostachyus	Giant star	65%
9	Andropogan gayanus	Gamba	60%
10	Pennisetum clandestinua	Kikuyu	60%
11	Ceuchrus biflora	Hedge long	50%
12	Chloris gayana	Phodes	50%
13	Setaria pumilla	Cartail	45%
14	Melinis minufliflora	Hyparrhenia	42%
15	Brachiaria brizautha	Signal	35%
16	Andropogon tectorum	Cenchrus biflora	35%
17	Eragrostis ferruginea	Love grass	30%
18	Dactyloctenium aegyptica	Crow foot	30%
19	Hypaechienia rufa	Jaragwa	30%

Feed resources in zone III

Grasses

Some commonly available grasses for feeding small ruminants in zone III is shown in Table 4.3. The table shows Pangola, Gamba, Guinea, Carpet and Giant star grass having higher percentage frequency occurrence in the zone. The less widely distributed amongst the grasses are Rhode, Bermuda, Hedge long and Molasses grass. The pattern of distribution of feed resources within zones could be due to mean variation in the annual rainfall received which supports the production of common grasses and browses (Akosim *et al.,* 1999).

Table 4.3: Commonly available feed resources (grasses) for feeding small ruminants in Zone III, Adamawa state.

	Botanical names	Common names	% frequency availability
1	*Digitaria decumbens*	Pangola	90%
2	*Andropogon gayanus*	Gamba	85%
3	*Panicum maximum*	Guinea	80%
4	*Cynodon plectostachyus*	Giant star	75%
5	*Axonopus compressus*	Carpet	70%
6	*Hypaechenia rufa*	Jaragwa	70%
7	*Setaria pumilla*	Cartail	70%
8	*Pennisetum clandsetinum*	Kikuyu	65%
9	*Brachiaria*	Signal grass	65%
10	*Digitaria smutsii*	Finger	65%
11	*Imperata cylindrical*	Signal	60%
12	*Dactyloctenium aegyptium*	Crowfoot	55%
13	*Cenchrus biflorus*	Buffalo grass	50%
14	*Pennisetum purpureum*	Elephant	45%
15	*Chloris gayana*	Phodes grass	45%
16	*Cenchrus biflorus*	Hedge long	40%
17	*Eragrostis spp*	Gragrostis grass	40%
18	*Cynodon dactylon*	Bermuda grass	40%
19	*Melinis minufliflora*	Molasses grass	35%

Feed resources in zone IV

Grasses

Table 4.4 shows the percentage distribution of some common grasses in zone IV. Kikuyu, Jaragwa, Carpet, Signal, Gamba, and Guinea grasses had higher occurrences in the zone. While Giant star, Rhode and love grass were the least in occurence in the zone. The widely distribution of feed resources in this zone might have been due to the differences of rainfall received which tallies with Akosim *et al* (1999).

Table 4.4: Commonly available feed resources (grasses) for feeding small ruminants in Zone IV, Adamawa state.

	Botanical names	Common names	% frequency availability
1	*Pennisetum clandestinum*	Kikuyu	80%
2	*Hyparrechenis rufa*	Jaragwa	78%
3	*Axonopus compresus*	Carpet	75%
4	*Panicum maximum*	Guinea	70%
5	*Andropogon gayanus*	Gamba	70%
6	*Brachiaria brizantha*	Signal	70%
7	*Pennisetum purpureum*	Elephant	70%
8	*Digitaria decumbens*	Pangola	70%
9	*Melinis minufliflora*	Hyparrheania	70%
10	*Setaria pumilla*	Cartail	65%
11	*Digitaria smutsii*	Finger	65%
12	*Cynodon dactylon*	Brachiaria	65%
13	*Dactyloctenium aegyptica*	Crowfoot	60%
14	*Gragristis spp*	Aristida longiflora	60%
15	*Imperata cylindrice*	Spear	55%
16	*Cenchrus biflorus*	Hedge long	50%
17	*Chloris gayana*	Rhode grass	50%
18	*Cynodon plectostachyus*	Giant star	45%
19	*Andropogon etctorum*	Love grass	35%

Across all the zones the following grasses are found to have higher frequency occurences: Pangola, Guinea, Gamba, and Elephant grasses.

Feed resources in zone I

Browse Plant:

The percentage frequency distribution of some common browse plants in zone I show ficus, leucaena, Christ thorn as the most abundant browse plants. (Table 4.5) Browse plants that are less distributed in the zone are fig tree and shea butter. These browses are important and are available to herdsmen for feeding ruminants. This findings agrees with Yahaya *et al.* (2000) that traditional herdsmen and other pastoral groups habitually cut down branches from various tree species (*Acacia*, *Adansonia*, *Ficus*) making them available to livestock during the dry season.

Table 4.5: Commonly available feed resource (browse plants) for feeding small ruminants in Zone I, Adamawa State.

	Botanical names	Common names	% frequency availability
1	*Ficus sycomorus*	Ficus	87%
2	*Leucaena leucocephala*	Leucaena	83%
3	*Khaya senegalensis*	mahogany	80%
4	*Ziziphus spina-christi*	Christ thorn	78%
5	*Anogeisus leicarpus*	Chewing stick tree	76%
6	*Acacia nitolica*	Egyptian thorn	75%
7	*Pterocarpus erinaceus*	African teak	75%
8	*Securidara longepe dun culata*	Violet tree	74%
9	*Annona senegalensis*	Wild custard apple	70%
10	*Afzelia africana*	Apa tree	70%
11	*Ziziphus mauritania*	Jujube tree	68%
12	*Acacia sieberiana*	White thorn	65%
13	*Prosopis Africana*	Iron wood	60%
14	*Balanite aegyptica*	Thorn tree	58%
15	*Ficus polita*	Fig tree	55%
16	*Parkia clappertoniana*	African locust bean tree	53%
17	*Ficus platyphylla*	Fig tree	50%
18	*Ximeria americana*	Wild	45%
19	*Vitellaria Parkia*	Shea butter tree	43%
20	*Afromosia laxiflora*	False dalbergia	40%

Feed resources in zone II

Browse plants

Table 4.6 shows the distribution of some commonly available browse plants in zone II. The percentage frequency distribution revealed that Christ thorn, ficus, mahogany and lecucaena ranked the highest in the zone. Whereas Egyptian thorn and chewing stick have lower perecentage occurrence in the zone. Many tree and shrubs species have been documented as useful animal fodders. Farmers in this zone feed their animals either the pods, leaves or twig. Acacia tree pods are amongs some pods fed to ruminants as a source of protein during the dry season in this zone. This finding is in line with the report documented by Mohammed and Kibon (1994) that *Acacia albida* pods could consistute 30% of complete ration supplement for sheep and goats. Maina-Baba (1989) revealed that as much as 45% *Acacia sieberiana* could be substituted for maize bran in the diet of growing sheep in the Sudano-sahelian zone of Nigeria, hence justified its utilization as basal diets and supplement in this study.

Table 4.6: Commonly available feed resource (browse plants) for feeding small ruminants in Zone II, Adamawa State.

	Botanical names	Common names	% frequency availability
1	*Ficus sycomorus*	Ficus	76%
2	*Zizphus spina Christ*	Christ thorn	76%
3	*Leucaena leucocephala*	Leucaena	75%
4	*Khaya senegalensis*	Fig tree	70%
5	*Faidherbia albida*	Acacia albida	70%
6	*Balanite aegyptica*	Desert date	70%
7	*White thorn tree*	Acacia spp	70%
8	*Annona senegalensis*	Wild custard apple	70%
9	*Terminalia avicenioides*	Terminalia	67%
10	*Alanite aegyptica*	Desert date	65%
11	*Zizphus mauritania*	Jujube tree	65%
12	*Pteleopsis suberosa*	Water tree	65%
13	*Prerocarpus erina cues*	African teak	65%
14	*Moringa oleifera*	Moringa	60%
15	*Gerdinia aqualla*	Iron wood	60%
16	*Sterospermum kunthiane*	Calabash tree	60%
17	*Acacia nitolica*	Egyptian thorn	55%
18	*Anogeusus leicarpus*	Chewing stick	50%

Feed resources in zone III

Browse plants

Table 4.7 shows the results of survey of browse plants that are used in feeding small ruminants in Adamawa State. Ficus, Fig tree and dry zone Mahogany have the highest percentage availability (80%), (77%) and (75%) in zone III. While Shea butter tree and leucaena were recorded as the least occurrence with 45% and 40% respectively. Results shows that these browse are widely spread in the state. This finding tallies with Victor *et al.* (2001) that a wide range of Geneva of multipurpose trees and shrubs exists naturally in the semi arid zone and are used as browse plants.

Table 4.7: Commonly available feed resource (browse plants) for feeding small ruminants in Zone III, Adamawa State.

	Botanical names	Common names	% frequency availability
1	*Ficus sycomorus*	Ficus	80%
2	*Khaya senegalensis*	Fig	77%
3	*Balanite aegyptica*	Desert date	76%
4	*Annona senegalensis*	Wild custard apple	75%
5	*Daniella oliveri*	Copulba balsam	73%
6	*Acacia sieberiana*	White thorn tree	70%
7	*Faidherbia albida*	Gawo	65%
8	*Zizphus Mauritania*	Jujube tree	65%
9	*Parkia clappertoniana*	Africana locust bean tree	63%
10	*Moringa oleifera*	Monringa	60%
11	*African teak*	Pterocarpus erinaceus	60%
12	*Gardenia aqualla*	Iron wood	56%
13	*Anogeissus vogelii*	Chewing stick	55%
14	*Sterospermum kunthianu*	Calabash tree	50%
15	*Balanite aegyptica*	Christ thorn	50%
16	*Vitellaria Park*	Shea butter tree	45%
17	*Dichrosta chyus cinerea*	Egyptian thorn	45%
18	*Leuceana leucocephala*	Leucaena leaves	40%

Feed resources in zone IV

Browse plants

The summary of field survey of browse plants used for feeding small ruminants in zone IV is shown in Table 4.8. From the Table Acacia and fig tree ranked the highest in percentage availability in zone IV. Whereas Moringa and *Prosopis africana* recorded the lowest percent distribution in the zone. Browse plants are widely used as livestock feed and play a vital role as a complementary source of protein, vitamins and minerals for livestock species during the long dry season in the arid and semi arid areas (NAS, 1979).

Table 4.8: Commonly available feed resource (browse plants) for feeding small ruminants in Zone IV, Adamawa State.

	Botanical names	Common names	% frequency availability
1	*Ficus sycomorus*	Ficus	90%
2	*Faidherbia albida*	Acacia	88%
3	*Khaya senegalensis*	Fig tree	85%
4	*Ziziphus spina-christi*	Christ thorn	80%
5	*Parkia clapper tonia*	Locust bean	76%
6	*Leucena leucocephala*	Leucena	70%
7	*Ziziphus mauritania*	Jujube tree	70%
8	*Daniella oliveri*	Copulba balsam	60%
9	*Acacia sieberiana*	White thorn	60%
10	*Acacia nitolica*	Balanite aegyptica	60%
11	*Annona senegalensis*	Wild custard apple	60%
12	*Terminalia avicenioides*	Terminalia	55%
13	*Anogeisus leicerpus*	Chewing stick	55%
14	*Balanite aegyptica*	Desert date	50%
15	*Anogeissus vogelii*	African teak	50%
16	*Moringa oleifera*	Moringa	40%
17	*Prosopis Africana*	Iron wood	40%

Across all the zones the following browses are found to have higher frequency percentages: Ficus, Leucaena, Mahogany, and Acacia.

Feed resources in zone I

Crop Residues:

Table 4.9 shows some crops residues namely, cowpea haulms, groundnut haulms, maize stover, sorghum stover as the most abundant residues for feeding ruminants in zone I, Adamawa state. They are mostly available during the dry season. Some crop residues are available in smaller quantities. These include banana leaves, sweet potato leaves, Bambara leaves and cotton vines. Smith (2001) has listed that the major crops grown in the tropics of West Africa and which provide residues of potential value to goats and sheep as maize, sorghum, rice, groundnut, cowpea, cassava, yams, banana/plantain, oil palm and cocoa.

Table 4.9: Commonly available Feed Resources (Crop Residues) for feeding small ruminants in Zone I, Adamawa state,

	Botanical names	Common names	% frequency availability
1	*Vigna unguiculata*	Cowpea haulms	95%
2	*Arachis hypogea*	Groundnut haulm	90%
3	*Zea mays*	Maize stover	84%
4	*Sorghum bicolor*	Sorghum stover	75%
5	*Oryza sativa*	Rice straw	72%
6	*Panicum miliaceum*	Millet stover	41%
7	*Ipomea batatas*	Sweet potato leaves	35%
8	*Glycine max*	Soya bean leaves	30%
9	*Manihot esculanta*	Cassava leaves	15%
10	*Voandzea sabterranea*	Bambara leaves	12%
11	*Saccharatum*	Sugar cane tops	10%
12	*Gossypium spp*	Cotton leaves	9%
13	*Saccharatum*	Bagasse	8%
14	*Musa spp*	Babana leaves	7%

Feed resources in zone II

Crop Residues:

Table 4.10 shows frequency distribution of some crop residues used for feeding small ruminants in zone II of Adamawa state. From the Table cowpea haulm, groundnut haulm and maize cobs recorded the highest % availability while cassava leaves banana leaves and sugarcane tops were the lowest. The results obtained is in agreement with Alhassan *et al*. (1986), who reported that maize stover, sorghum stover, cowpea haulms, and groundnut haulms are found in abundance in some farm lands in northern Nigeria during the havestting period early in the the dry season.

Table 4.10: Commonly available Feed Resources (Crop Residues) for feeding small ruminants in Zone II, Adamawa state.

	Botanical names	Common names	% frequency availability
1	*Vigna unguiculata*	Cowpea haulms	95%
2	*Hypogea spp*	Groundnut haulms	90%
3	*Zea mays*	Maize cobs	75%
4	*Sorghum bicolor*	Sorghum stover	74%
5	*Zea mays*	Maize stover	70%
6	*Ipomea batatas*	Sweet potato leaves	45%
7	*Paricum miliaceum*	Millet stover	43%
8	*Dyscorea spp*	Yam vines	20%
9	*Saccharatum*	Sugarcane tops	17%
10	*Musa spp*	Banana leaves	15%
11	*Saccharatum*	Bagasse	15%
12	*Manihot esculanla*	Cassava leaves	11%
13	*Gossypium hirsutum*	Cotton vines	10%
14	*Voandzea sabterranea*	Bambara leaves	05%

Feed resources in zone III

Crop Residues:

Some commonly available crop residues for feeding ruminants in zone III of Adamawa state is shown in Table 4.11. Cowpea haulms, groundnut haulms and sorghum Stover are the most available crop residues in the zone. The other crops residues found in lesser extent are cassava leaves, sweet potato leaves, yam vines and baggase. Sajo and Kadams (1999) have reported large scale cultivation of cowpea, groundnut, maize and sorghum crops in the zone of which their residues are in abundance during the harvest season.

Table 4.11: Commonly available Feed Resources (Crop Residues) for feeding small ruminants in Zone III, Adamawa state.

	Botanical names	Common names	% frequency availability
1	*Hypogea spp*	Groundnut haulms	95%
2	*Vigna unguiculata*	Cowpea hay	90%
3	*Sorhgum bicolor*	Sorghum stover	76%
4	*Oryza sativa*	Rice straw	65%
5	*Zea mays*	Maize stover	65%
6	*Zea mays*	Maize cobs	65%
7	*Panicum miliceum*	Millet stover	41%
8	*Ipomea batatas*	Sweet potato leaves	25%
9	*Gossypium hirsutum*	Cotton leaves	20%
10	*Musa spp*	Banana leaves	15%
11	*Manihot esculanta*	Cassava leaves	14%
12	*Saccharatum spp*	Sugar cane tops	10%
13	*Dyscorea spp*	Yam vines	5%
14	*Sacharatum spp*	Bagasse	5%

Feed resources in zone IV

Crop Residues:

Table 4.12 reveals some crop residues that are produced in Zone IV of Adamawa state. The percentage frequency distribution shows cowpea haulms, groundnut haulms, maize cobs, millet stover, ranked as the highest crop residues for feeding small ruminants while soya bean leaves, yam vines, sugarcane tops and bagasse were the least amongst the crop residues in the zone. These products and by-products are used in different combinations for feeding ruminants in the state (Sajo and Kadams, 1999).

Across all the zones the following crop residues are found to have higher frequency distribution; cowpea hay, groundnut hay, maize stover, and rice straw.

Table 4.12: Commonly available Feed Resources (Crop Residues) for feeding small ruminants in Zone IV, Adamawa state.

	Botanical names	Common names	% frequency availability
1	*Vigna unguiculata*	Cowpea hays	95%
2	*Hypogea spp*	Groundnut haulms	90%
3	*Zea mays*	Maize cobs	73%
4	*Panicum miliacum*	Millet stover	73%
5	*Ipomea batatas*	Sweet potato leaves	70%
6	*Sorghum bicolor*	Sorghum stover	66%
7	*Zea mays*	Maize stover	65%
8	*Oryza sativa*	Rice straw	62%
9	*Musa spp*	Banana leaves	15%
10	*Saccharatum spp*	Sugar cane tops	15%
11	*Gossypium hirsutum*	Cotton vines	15%
12	*Voandzea sbaterranea*	Bambara leaves	10%
13	*Glycine spp*	Soyabean leaves	8%
14	*Saccharatum spp*	Bagasse	7%
15	*Dyscorea spp*	Yam vines	05%

Feed Resources in zone I

Agricultural By-Products:

Some agricultural by-products that are widely distributed for feeding small ruminants in zone I is shown in Table 4.13. The percentage frequency distribution revealed cowpea husk, maize bran, brewers waste and sorghum husk that top the list of feeds. The less available ruminant feeds are: sorghum bran, groundnut cake and molasses. This coincides with Smith (2001) that agricultural by-products may be rich in nitrogen (oil seed cakes, brewery) and less in widespread geographically since they are produced at factory sites.

Table 4.13: Commonly available feed resources (Agricultural By-Products) for feeding small ruminants in Zone I, Adamawa state.

	Botanical names	Common names	% frequency availability
1	*Vigna unguiculata*	Cowpea husk	85%
2	*Zea mays*	Maize bran	80%
3	*Sorghum bicolor*	Brewers waste	75%
4	*Sorghum bicolor*	Sorghum husk	75%
5	*Oryza sativa*	Rice bran	65%
6	*Dyscorea spp*	Yam peels	60%
7	*Ipomea batatas*	Sweet potato peels	55%
8	*Gossypium hirsutum*	Cotton seed cake	25%
9	*Sorghum bicolor*	Sorghum bran	25%
10	*Musa spp*	Banana peels	18%
11	*Hypogea spp*	Groundnut cake	15%
12	*Citrus spp*	Orange froth	15%
13	*Panicum miliaceum*	Millet bran	10%
14	*Saccharatum spp*	Molasses	5%

Feed resource in zone II

Agricultural by-products

Table 4.14 shows some available agricultural by-products in zone II of Adamawa state. Maize bran, brewers waste and sorghum husk, ranked the highest in availability; while banana leaves, orange froth and molasses were the lowest among the available feeds. Fadel (1999) had also repored that the agricultural by-products are in abundance, have higher nutrients value and are being used as feedstuff for feeding small ruminants.

Table 4.14: Commonly available feed resources (Agricultural By-Products) for feeding small ruminants in Zone II, Adamawa state.

	Botanical names	Common names	% frequency availability
1	*Zea mays*	Maize bran	90%
2	*Vigna unguiculata*	Cowpea husk	87%
3	*Sorghum bicolor*	Sorghum husk	70%
4	*Sorghum bicolor*	Brewers waste	70%
5	*Dyscorea spp*	Yam peels	65%
6	*Oryza sativa*	Rice bran	63%
7	*Manihot esculaenta*	Cassava peels	60%
8	*Ipomea batatas*	Sweet potato peels	60%
9	*Gossypium hirsutum*	Cotton seed cake	60%
10	*Sorghum bicolor*	Sorghum bran	40%
11	*Panicum miliaceum*	Millet bran	40%
12	*Musa spp*	Banana peels	25%
13	*Saccharatum spp*	Molases	15%
14	*Citrus spp*	Orange froth	10%

Feed resources in zone III

Agricultural by-products

Table 4.15 shows the highest and lowest percentage frequency distribution of available agricultural by-product for feeding small ruminants in zone III of Adamawa State. The by-products with the highest availability were cowpea husk, maize bran, yam peels and brewers waste. The least available feeds were molasses and millet bran respectively. This tally with Alhassan (1985) that a lot of Agricultural by-product are produced in some states of northern parts of Nigeria: Kano, Sokoto, Borno, Bauchi, Adamawa, Kaduna and Benue states.

Table 4.15: Commonly available feed resources (Agricultural By-Products) for feeding small ruminants in Zone III, Adamawa state

	Botanical names	Common names	% frequency availability
1	*Zea mays*	Maize bran	95%
2	*Vigna unguiculata*	Cowpea husk	90%
3	*Sorghum biclor*	Brewers waste	85%
4	*Dyscorea spp*	Yam peels	80%
5	*Manihot spp*	Cassava peels	70%
6	*Gossypium hirsutum*	Cotton seed cake	70%
7	*Oryza sativa*	Rice bran	65%
8	*Sorghum bicolor*	Sorghum husk	65%
9	*Ipomea batatas*	Sweet potato peels	60%
10	*Citrus spp*	Orange froth	60%
11	*Sorghum bicolor*	Sorghum bran	50%
12	*Saccharatum spp*	Molasses	35%
13	*Panicum miliaceum*	Millet bran	04%

Feed resources in zone IV

Agricultural By-Products

The percentage frequency distribution of agricultural by-products for feeding small ruminants in zone IV is shown in Table 4.16. Cottonseed cake, maize bran and cowpea husk ranked the highest agricultural by-products available in the zone. Some by-products that are less widely distributed in the zone although they are used in feeding small ruminants are sorghum husk, orange froth and millet bran. The findings of this research coincide with that of Preston and Leng, (1987). Some agricultural by-products, molasses and the like are obtainable in substantial quantities and are used in feeding small ruminants.

Across all the zones the following agricultural by-products are found to have higher frequency distribution availability: cowpea husk, maize bran, brewers waste, cotton seed cake.

Table 4.16 Commonly available feed resources (Agricultural By-Products) for feeding small ruminants in Zone IV, Adamawa state.

D Agricultural By-Products

	Botanical names	Common names	% frequency availability
1	*Gossypium hirsutum*	Cotton seed cake	85%
2	*Zea mays*	Maize bran	80%
3	*Vgina unguiculata*	Cowpea husk	80%
4	*sorghum bicolor*	Brewers waste	75%
5	*Mainhor esculata*	Cassava peels	65%
6	*Ipomea batatas*	Sweet potato peels	60%
7	*Dyscorea spp*	Yam peels	60%
8	*Saccharatum spp*	Molasses	50%
9	*Sorghum bicolor*	Sorghum bran	20%
10	*Citrus spp*	Orange froth	20%
11	*Hypogea spp*	Groundnut cake	10%
12	*Panicum miliaceum*	Millet bran	5%
13	*Sorghum bicolor*	Sorghum husk	4%
14	*Oryza sativa*	Rice bran	3%

4.2 Proximate Composition of local Feeds resources in Adamawa state

4.2.1. Proximate Composition of local Feeds resources in Zone I

The quality assessment of feed resources for the four zones is summarized in Tables 4.17-4.20 shows variations in proximate composition of grasses in zone I with Gamba, finger and cartail having higher crude protein while kikuyu and guinea grass had comparatively lower crude protein. For the browse plants, the fruit of acacia, leaves of chewing stick tree and mahogany leaves have relatively high crude protein while ficus leaves and terminalia fruits showed lower crude protein content. These variations are in agreement with the reports of NAP (2002) that types and compositions of plants at any one location on pasture or range is dependent on type and composition of the parent soil as well as moisture, radiant energy available for growth, previous and present management.

Proximate composition of crop residues for the various crops in zone I shows cowpea haulms and groundnut haulms having higher crude protein as compared to sorghum stover, rice straw and maize cobs which have low crude protein. Among the agricultural by-products; brewers waste, cowpea husk and maize bran ranked higher in crude protein as compared to rice bran and sorghum husk which have low crude protein.

Table 4.17. Proximate Composition of Feeds of Ruminant Animals in Adamawa State Zone I

A

S/NO	Grasses	DM	CP	CF	EE	ASH	NFE
1.	Gamba grasses	89	11.2	36	1.2	1.2	50.4
2.	Finger grasses	89	10	37	1.5	12.1	39.4
3	Cartail grasses	90	9.0	35.0	1.1	7.3	52.4
4.	Kikuyu grass	89.0	8.5	36.1	1.5	11.0	42.9
5.	Guinea grass	91	8.1	37.1	1.7	13.2	39.9
	Browse	**DM**	**CP**	**CF**	**EE**	**ASH**	**NFE**
1.	*Khaya senegalensis(leaves)*	87.1	12.6	32.0	1.6	6.5	47.3
2.	*Ficus sycomorus(leaves)*	90.0	9.2	30.1	2.0	14.1	44.6
3.	*Teminalia sp*	89.0	8.0	31	1.8	16	43.2
4.	*Acacia nitolica(fruits)*	88.6	22.0	29.0	1.1	12.5	35.4
5.	*Anogeissus leicarpus (leaves)*	91.0	19.0	29.0	3.0	11.0	38.0
	Crop Residues	**DM**	**CP**	**CF**	**EE**	**ASH**	**NFE**
1.	Groundnut haulms	91.6	11.6	29.0	1.8	5.5	52.1
2.	Cowpea haulms	91.0	16.0	26.0	1.6	6.0	50.4
3.	Maize cobs	91.3	2.2	36.0	0.7	2.7	58.6
4.	Rice straw	92	3.5	42.5	1.0	1.22	51.78
5	Sorghum stover	86.1	5.3	35.3	1.7	6.7	51.0
	Agricultural by products	**DM**	**CP**	**CF**	**EE**	**ASH**	**NFE**
1.	Cowpea husk	90.0	12.6	34	0.8	6.8	45.8
2.	Maize bran	91.0	8.8	11	1.6	11.0	67.6
3.	Brewers waste	88	12.75	4.1	7.0	12.0	64.15
4.	Rice bran	91	5.0	3.3	4.0	10.3	77.4
5.	Sorghum husk	90.0	4.4	33	1.0	7.1	54.5

4.2.2. Proximate composition of local feed resources in zone II

The proximate composition of grasses in zone II Table 4.18 show Elephant, gamba and hedge long grasses having higher crude protein as compared to guinea and Pangola grasses which have lower crude protein. Some browse plants Christ thorn ficus (leaves) having high crude protein compared to, balanite leaves and wild custard apple leaves having lower crude protein.

The proximate composition of crop residues shows that crude protein content was higher in cottonseed cake, cowpea haulms and groundnut haulms as against sorghum stover and maize cobs with lower CP. Among the agricultural by-products; brewers waste ranked the highest in terms of CP, followed by cowpea husk and maize bran while sorghum husk and rice bran were the least. Differences in micro-climate, grazing pattern and soil type might have accounted for the differences in fodders composition. The variations in nutrients content may be due to differences in soil fertility and genotype of plants which coincide with Tiseer *et al.* (2000) that heterogenecity and soil fertility influenced the distributive pattern of both native flora and soil legume.

Table 4.18. Proximate Composition of Feeds of Ruminant Animals in Zone II

	Grasses	DM	CP	CF	EE	ASH	NFE
1.	Guinea grass	92	8.5	36.0	1.6	9.7	44.2
2.	Pangola grass	91	7.7	36	1.0	9.5	45.8
3.	Hedge long grass	91	9.0	36.0	1.4	9.1	44.5
4.	Elephant grass	90	10.5	36.5	1.3	8.8	42.9
5.	Gamba grass	91	10.0	37.0	1.2	8.2	43.6
	Browse	**DM**	**CP**	**CF**	**EE**	**ASH**	**NFE**
1.	Dry zone mahogany	92	7.5	25	2.2	14	51.3
2.	*Stereospermum sp.*	91	8.0	26	1.5	13	51.5
3.	*Ficus sycomorus (leaves)*	90	8.8	30.1	1.8	13.0	46.3
4.	*Balanite aegyptiaca(leaves)*	91	6.6	31.1	1.6	11.0	49.7
5.	*Christ thorn*	92	14.0	21	1.8	8.0	57.2
6	Wild custard apple	90	5.6	27.0	0.8	12.	54.6
	Crop Residues	**DM**	**CP**	**CF**	**EE**	**ASH**	**NFE**
1.	Cowpea haulms	91.1	14.00	28.5	2.8	6.7	48.0
2.	Groundnut haulms	90.0	9.81	24.1	2.4	8.1	55.59
3.	Maize cobs	90.1	2.1	35.1	0.5	2.7	59.6
4	Sorghum stover	91.0	5.0	33.0	2.0	7.1	52.9
	Agric by-products	**DM**	**CP**	**CF**	**EE**	**ASH**	**NFE**
1.	Cowpea husk	92.0	9.5	36.1	0.7	6.3	47.4
2.	Maize bran	90	8.2	11.	1.6	8.5	70.7
3.	Brewers waste	88	12.75	12	7.3	9.0	59.2
4.	Rice bran	93.0	3.0	18.0	6.1	7.0	65.9
5	Sorghum husk	92.1	4.3	35.1	1.5	7.4	51.7

4.2.3. Proximate composition of local feed resources in zone III

Table 4.19, shows the proximate composition of different grass species in zone III. From the table, the Signal and Gamba grasses have higher CP while Pangola, Guinea and Jaragwa grasses have almost similar CP but are lower than Signal and Gamba grasses respectively. The crude fiber of all the species are almost the same; although variations existed among different species. This finding agrees with Stanton and Levalley (2007) that the nutritive values of the feeds vary in chemical composition. Among the browse plants in this zone, Capalba balsam and chewing stick trees have higher CP while mahogany, dry zone Mahogany trees and Fig trees have comparatively lower CP. This is in line with Norton (1994) that the chemical compositions of a selected range of tree species varies with soil types (location), plant part (leaf, stem and pods) age of leaf and stem.

The chemical composition of crop residues varies widely across the different crops with groundnut and cowpea haulms having higher CP than sugar cane tops, rice stover and sorghum stover having relatively similar values. Some, agricultural by-products as indicated in the table revealed that cottonseed cake has the highest CP, followed by cowpea husk and maize bran while yam and cassava peels have lower CP.

Table 4.19. Proximate Composition of Feeds of Ruminant Animals in Mayo Belwa Zone III

S/NO	Grasses	DM	CP	CF	EE	ASH	NFE
1.	Pangola grass	92.0	7.6	36.0	1.1	9.6	45.7
2.	Gamba grass	91.0	8.1	35.0	1.4	12.8	42.7
3.	Guinea grass	91.0	7.1	36.0	1.5	11.6	43.8
4.	Jaragwa	90.0	7.8	34.0	1.3	12.5	44.4
5.	Signal grass	91.0	8.2	33.0	1.1	10.6	47.1
	Browses	**DM**	**CP**	**CF**	**EE**	**ASH**	**NFE**
1.	Copalba balsam	91.0	14.0	21.0	1.8	10.0	53.2
2.	Mahogany tree	90.0	12.0	23.0	1.1	11.0	52.9
3.	Chewing stick	90.0	13.0	22.0	1.1	9.6	54.3
4.	Dry zone mahogany (leaves)	91.0	8.1	26.0	1.8	12.0	52.1
5.	Fig tree	86.20	10.2	35.1	3.6	25.6	25.5
	Crop residues	**DM**	**CP**	**CF**	**EE**	**ASH**	**NFE**
1.	Groundnut haulms	91.6	9.87	24.2	1.8	5.02	59.11
2.	Cowpea haulms	90.1	14.0	23.0	1.3	5.6	56.1
3.	sugar cane tops	31.33	3.0	1.44	0.8	2.1	92.66
4.	Rice stover	92.0	3.5	32.0	1.1	1.2	64.5
5.	Sorghum stover	92.0	3.5	30.0	1.5	13.0	52.0
	Agric by-products	**DM**	**CP**	**CF**	**EE**	**ASH**	**NFE**
1.	Cowpea husk	91.4	9.63	36.4	1.2	6.5	46.27
2.	Maize bran	91.3	8.3	10.4	4.0	3.10	74.2
3.	Yam peels	82.0	5.0	20.0	1.1	6.1	67.8
4	Cassava peels	80.1	5.22	21.6	1.5	2.8	68.88
5.	Cottonseed cake	94.6	36.50	14.0	23.9	5.20	21.3

4.2.4. Proximate composition of local feed resources in zone IV

Table 4.20 shows the proximate composition of different grass species in zone IV. From the table, gamba ranked the highest in terms of crude protein content, this was followed by Bracharia, Signal and Kikuyu grasses; the least were Pangola and Guinea grasses. Among some browse plants Leucaena, ranked the highest followed by Acacia seeds; Mahogany bean and Christ thorn also have relatively high crude protein content. Fig tree seems to be having the lowest crude protein content. Most browse plants have relatively higher crude protein. This tallies with report of Mecha and Adegbola (1980) that the crude protein content of trees, shrubs and herbs were higher than those of grasses.

The table indicated that some crop residues cowpea and groundnut haulms have higher crude protein as compared to sweet potato haulms, sugar cane tops and sorghum stover. Among the agricultural by-products as shown in the table, cottonseed cake tops the least in terms of crude protein; this was followed by brewers waste, while maize bran, molasses and sweet potato peels have lower crude protein contents. The results of the chemical analysis indicated that there are variations in chemical constituents of feed resources, this finding agrees with the report of Stanton and Levalley (2007) that nutritive values of feeds vary. Chemical composition may be due to differences in micro-climate, grazing pattern and soil type.

Table 4.20: Proximate Composition of Feeds of Ruminant Animals in Zone IV

S/NO	Grasses	DM	CP	CF	EE	ASH	NFE
1.	Gamba grass	89	10.2	37	1.3	11.0	40.5
2.	Pangola grass	92	7.5	35	1.1	9.5	46.9
3.	Guinea grass	90	7.7	36	1.7	12.6	42.0
4.	Bracharia	91	8.0	35	1.8	12.0	43.2
5.	Signal grass	90	8.2	36	1.5	10.0	44.3
6.	Kikuyu grass	88	8.2	35	1.9	11.8	43.1
	Browses	**DM**	**CP**	**CF**	**EE**	**ASH**	**NFE**
1.	*Acacia albida*	88.5	14.4	28.9	1.5	11.0	44.2
2.	Fig tree	86.7	9.0	30.1	1.8	12.0	47.1
3.	*Terminalia laxiflora*	89.0	7.4	27.0	1.1	10.0	54.5
4.	Mahogany bean	90.0	10.2	26.0	1.6	10.0	52.5
5.	*Christ thorn*	91.0	12.0	23	1.5	8.8	54.7
6.	Leucaena leucaena	88.5	25.09	27.4	10.3	10.14	32.66
	Crop residues	**DM**	**CP**	**CF**	**EE**	**ASH**	**NFE**
1.	Cowpea haulms	91.6	14.2	24.1	1.9	5.6	52.2
2.	Groundnut haulms	91.0	9.86	26.1	1.8	5.0	55.6
3.	Sweet potato haulms	81.2	6.0	20.1	1.8	2.7	69.4
4.	Sugar cane tops	35.6	4.3	3.1	0.64	2.3	89.66
5.	Sorghum stover	85.0	4.8	31.0	1.6	1.4.0	61.2
	Agric by-products	**DM**	**CP**	**CF**	**EE**	**ASH**	**NFE**
1.	Cotton seed cake	91.2	36.50	8.99	2.5	7.54	47.9
2.	Brewers waste	94.30	12.75	1.30	1.6	15.0	40.5
3.	Maize bran	91.3	8.52.	11.6	1.6	4.5	56.9
4.	Sweet potato peels	81.2	6.0	20.1	1.8	2.7	49.6
5.	Molasses	81.1	5.6	16.9	1.8	21.6	48.6

These variations in chemical composition observed in different feed resources conducted are in agreement with the reports of NAP, (2002) that types and compositions of plants at any one location on pasture or range is dependent on type and composition of the parent soil as well as moisture, radiant energy available for growth and previous and present management.

4.3. Rumen Degradability of Feeds

Tables 4.21 and 4.22 show rumen degradability values (%) for basal and supplements respectively. It was observed that roughages are bulky, containing more than 18% crude fiber, and with low digestibility (NRC, 1985). Roughages (basal) are more in quantity and they usually consists of pastures, silages, hay and crop wastes while supplements had less crude fibre (CF) and were readily digestible compared to basal feeds. The results showed higher degradability values in supplements than the basal feeds. This observation is in line with the reports of Bogoro *et al*. (1999) that some basal diets like stovers and straws have low degradability as compared to supplements because of their fibrous nature. This implies a long rumen residence time of the straw to be broken down to fine particles enough before leaving the rumen. The high crude fibre in the basal feeds confirmed the fact that degradability decreases with increasing fibre content (Fasakin *et al*., 2001).

The amount of rumen degradability at 48hrs and above reported from this study is an indicative measure of digestibility as the feeds must

Table 4.21. Percentage Rumen Degradability of Basal Feeds Incubated in the Rumen of Cattle (%)

Time of incubation (hrs)	Cowpea hay	Cowpea husk	Groundnut hay	Digitaria grass hay	Elephant grass hay	Gamba grass hay	Guinea grass hay	Sorghum stover	Maize stover	Maize cob	Rice straw	*Khaya senegalensis*	*Ficus sycomorus*	*Acacia nilotica*	*Leucaena L.*
6	28.9	25.2	28.2	30.2	31.2	29.6	28.8	17.6	15.4	16.1	13.1	39.1	42.1	31.1	33.4
12	36.7	38.3	32.5	34.6	35.1	33.1	34.0	21.9	19.9	20.6	15.1	41.5	54.2	36.1	44.3
24	44	47	41.5	41.3	45.6	43.7	44.6	26.4	22.1	26.8	19.6	48.0	63.2	42.1	58.2
48	62	65.2	56	56.5	58.2	55.6	57.4	39.6	26.5	32	26.2	71.1	69.5	48.2	66.3
72	80	70.0	72.1	71.7	68.1	69.2	66.6	46.2	33.1	38.9	32.7	77.2	71.2	54.0	69.4
96	88	80	76.4	76	75.4	72.5	74.1	54.3	44.1	41.55	39.3	81.4	76.0	61.1	70.6

Table 4.22: Percentage Rumen Degradability of Supplement Feeds Incubated in the Rumen of Cattle (%)

Time of incubation (hrs)	Brewers waste	Maize bran	Cotton seed cake	Rice bran	Sorghum bran	Millet bran	Yam peels	Cassava peels	Sweet potato peels
3	31.8	36.5	28.6	11.6	39.5	38.3	31.5	29.4	30.1
6	38	43.8	135.7	14.8	45.3	44.5	35.7	35.1	36.5
12	45.9	54.7	42	18.4	51.6	50.3	43.6	45.3	44.1
24	60	65.7	57	25.3	62.3	63.5	54.8	55.4	56
36	70.7	80.3	71.4	29.5	77.5	75.3	65.2	66.2	67.3
48	81.3	87.6	78.6	35.9	81.1	80.3	76.4	75.3	77.1

have been soaked sufficiently before the 48hrs mark to facilitate digestion by microorganisms (Adu *et al*., 1993).This also tallies with the report of Abiliza and Muya (1991) that the DM and OM degradability values at 48hrs of incubation time are important as this period is closer to the mean retention time of 48hrs for fibrous feeds in the rumen.Thus the 48 hr degradation values will be taken as indicative of *in-vivo* digestibility co-efficient for the different components. The degradability values for forages in this study at 48hrs incubation almost coincide with 55.1% as reported by Smith *et al.* (1991). Also the dry matter degradability values for browse at 48hrs incubation, varied from 48.2 to 71.1 % which falls within the report of Smith *et al.* (1991). Feeds with lower degradabilities have poorer nutritive values which agree with Abiliza and Muya (1991). The effective degradability of supplements reported from this study implies that supplements are most suitable in feeding conditions than the basal.

The *in-situ* dry matter degradability values obtained will be usefull in identifying the best materials for use in practical ruminant diet. The result obtained indicated that a wide variety of browse species, crop residues and byproducts have high nutritional value. They may be used as supplementary feeds during the dry season when forage quality is low (Smith *et al*., 1991).

4.4. Classification of Feeds into Basal and Supplements

On the basis of the chemical analysis and rumen degradability, feeds were grouped into two types, basal and supplements (Table 4.23). The reasons for the grouping were because

Table 4.23: Nutrient Composition of Ruminant Feedstuff in Adamawa State.

	Basal feeds	DM	CP	CF	EE	ASH	NFE	48 hours Degradability value %
1	*Khaya senegalensis*	92.0	17.6	28.0	2.6	12.6	61.0	81.4
2	*Ficus sp.*	90	9.2	30.1	2.0	14.1	58.0	76.0
3	Leucaena leaves	88.5	20.0	27.1	1.3	10.1	50.0	70.6
4	Cowpea husk	91.4	9.62	36.24	1.20	6.50	48.6	80.0
5	Cowpea hay	91.6	9.87	24.2	.8	5.0	50.0	88.0
6	Elephant grass hay	90.0	8.0	36.1	0.8	6.9	47.0	75.4
7	Guinea grass hay	91.0	7.0	36.0	1.5	11.6	40.0	74.1
8	Pangola grass hay	93.0	7.60	29.0	3.0	9.7	45.0	76.0
9	Groundnut hay	91.6	9.87	24.2	1.8	5.02	51.0	76.4
10	Gamba grass hay	92.3	8.0	35.0	0.6	8.1	50.2	72.5
11	*Acacia albida* pods	91.0	15.0	23.0	1.8	11.0	50.0	61.1
12	Sorghum stover	92.0	3.5	30.0	1.5	13.0	49.0	54.3
13	Maize cob	91.3	2.2	30.0	1.8	4.5	47.9	41.55
14	Maize stover	91.0	3.6	32.0	1.2	5.2	46.2	44.1
15	Rice straw	92.0	3.5	32.0	1.1	1.2	44.0	39.3
Supplements								
1	Maize bran	91.3	8.30	10.4	4.0	3.1	56.9	87.6
2	Brewers waste	94.30	12.75	4.30	1.6	15.6	40.5	81.3
3	Sorghum bran	91.0	8.1	17.3	1.8	25.1	55.1	81.1
4	Millet bran	93.1	8.6	28.6	1.7	22.1	53.6	80.3
5	Cottonseed cake	93.40	36.50	14.0	23.9	5.2	50.0	78.6
6	Sweet potato peels	80.0	6.0	19.0	1.5	5.1	48.6	77.1
7	Yams peels	82.0	5.0	20.0	1.1	6.1	50.0	76.4
8	Cassava peels	80.6	5.6	20.2	1.7	4.1	67.1	75.3
9	Rice bran	94.0	3.0	30.22	1.1	26.5	33.4	35.9

basal feeds were found to be bulky and that they have high CF and low digestibility. Basal feeds are fibrous and exist in large quantities as compared to supplements which are smaller in quantity but higher in quality. This tally with the report of Parra and Escobar (1985) that roughages are more in quantity and they usually consist of pastures silages, hay and crop wastes while supplements had less crude fibre (CF) and were readily digestible compared to basal feeds.

4.7 . Ranking of Feeds based on degradabaility values

Table 4.24 shows ranking of feeds on the basis of availability and degradability (digestibility). It was observed that some feeds have relatively high nutritive values but low degradabilities. Therefore ranking was done on the basis of availability of feeds to ruminant farmers and degradability values.

Table 4.24. Ranking of Feeds based on degradability values

1	Cowpea hay	88.0
2	Maize bran	87.6
3	*Khaya senegalensis*	81.4
4	Brewers waste	81.3
5	Sorghum bran	81.1
6	Millet bran	84.3
7	Cowpea husk	80.0
8	Cottonseed cake	78.6
9	Sweet potato peels	77.1
10	Groundnut hay	76.4
11	Yam peels	76.4
12	Pangola grass hay	76.0
13	*Ficus sp*	76.0
14	Elephant grass	75.4
15	Cassava peels	75.3
16	Guinea grass	74.1
17	Gamba grass	72.5
18	*Leucaena sp*	70.6
19	*Acacia sp.*	61.1
20	Sorghum stover	54.3
21	Maize stover	44.1
22	Maize cob	41.55
23	Rice straw	39.3
24	Rice bran	35.9

Experiement II

4.8 Chemical Composition of the Experimental Diets

The experimental diets were selected based on their availability and high degradation values (Tables 4.21 and 4.22). The chemical composition of the experimental diets is shown in Table 4.25. The dry matter (DM) content of groundnut haulms (91.6%) agrees with the values (91.08%) reported by Siulapwa and Simukoko (1998), but is slightly lower compared to that reported by Yahaya *et al.* (1999) who obtained 94%. The DM content of maize bran, brewers waste and cottonseed cake are close to those reported by Tuah *et al.* (1985) and Siulapwa and Simukoko (1998).

The crude protein (CP) content of groundnut haulms (9.87%) is much higher than 5.6 – 9.2% reported by FAO (1981) respectively. This is in contrast with the report of Savadogo *et al.*, (2000) that, under practical farming conditions the nutritive value and crude protein values are often lower than those from research farms because groundnut and cowpea are primarily grown for gains. The 8.3% CP content of maize bran recorded is lower than 12.73% respectively reported by Tuah *et al.* (1985) while that of cottonseed cake 36.5% is lower than 43.28% reported by Ikrior and Fetuga (1985). The difference in crude protein content may be due to stage of harvest and method of preservation.

Table 4.25: Chemical composition of experimental diets

	Basal			Supplements			
Chemical component	Cowpea husk	Groundnut haulms	Cowpea hay	*Digitaria decumbens* (P.grass)	Maize bran	Brewers waste	Cotton seed cake
Dry matter	91.40	91.6	91.6	93.0	91.30	94.30	93.40
Crude protein	9.62	9.87	14.00	7.60	8.30	12.75	36.50
Crude fiber	36.24	24.2	28.0	29.0	10.4	4.30	14.0
Either extract	1.20	2.8	18.9	3.0	4.0	1.6	23.9
Ash	6.50	5.0	5.6	9.7	3.1	15.6	5.20

The ether extract (EE) percentage in groundnut haulm (2.8%) was higher than 1.5% reported by Yahaya *et al.* (1999), that of maize bran (4.0%) is within the range of 1.5% and 6.1% reported by Njei and Reid. (1995). The ash content (5.0%) for groundnut haulm is also within the range of 2.5% and 8.5% as reported by Yahaya *et al.* (1999) and ash content of maize bran (3.1%) is slightly higher than 2.4% according to Njei and Reid. (1995). The ash content of cottonseed cake (5.2%) is lower than that reported by Adegbola (2002).

The crude fiber content in groundnut haulms (34.6%) is similar with 34.9% reported by Yahaya *et al.* (1999). The CF of maize bran (10.4%) is lower compared to research reports. In case of brewers waste and cottonseed cake the crude fiber percentage for brewers waste is lower (4.3) but cotton seed cake (14.0) is higher than 11.32% as reported by Siulapwa and Simukoko (1998).

4.7 Dry Matter Intake

The results of the dry matter intake (g/Animal/day) of the diets are shown in Table 4.26. The dry matter intake ranged from 801.77 to 960. The highest DMI ($p<0.05$) was recorded in T_2 (960.4) followed by T_6 (942.6g) while the lowest was in T_5 (801.77g). Total dry matter intake of basal diets increased linearly with increase in the levels of supplementation.

Table 4.26: Nutrient utilisation of Rams fed cowpea husk and *Digitaria decumbens* grass with different supplements

Indices parameter	Treatments								
	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	SEM
Total Feed Intake (g/d/)	807.93^c	960.4^a	820.83^b	871.28^{ab}	801.77^c	942.67^a	807.59^c	881.73^{ab}	0.15
Basal Feed Intake	807.93^c	690.4^a	610.0^b	640.78^{ab}	801.77^c	697.67^a	627.09^c	601.73^b	0.13
Supplement feed intake	0^c	270.0^a	210^b	230.5^{ab}	0^c	245.80^a	180.50^c	280.03^b	0.03
Water intake (litre)	2.5^b	3.20^a	2.6^b	2.6^b	2.5^b	2.6^b	2.46^b	2.36^b	0.003
Dry matter digestibility (%)	57.8^c	69.2^a	61.2^b	61.9^b	61.8^b	$60.6b^{bc}$	57.8^c	62.6^b	0.44
Crude protein digestibility (%)	67.4^a	66.9^{ab}	66.2^{ab}	68.3^a	63.07^b	68.00^a	63.03^b	66.6^{ab}	0.45
Crude fibre digestibility (%)	54.1^b	58.03^a	58.1^a	53.2^b	52.7^b	53.1^b	44.9^c	53.7^b	0.37

abc: Means on the same row with different superscript are significantly different ($p<0.001$).

T_1= Cowpea husk only
T_2 = Cowpea husk + CSC
T_3=Cowpea husk + BW
T_4= Cowpea husk +MB
T_5= Grass only
T_6= Grass + CSC
T_7= Grass + BW
T_8= Grass + MB

The preference of rams for CSC was probably due to its ability to release large amounts of intact protein to the small intestine (Kellaway and Leibhog, 1983). The higher DMI of CSC supplemented treatments can be explained by the fact that CSC did not only provide essential nutrients to maintain optimal rumen activity but was also more rapidly degraded in the rumen (Ngawa and Tawah, 2002). This finding agree with the report of Ojo *et al.*, (2001) that supplementation of cereal residues and agricultural by-products increase dry matter intake; because cotton seed cake serves as a good source of nitrogen.

4.7.1 Dry matter digestibility (DMD).

The mean value for the DMD is presented in Table 4.26. The value for DMD ranged from 57.83% to 69.2% with T2 (69.20%) having recorded the highest DMD and the least was obtained in T_7 (57.833%). Dry matter digestibility was significantly ($p<0.05$) affected by supplementation. Cowpea husk supplemented with cotton seed cake gave the highest nutritent digestibility. This is in agreement with the report of Adeloye (1994) that supplementation of cowpea husk increased the values of dry matter digestibility.

4.7.2 Crude Protein Digestibility (CPD)

Crude protein digestibility of cowpea husk and grass fed with different supplements as reflected in Table 4.26. The CPD ranged from 63.03% to 68.3% with T_4 (68.33%) having the highest digestibility and T_7 (63.03%) had the lowest. Therefore, supplementation increased digestibility of CP in rams. This agrees with Hossain *et al* (2003) that the digestibility of CP was increased by supplementation of dietary energy along with other nutrients to the host animal. It coincides with Adams *et al*. (1995) that ammoniation or supplementation increased digestibility in sheep. Similarly, Hannah *et al*. (1991) reported that the digestibility of low quality roughage can be improved by either treatment or supplementation which was used in this experiement.

4.7.3 Crude Fibre Digestibility

The result of Crude fibre digestibility of the diets is shown in Table 4.26. The crude fibre digestibility ranged from 44.97 in (T_1) to 58.03 (T_2). A significantly ($P<0.05$) higher digestibility of the diets were recorded in most of the treatments i.e T_1, T_4, T_5, T_6 and T_8 while an insignificant ($P>0.05$) digestibility were obtained in T_2, T_3 and T_7 respectively. Supplementation had significant effect on treatments T_2 (cowpea husk + CSC), T_3 (cowpea husk + BW), T_6 (Grass + CSC) and T_8 (Grass + MB) while an insignificant effect of supplementation was recorded in T_4 (cowpea husk + MB) and T_7 (Grass + BW). A substitution reaction was observed in this experiment. In some treatments instead of recording higher digestibilities, lower digestibilities were obtained that is, experimental animals consumed more of supplements diets than the basal diets.

It was observed that fibre digestibility increased in treatments especially where protein sources were supplemented. This result agrees with the findings of Owen (1993) who reported increased CFD as a result of supplementation.

4.7.4 Water intake

Daily water intake of rams fed cowpea husk and *D. decumbens* grass with different supplements were summarized in Table 4.26. The daily water intake ranged from 2.36 to 3.2litres/animal/day. The highest water intake was recorded in T_2 and lowest in T_8. The results obtained in this study fall within the range reported by ARC (1984), for water intake of rams under varying environmental temperatures. The water intake of Nigerian sheep and goat is influenced by diet types, diet combinations and processing methods. The values in this study are however higher than 1.5 to 2.0L\day reported by Adegbola and Obioha (1984) for West African dwarf sheep. However, when water intake was expressed per kg DMI, a higher ($p< 0.05$) intake was recorded in T_2 compared to the rest of the treatments. This suggests that rams consumed more water probably because of the high content of ether extract in cotton seed cake.

4.7.5 Live Weight Gain

The live weight changes of rams fed treatment diets are summarized in Table 4.27. The detail of the live weight changes over the experiemental period is given in Appendix 3. The live weight changes of the rams varied from 32.1 to 88.9g/day/animal, in T_5 and T_2 respectively.

Average daily live-weight gain of rams on cowpea husk supplemented with cotton seed cake was significantly ($p<0.05$) higher than that of rams on the other treatments. This agreed with Hossain *et al*. (2003) that supplementation of protein based supplement increase intake and growth performance. Similarly, Tien and Beyen (2004) also observed that supplementation increased growth performance in Lamb as compared with control (unsupplemented).

The findings of this study showed that T_1 had the highest daily live weight gain confirming cottonseed cake with high dietary nitrogen (CP) as the most suitable supplement. This agrees with Siulapwa and Simukoko (2001) who observed that increased nitrogen supplement increased DMI resulting in increased live weight gain, thus indicating an increase in live weight gain as the experiment continued; this implies positive responses of the experimental animals to the diets.

Table 4.27: Growth performance of Rams fed cowpea husk or *Digitaria decumbens* grass with different supplements.

	Treatments								
Indices	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	SEM
Initial live weight (kg)	21.5^a	21.5^a	21.5^a	21.5^a	21.5^a	21.5^a	21.5^a	21.5^a	0.01
Final live weight (kg)	23.5^b	26.83^a	23.8^b	24.5^b	23.3^b	25.8^a	24.2^b	24.8^b	0.02
Live weight gain (kg)	2.0^d	5.33^a	2.3^d	2.9^c	1.8^d	3.7^b	2.7^c	3.2^b	0.62
Daily live weight gain (g)	35.7^d	88.9^a	41.1^c	51.8^c	32.1^d	66.1^b	48.2^{bc}	57.1^c	0.80

Means on the same row with different superscript are significantly different ($p<0.001$).

T_1= Cowpea husk only
T_2 = Cowpea husk + CSC
T_3= Cowpea husk + BM
T_4= Cowpea husk+ MB
T_5= Grass only
T_6= Grass + CSC
T_7= Grass + BW
T_8= Grass + MB

4.7.6. Experiment III:

Dry matter intake

The results of the dry matter intake (g/animal/day) of the diets of rams fed groundnut or cowpea hays are shown in Table 4.28. The dry matter intake between the treatments given to Yankasa Rams ranged within 766.70 to 947.69g/h/d. The highest DMI was recorded in T_6 (947.69 g/h/d) followed by T_8 (883.175g). Most of the treatments were significantly different as shown in Table 25.

The highest DMI (947.69g/h/d) of rams fed cowpea hays with different supplements was recorded in T_6 where rams were fed cowpea hay supplemented with CSC. Lowest dry matter intake of animals on cowpea hay only was recorded in T_5 (844.69g/h/d). Similarly, the highest dry matter intake of rams was obtained in T_2 (850.53g/h/d). The lowest dry matter intake of 766.7g/d/h was recorded in T_1 i.e control. This experiment shows that rams supplemented consumed more than the unsupplemented (group). This is in consistent with the report of Bailey and Sim (1998) that an increase of organic matter intake in sheep fed diet supplemented with CSC meal was better as against control group.

The increased dry matter intake and growth rate of rams suggested that supplementation improved the nutritive value of grass and crop residues. This could be accounted for by the higher CP content and digestibility of supplemented diets compared to control diets.

Table 4.28. Nutrient utilization of Rams fed cowpea hay or groundnut hays with different supplements.

	Treatments								
Indices	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	SEM
Dry matter intake (g/d/)	766.7^{e}	850.53^{c}	775.56^{de}	797.08^{d}	844.69^{c}	947.69^{a}	850.49^{c}	883.18^{b}	0.81
Water intake (litre/day)	2.9^{a}	3.4^{a}	3.1^{a}	3.4^{a}	2.9^{a}	3.4^{a}	3.2^{a}	3.3^{a}	0.46
Dry matter digestibility (%)	57.1^{ab}	53.9^{b}	58.4^{a}	63.3^{a}	59.5^{a}	61.7^{a}	59.3^{a}	52.4^{b}	0.65
Crude protein digestibility (%)	64.1^{b}	68.1^{a}	63.8^{b}	68.1^{a}	63.5^{b}	68.1^{a}	60.3^{c}	68.2^{a}	0.85
Crude fubre digestibility (%)	56.9^{b}	56.1^{b}	59.1^{a}	54.1^{c}	51.0^{c}	59.3^{a}	56.8^{b}	57.1^{ab}	0.61

Means within the same row and with same letters are not significantly different ($p>0.05$)

Key:

T_1 = Groundnut hay only
T_2 = Groundnuy hay + CSC
T_3 = Groundnut hay + BW
T_4 = Groundnut hay + MB

T_5 = Cowpea hay only
T_6 = Cowpea hay + CSC
T_7 = Cowpea hay + BW
T_8 = Cowpea hay + MB

4.7.7 Dry Matter Digestibility

Table 4.28 shows dry matter digestibility of rams fed cowpea or groundnut hays with different supplements. The highest dry matter digestibility was obtained in T_4 while the lowest was recorded in T_2. The dry matter digestibility values for rams fed cowpea hays with different supplements in Table 4.28 revealed that T_6 recorded the highest digestibility where cowpea hays was supplemented with CSC. The lowest dry matter digestibility was obtained in T_8 when cowpea hay was supplemented with maize bran. This result indicates that supplementing the basal diets had no significant difference in dry matter digestibility. That is to say, supplementation did not-influence dry matter digestibility across treatments. This corroborates with the observation of Adams *et al*. (1995) that ammoniation or supplementation had no effect on dry matter digestibility but tended to increase digestibility of crude fiber by sheep. This observation is contrary to Hossain *et al.* (2003) who reported increase in dry matter digestibility, organic mater and crude fibre as the level of dietary energy supplementation was increased.

4.7.8. Crude Protein Digestibility

Table 4.28 summarized the Crude Protein digestibility of cowpea or groundnut hays fed to rams with different supplements. The highest Crude Protein digestibility was obtained in T_8 (68.2%) while the lowest was recorded in T_8 (60.3%). The crude protein digestibility values obtained in these studies were comparable to the value obtained for goats fed maize Stover/brewers waste grain silage. Similarly, the result obtained from this study was within the value reported by Yahaya *et al*. (2001). Where Yankasa rams were fed cowpea hays or groundnut hays with different supplements.

4.7.9 Crude Fiber digestibility

Table 4.28 shows crude fiber digestibility with T_6 (59.3%) having the highest values of crude fibre digestibility followed by T_3 (59.1) and the least was recorded in T_1 (56.9). Fibre digestibility increased in all the treatments especially where Protein sources were supplemented. This result agrees with the findings of Owen (1993) who reported increased crude fibre digestibility with supplementation. Hence, rams supplemented with CSC, MB and BW had higher digestibility values and better performance. This is in conformity with the findings of Ojabo (1985), that groundnut haulms is used extensively on feeding of ruminants especially during the dry season to fatten or reduce weight losses in Sudan Sahel and guinea Savannah zones of Northern Nigeria. Bailey and Sim (1998) made similar observations that differences in digestibility may be the result of addition of protein and carbohydrate, rather than an increase in digestibility of the hay. Therefore additon of supplement improved ($p<0.01$) the digestible and metabolize energy of the total diet.

4.8 Water intake.

Table 4.28 shows water intake of rams fed cowpea or groundnut hays as basal feeds with different supplements. The daily water intake ranged from 2.9 - 3.4 litres/d with T_2, T_4 and T_6 being the highest (3.4lit/d) while rams on T_1 and T_5 (2.9lit/a/d). There was an increase in daily water intake recorded in those rams that were suppelemnted than control (unsupplemented). The range of values recorded in this study (2.9 – 3.4 L/a/day) was within 2.0 – 3.0l/d reported by ARC (1984). All the rams performed better in terms of water intake as compared to control, showing that the supplements increased DMI.

4.8.1 Live Weight Gain

Daily live weight gain of rams fed cowpea or groundnut hays is shown in Table 4.29. The mean live weight gain ranged from 66.07 to 115.3g/h/d and these were significantly different. The daily live weight gain was very much high or for rams fed cowpea hay supplemented with cotton seed cake. An increase in the weight of the rams indicated that nutrients in the diets were adequate for growth performance. The results of this experiement are in line with the report of Siulapwa and Simukoko (2001) who observed that increase in nitrogen supplementation increased growth rate. Treatment T_6 had the highest daily live weight gain, showing that CSC with high dietary nitrogen (CP) served as the best supplement. Rams supplemented with CSC had relatively higher weight gains than those supplemented with cereal by – products. The reason could possibly be that CSC, apart from supplying nitrogen, supplies energy and other nutrients.

Cottonseed cake was the most effective protein supplement in terms of both intake and weight gain. In the supplemented groups, the quantity of protein offered was similar, suggesting that the intake of basal diet was influenced by the source of protein supplement.

Table 4.29. Growth performance of Rams fed cowpea hay or groundnut haulm with different supplements

	Treatments								
Indices	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	SEM
Initial weight (kg)	19.0^a	19.0^a	19.1^a	19.1^a	19.1^a	19.1^a	19.0^a	19.0^a	0.02
Final weight (kg)	24.2^b	24.5^{ab}	22.8^c	24.3^b	23.9^b	26.02^a	24.0^a	25.3^a	0.41
Mean weight gain (kg)	5.2^c	5.4^c	3.7^d	5.3^c	4.8^{cd}	6.92^a	5.0^c	6.2^b	0.42
Daily weight gain (g)	92.9^c	96.4^c	66.07^e	94.6^c	85.7^d	115.3^a	89.3^{cd}	110.7^b	7.49

Means within the same row and with the same letters are not significantly different ($p>0.05$)

T_1 = Groundnut hay only
T_2 = Groundnut hay + CSC
T_3 = Groundnut hay + BW
T_4 = Groundnut hay + MB
T_5 = Cowpea hay only
T_6 = Cowpea hay + CSC
T_7 = Cowpea hay +BW
T8 =Cowpea hay +MB

4.9 Experiment IV:

Feed Intake, Digestibility and Microbial N Supply

The results of dry matter intake, diet digestibility and microbial Nitrogen supply of rams fed cowpea husk or *Digitaria decumbens* (pangola) grass with different supplements (maize bran, cotton seed cake and brewers waste) is shown in Table 4.30. The highest dry matter intake (850.03g and 810.1g) were recorded in animals fed cowpea husk or grass supplemented with CSC (T_2 and T_6). While the lowest dry matter intake of 680.1g/animal/d and 670.1g per animal/d were obtained in the unsupplemented (control) groups T_1 and T_5. This finding is consistent with the report of Bailey and Sim (1998) who reported that organic matter intake of sheep supplemented with CSC meal was higher ($P<0.01$) than lambs fed with hay (control) only.

Table 4.30 shows the results of nutrients digestibility of cowpea husk or grass which ranges from 55.2% to 69.02%. The highest nutrients digestibility was recorded in T_2 (69.02%) where cowpea husk was supplemented with CSC and the lowest in the unsupplemented T_1 (56.6%) cowpea husk only (control). Digestible organic mater and Nitrogen intake were highest in the supplemented groups than the unsupplemented (control). This suggests that supplementation increases digestible nutrients intake thereby increasing total dry matter consumption. This findings agrees with Hossain *et al*. (2003) that the digestibility of organic mater, dry matter and crude fibre increased significantly ($p<0.05$) as the level of dietary energy supplementation was increased.

Retained Nitrogen ranged from 6.9 to 10.7g/day and showed significant difference between treatments ($p<0.05$). The highest retained nitrogen was recorded in T_2 (10.g) while T_5 (6.9g) recorded the lowest.

Table 4.30: Feed intake, digestibility, retained nitrogen and estimated microbial nitrogen supply in Rams fed cowpea husk or grass with different supplements

	Treatments								
Parameters	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	SEM
DMI (g/a/d)	680.1^{f}	850.03^{a}	731.1^{e}	780.03^{d}	650.03^{b}	810.1^{f}	670.1^{g}	820.1^{b}	27.07
OMI (g/a/d)	657.9^{g}	839.1^{a}	724.5^{e}	784.0^{d}	624.7^{h}	795.1^{c}	660.3^{f}	807.1^{b}	28.25
DOMI (%)	427.8^{c}	545.5^{a}	470.1^{e}	427.6^{g}	406.1^{h}	516.8^{c}	429.1^{f}	524.7^{ga}	18.38
Nitrogen Intake (g/kg)	42.5^{c}	53.13^{a}	45.69^{b}	48.75^{ab}	40.63c	50.63^{a}	41.88^{c}	51.26^{a}	6.78
Digestibility of nitrogen (%)	56.6^{b}	69.02^{a}	58.3^{b}	61.2^{ab}	55.2^{b}	63.0^{a}	58.5^{b}	62.6^{a}	1.38
Urine nitrogen (L)	20.92^{c}	30.70^{a}	22.70^{c}	28.82^{a}	20.83^{c}	26.90^{ab}	21.60^{c}	29.16^{a}	3.48
Feaces Nitrogen (g/kg)	12.77^{b}	11.73^{bc}	17.07^{a}	11.23^{c}	12.90^{b}	14.13^{b}	12.68^{b}	13.30^{b}	2.30
Retained Nitrogen (g/a/d)	7.03^{b}	10.7^{a}	7.7^{d}	8.7^{c}	6.9^{f}	9.6^{d}	7.6^{d}	8.8^{c}	0.47
Microbial protein g Nitrogen/ gN/kgDOMI	38.45^{c}	56.40^{a}	45.10^{b}	52.1^{a}	30.40^{d}	53.10^{a}	49.10^{b}	50.41^{ab}	1.79

Means within the same row and with the same letters are not significantly different ($p>0.05$).

T_1= Cowpea husk Only
T_2= Cowpea husk + CSC
T_3= Cowpea husk + BW
T_4= Cowpea Husk + MB
T_5= Grass only
T_6= Grass + CSC
T_7= Grass + BW
T_8= Grass + MB

DMI = Dry Matter Intake
OMI = Organic Matter Intake
DOMI = Digestible Organic Matter Intake

The retained nitrogen supply was closely related to intake of digestible organic matter intake (DOMI). The relationship between intake of DOMI and MN was the same for all the diets. This result agrees with the values of 5.9 to 10.4 gN/day reported by Kibon *et al*. (2001).

The rams fed T_2 had the highest microbial protein nitrogen of 56.4gN/kgDOMI while the lowest value of 30.4gN/kgDOMI was recorded in animals fed $T_{5.}$ This findings agrees with Orden *et al*. (2000) that supplementation in sheep resulted to increase in total dry matter intake and N digestibility which eventually improve N retention and microbial protein synthesis.

Cowpea husk supplemented with cotton seed cake had significant effect on DMI than other treatments indicating that microbial protein supply increased with cotton seed cake supplementation.

The result of nitrogen balance (retention) of rams fed cowpea husk or grass with different supplements is shown in Table 4.30. It shows that rams fed cowpea husk or grass supplemented with CSC, MB and BW gave a higher ($P<0.05$) N-retention compared with the control groups. Almost half of the N consumed was voided through the faeces, the control groups. The feacal N loss in this study was significantly higher in the supplemented than the control. This could be due to greater proportion of N attached to the cell wall which typically had lower degradability (Orden *et al*., 2000).

The retained nitrogen ranged from 7.03 to 9.5 gN/day with significant ($p<0.05$) difference between treatments (Table 4.31). Similarly, the results obtained here are within the range of 4.9 to 9.6gN/d reported by Rameirex-Aviles *et al.* (2004). They opined that *Gliricidea sepium* when incorporated into low quality diet of grasses increased retained nitrogen in the small intestine of sheep. This is attributed to a more balanced supply of energy and nitrogen to the

Table 4.31. Feed intake, digestibility and estimated microbial N supply in Rams fed cowpea hay or groundnut haulms with difficult supplement.

				Treatment					
Parameters	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	SEM
DMI (g/a/d)	700.03^{h}	810.3^{d}	710.7^{g}	720.3^{f}	750.6^{e}	910.4^{a}	810.5^{c}	870.2^{b}	27.39
OMI (g/a/d)	679.4^{b}	791.0^{c}	705.7^{g}	712.2^{f}	750.0^{e}	899.6^{a}	789.3^{d}	861.4^{h}	27.37
DOMI (%)	441.6^{h}	514.2^{c}	458.7^{g}	462.9^{f}	484.3^{e}	584.7^{a}	513.1^{d}	560.0^{b}	17.85
Nitrogen Intake (g/kg)	43.77^{c}	50.64^{b}	44.42^{c}	45.02^{c}	46.91^{c}	56.90^{a}	50.66^{b}	54.39^{a}	11.63
Digestibility of Nitrogen (%)	55.7^{b}	57.3^{ab}	56.0^{b}	60.2^{a}	58.5^{ab}	62.1^{a}	57.4^{ab}	60.1^{a}	0.64
Urine Nitrogen (L/kg)	20.04^{c}	27.53^{ab}	22.12^{c}	26.32^{b}	24.17	28.70^{a}	27.06^{ab}	30.09^{a}	3.21
Feaces nitrogen (g/kg)	16.70^{ab}	15.41^{b}	15.20^{b}	10.10^{c}	15.04^{b}	18.70^{a}	15.20^{b}	15.10^{b}	4.52
Retained Nitrogen (gN/Kg)	7.0^{f}	7.7^{e}	7.13^{f}	8.6^{c}	7.7^{e}	9.5^{a}	8.4^{d}	9.2^{f}	0.32
Microbial protein (gNitrogen/kg DOMI)	54.0^{a}	43.4^{b}	40.8^{b}	55.3^{a}	50.4^{ab}	58.4^{a}	48.6^{ab}	56.9^{a}	1.76

Means within the same row and with same letters are not significantly different ($p>0.05$)

T_1= Groundnut hay only
T_2= Groundnut hay + CSC
T_3= Groundnut hay + BW
T_4= Groundnut hay + MB

T_5= Cowpea hay only
T_6= Cowpea hay + CSC
T_7= Cowpea hay + BW
T_8= Cowpea hay + MB

DMI = Dry Matter Intake

OMI = Organic Matter Intake

DOMI = Digestible Organic Matter Intake

rumen microorganisms. The result of this research is in line with the findings of Barley and Sim (1998) who revealed that nitrogen balance was more favourable ($p<0.01$) for supplemented lambs (+5.7 gN/day) than for unsuppelemnted lambs (+1.7 gN/day). They opined that lambs supplemented with gamagrass grain (+6.3 gN/day) retained more ($p<0.01$) nitrogen than lambs supplemented with cottonseed meal (+5.0 gN/day) even though nitrogen intake was similar ($p=0.98$).

Table 4.31 shows results of dry matter intake, diet digestibility and retained nitrogen of rams fed cowpea or groundnut haulms with different supplements. The highest dry matter intake (910.4 and 810.3g/a/d) were recorded in T_6 (cowpea hay + CSC) and T_2 (Groundnut hay + CSC) while the lowest dry matter intake of 750.6 and 700.03g/a/d were obtained in T_5 (cowpea hay only) and T_1 (groundnut hay control groups). Supplementation increased ($p<0.05$) total dry matter consumption. This agrees with Orden *et al.* (2000) that supplementation of feeds resulted in an increased total dietary consumption. Those treatments that were supplemented performed better in terms of total dry matter intake than the control groups.

The digestibilities of diets are also shown in Table 4.31. Nutrients digestibility ranges from 55.7% to 62.1% with supplemented treatments having the highest digestibilities and the lowest digestibilities were recorded in the unsupplemented (groups). Rams fed groundnut hay supplemented with maize bran T_4 (60.2%) recorded higher digestibility as compared to control T_1 (55.7%) groundnut hay only. Similarly, rams fed cowpea hay supplemented with cottonseed cake T_6 (62.1%) gave the highest digestibility.

4.9.1 Rumen Ammonia Nitrogen Concentration.

Results of rumen ammonia nitrogen concentration of rams fed cowpea husk or grass with different supplements are shown in Tables 4.32. The highest rumen NH_3-N concentration was obtained in T_2 (cowpea husk + CSC) and the lowest in T_1, cowpea husk only, control.

Table 4.32: Rumen Ammonia Nitrogen (NH_3-N), total volatile fatty acids (VFA) concentration and pH in Yankasa Rams fed cowpea husk or *D. decumbens* with different supplements.

	Treatments								
Parameters	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	SEM
Ammonia (mg/100ml)	53.8^{f}	94.60^{a}	80.5^{b}	62.2^{d}	51.8^{f}	83.1^{b}	58.1^{e}	76.5^{c}	5.55
TotalVFA Mmol/100ml)	36.3^{d}	102.7^{a}	38.5^{d}	44.1^{cd}	38.5^{cd}	46.1^{b}	38.5^{d}	52.5^{c}	9.70
pH	6.60^{b}	6.78^{a}	6.62^{ab}	6.60^{ab}	6.60^{b}	6.73^{b}	6.62^{ab}	6.63^{ab}	0.18

Means within the same row and with the same letters are not significantly different ($p>0.05$).

Key

T_1= Cowpea husk only

T_2= Cowpea husk + CSC

T_3= Cowpea husk + BW

T_4= Cowpea husk +MB

T_5= Grass only

T_6= Grass+CSC

T_7= Grass + BW

T_8=Gras + MB

The significantly higher ($P<0.05$) rumen NH_3-N in the supplemented group suggests that supplementation provided additional degradable N on top of the readily soluble N from crop residues or grass (Orden *et al*., 2000).

Table 4.33 shows the result of feeding cowpea hay or groundnut haulms with different supplements to rams on NH_3 – N concentration. The results indicate a higher proportion (106.2 mg/100ml NH_3-N) was released in T_6 (cowpea hay + CSC), while the lowest NH_3 - N concentration was recorded in T_1 (59.1) in which groundnut haulms only (control) was fed.. Rumen NH_3 – N levels were higher ($P< 0.05$) in supplemented than the control groups. The levels of rumen NH_3 recorded in this study is higher than the recommended 50mg/l (Satter and Slyter, 1974) for maximum microbial growth that could effect optimum performance. Lower values of 50mg/l inhibit microbial activity, while much higher values lead to appreciable nitrogen loss by absorption through the ruminants' epithelium.

4.9.2 Rumen Volatile Fatty Acids

The result of total volatile fatty acids (VFA) obtained in this study for rams fed cowpea husk or grass with different supplements is shown in Table 4.32 The highest VFA was recorded in T_2 (102.7Mmol/100ml) where CSC supplemented cowpea husk and the lowest was obtained in the unsupplemented group T_1 (36.3 Mmol/100,). The total VFA concentration obtained in this study was higher than what Olaleru (1995) reported (4.48 – 4.85Mmol/100ml).

Table 4.33 shows total VFA released where animals were fed cowpea hay or groundnut haulms with different supplements. The highest volatile fatty acid produced was in T_6 and the lowest was recorded in T_1. Rams fed supplemented diets had substantial quantities of VFA which led to their better performances .This tallies with the report of Adegbola (2002) that a favorable performance of rams is recorded with optimum production of VFA.

Table 4.33: Rumen Ammonia Nitrogen (NH_3-N), total volatile fatty acids (VFA) concentration and pH in Yankasa Rams fed cowpea hay or groundnut haulms with different supplements.

	Treatments								
Parameters	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	SEM
Ammonia (mg/100ml)	66.8^{d}	68.5^{d}	59.1^{d}	78.0^{c}	66.5^{d}	106.2^{a}	81.8^{c}	81.8^{c}	5.70
TotalVFA (Mmol/100ml)	65.7^{fe}	73.9^{df}	80.6^{f}	76.6^{cd}	88.4^{df}	107.7^{a}	79.9^{c}	79.9^{c}	4.90
pH	6.62^{ab}	6.62^{ab}	6.64^{ab}	6.65^{ab}	6.60^{ab}	6.74^{a}	6.66^{a}	6.72^{a}	0.14

Key

Means within the same row and with same letters are not significantly different ($p>0.05$)

T_1= Groundnut hay only
T_2= Groundnut hay + CSC
T_3= Groundnut hay + BW
T_4= Groundnut hay + MB
T_5= Cowpea hay only
T_6= Cowpea hay + CSC
T_7= Cowpea hay + BW
T_8= Cowpea hay+MB

4.9.3 Rumen pH Concentration

Tables 4.32 and 4.33 showed pH concentrations of animals fed cowpea husk or grass with different supplements and cowpea hay or groundnut haulms with different supplements. Higher pH was recorded in animals fed supplemented diets compared with the basal. The reason could have been as a result of the fact that these supplememts are leguminous crops which naturally stored nitrogen in their root nodlues. Rumen pH increased significantly ($p<0.05$) with supplementation hence tending towards alkalinity. This pH condition is known as the best for feed conversion inside the rumen. The pH concentrations obtained in this study agreed with the reports of Orskov and Ryle (1998) who further stated that cellulolytic bacteria needed pH between the range 6.2 and 7.0 in order to multiply for feed conversion in the rumen. Rumen pH, values in all the treatments were suitable for fibre digestion and optimum microbial protein synthesis (Orskov, 1994).

CHAPTER FIVE

5.0 SUMMARY, CONCLUSION AND RECOMMENDATION

5.1. SUMMARY

In experiment 1 field survey for identification of resources for feeding ruminants was carried out .The state was divided into four zones: Mubi, Gombi, Mayo-Belwa and Guyuk. Feed resources were identified and selected based on preference and chemical analysis. Percentage availability of the survey revealed that pangola grass, guinea grass, gamba elephant ficus, leucaena, mahogany, acacia, cowpea hay, groundnut hay, maize stover, rice straw, cowpea husk, maize bran, brewers, cottonseed cake were the most available in the state.

Proximate composition of some available feeds showed a range of 7.1% - 11.2% for crude protein and 33.0% – 38.0% for crude fibre for the following grasses: Guinea, Pangola, Gamba, Kikuyu, Finger, Elephant, Signal, Jaagwa and Bracharia. Some browse plants had a range of 6.6% -25.09% for crude protein and 21.0% - 30.0% for crudee fibre for *Ficus sycomorus*, *Ficus platyphylla*, Christ thorn, Acacia, Mahogany, Custard apple and *Balanite aegyptica*. The crop residues such as cowpea hay, groundnut haulms, maize cob, sorghum stover and maize stover were analysed with crude protein (3.0% - 16.5%) and crude fibre (14.0% - 42.5%) recorded. The Agricultural by-products analsyed had crude protein (4.4% - 36.50%) and crude fiber (3.3% - 36.4%)

The degradability of the feeds was determined using rumen degradability for proper ranking of the feeds.The results showed that more than 50% of the following feeds degraded at 48 hours: *Khaya senegalensis*, *Ficus sycomorus*, *Leucaena*, cowpea husk, cowpea hay, elephant grass hay, guinea grass hay, groundnut haulms, pangoila grass hay, gamba grass hay, maize bran, brewers waste, sorghum bran, millet bran, cottonseed cake, sweet-pottao peels, yam peels and cassava peels.

Based on chemical analysis and rumen degradability results feeds were classified into basal and supplements. Feed that were bulky (groundnut hay, cowpea husk, maize stover) which have more than 18% crude fibre were classified as basal while those with less than 18% crude fibre and are lesser in quantity, (maize bran, brewers waste, cottonseed cake and yam peels as supplements) were classified as supplements.

In experiement II, twenty four (24) Yankasa rams were fed cowpea husk or pangola grass as basal diets with cottonseed cake, brewers waste and maize bran as supplements. The highest dry matter intake (960.45g/a/d) was recorded in Yankassa rams fed T_2 (cowpea husk + CSC) and lowest in rams fed T_5 (grass only). The dry matter digestibility ranged from 57.8 % - 69.2%. The highest Live weight gain (88.9g/a/d) was recorded in T_2 while lowest (32.1g/a/d) in T_5. Highest water intake (3.2L/a/d) was obtained in T_2 and lowest (2.3L/a/d) in T_8.

In experiement III, twenty four (24) Yankasa rams were fed cowpea hay or groundnut haulms as basal diets with cottonseed cake, brewers waste and maize bran as supplements. The highest dry matter intake (947.7g/a/d) was recorded in T_6 (sowpea hay + CSC) while the lowest (766.7g/a/d) in T_1 (Groundnut hay only). The dry matter digestibility ranged from 51% - 68%. The highest Live weight gain (115.3g/a/d) was recorded in T_6. Water intake ranged from 2.9 - 3.4 (L/a/d).

In experiement IV, Yankassa rams were divided into two groups. In group A, Eight (8) rams were fed cowpea husk or grass with different suppelements as in Experiment III. The highest estimated retained nitrogen (10.7gN/kg DOMI) was recorded in T_2 (cowpea husk + CSC) and the lowest, (6.9gN/kg) in T_5 (grass only). Group B comprised of another eight (8) rams fed groundnut haulms or cowpea hay with different supplements as in experiment III.The result showed highest retained nitrogen, (9.5gN/kg) in T_6 (cowpea hay + CSC) and the lowest of 7.0gN/kg was recorded in T_1 (groundnut haulms only). Rumen ammonia recorded ranged from 51-94.60, Total VFA 36.3-102.7 Mmol, pH of 6.60-6.78 for rams fed cowpea husk or grass with different supplement. Rams fed cowpea or groudnut haulms with different supplements had Rumen Ammonia, 59.1-103.2 Mmol, Total VFA, 65.7-107.7 and pH 6.60-6.74.

Conclusion

Local feeds resources for feeding small ruminants are in abundance in Adamawa state. Field survey conducted revealed that Pangola grass, Guinea grass, Carpet grass, Gamba grass, Elephant grass, Finger grass and among browse are *Ficus sychomorus*, *Khaya senegalensis*, Christ thorn, Leucaena, Mahogany, Wild apple, *Balanite aegyptica* and Acacia were the most abundant feed resources in the state. Also cowpea hay, groundnut haulms, sorghum stover, maize cobs, maize stover, rice straw, sweet potato leaves were identified as some of the crop residues for feeding small ruminants. Some Agricultural by-products like maize bran, brewers wastes, cassava peels, yam peels and cowpea husk are in abundance in the state.

Based on the proximate composition, the feed resources were classified as basal and supplement feeds and ranked according to the rumen degradability results. Rams fed cowpea husk+ CSC had the highest dry matter intake and Live weight gain.

Recommendation

Based on the results of this study, Yankassa Rams performed better when fed either cowpea hay or cowpea husk supplemented with cottonseed cake but for profitability and sustainability cowpea husk supplemented with cottonseed cake is recommended.

Contribution to knowledge

i. This can be used as data for small ruminants in the state.

ii. The findings of this research can be used for upgrading agricultural policies for small ruminants production adanamawa state.

iii. Extension officers can also use the knowledge to etahc farmers at various levels in their domain.

iv. It can also be used in trianign workshops for small ruminant farmers in Adamawa state.

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APPENDIX I.

EFFECT OF GRASS AND COWPEA HUSK AND DIFFERENT SUP PLEMENTS WITHIN THE TREATMENTS DRY MATTER

ANOVA Table:

Source of variation	Degrees of freedom	Sum of squares	Mean square
Treatment (between columns)	7	936728	133818
Individual (between rows)	23	255423	11105
Random (residual)	161	802321	4983.4
Total	191	1994471	

F = 26.853 =MStreatment/MSresidual

Summary of Data

Group	Number of Points	Mean	Standard Deviation	Standard Error of Mean	Median
T1	24	1007.2	117.82	24.049	1012.7
T2	24	881.73	56.924	11.620	893.70
T3	24	801.77	43.204	8.819	797.15
T4	24	807.59	91.146	18.605	837.50
T5	24	820.83	46.244	9.440	827.95
T6	24	942.67	70.848	14.462	965.65
T7	24	807.93	67.129	13.703	794.65
T8	24	871.28	83.841	17.114	850.90

APPENDIX II

EFFECT OF COWPEA HUSKS AND GRASS WITH SUPPLEMENTS WITHIN THE WEEKS DRY MATTER INTAKE

One-way Analysis of Variance (ANOVA)

ANOVA table:

Source of variation	Degrees of freedom	Sum of squares	Mean square
Treatments (between columns)	23	255423	11105
Residuals (within columns)	168	1739048	10351
Total	191	1994471	

F = 1.073 =(MStreatment/MSresidual)

Summary of Data

Group	Number of Points	Mean	Standard Deviation	Standard Error of Mean
WK1	24	822.8	92.29	33.34
WK2	24	842.98	92.35	32.65
WK3	24	856.03	83.80	29.63
WK4	24	862.04	141.43	50.00
WK5	24	901.99	82.80	29.27
WK6	24	873.39	117.15	41.42
WK7	24	889.28	82.20	29.06
WK8	24	892.51	92.46	32.69

APPENDIX III

EFFECT OF WATER INTAKE ON RAMS FED COWPEA HUSKS AND GRASS

ANOVA Table:

Source of variation	Degrees of freedom	Sum of squares	Mean square
Treatment (between columns)	7	10.484	1.498
Individual (between rows)	23	42.717	1.857
Random (residual)	161	50.818	0.3156
Total	191	104.02	

F = 4.745 =MStreatment/MSresidual

Summary of Data

Group	Number of Points	Mean	Standard Deviation	Standard Error of Mean	Median
T1	24	3.213	0.8083	0.1650	2.900
T2	24	2.367	0.5370	0.1096	2.400
T3	24	2.513	0.8794	0.1795	2.400
T4	24	2.525	0.5914	0.1207	2.450
T5	24	2.638	0.7717	0.1575	2.500
T6	24	2.650	0.6744	0.1377	2.700
T7	24	2.571	0.6491	0.1325	2.600
T8	24	2.642	0.7283	0.1487	2.600

APPENDIX IV

EFFECT OF WATER INTAKE ON RAMS FED COWPEA HUSKS AND GRASS

Repeated Measures Analysis of Variance

ANOVA Table:

Source of variation	Degrees of freedom	Sum of squares	Mean square
Treatment (between columns)	23	42.717	1.857
Individual (between rows)	7	10.484	1.498
Random (residual)	161	50.818	0.3156
Total	191	104.02	

F = 5.884 =MStreatment/MSresidual

Summary of Data

Group	Number of Points	Mean	Standard Deviation	Standard Error of Mean	Median
WK1R1	8	3.388	0.8509	0.3009	3.250
WK1R2	8	3.375	0.5203	0.1840	3.400
WK1R3	8	2.875	0.5258	0.1859	2.800
WK2R1	8	3.475	0.9192	0.3250	3.650
WK2R2	8	3.713	0.6999	0.2474	4.000
WK2R3	8	3.488	0.9790	0.3461	3.500
WK3R1	8	2.225	0.4833	0.1709	2.250
WK3R2	8	2.175	0.3808	0.1346	2.150
WK3R3	8	2.325	0.4621	0.1634	2.450
WK4R1	8	2.363	0.5975	0.2112	2.300
WK4R2	8	2.300	0.4986	0.1763	2.450
WK4R3	8	2.100	0.4504	0.1592	2.150
WK5R1	8	2.463	0.7170	0.2535	2.500
WK5R2	8	2.438	0.5854	0.2070	2.500
WK5R3	8	2.463	0.4779	0.1690	2.600
WK6R1	8	2.488	0.5463	0.1931	2.450
WK6R2	8	2.788	0.6334	0.2240	2.900
WK6R3	8	2.288	0.5303	0.1875	2.450
WK7R1	8	2.563	0.6653	0.2352	2.550
WK7R2	8	2.463	0.4340	0.1535	2.500
WK7R3	8	2.200	0.3891	0.1376	2.150
WK8R1	8	2.638	0.6346	0.2244	2.550
WK8R2	8	2.450	0.5425	0.1918	2.500
WK8R3	8	2.313	0.4970	0.1757	2.450

APPENDIX V

EFFECT OF WATER INTAKE ON RAMS FED COWPEA AND GROUNDNUT HAYS

ANOVA Table:

Source of variation	Degrees of freedom	Sum of squares	Mean square
Treatment (between columns)	7	8.063	1.152
Individual (between rows)	23	11.880	0.5165
Random (residual)	161	26.263	0.1631
Total	191	46.206	

F = 7.061 =MStreatment/MSresidual

Summary of Data

Group	Number of Points	Mean	Standard Deviation	Standard Error of Mean	Median
T1	24	3.379	0.5389	0.1100	3.450
T2	24	3.392	0.2992	0.06106	3.450
T3	24	2.904	0.5544	0.1132	2.950
T4	24	3.413	0.2802	0.05720	3.400
T5	24	3.075	0.4711	0.09617	3.000
T6	24	3.263	0.4271	0.08719	3.350
T7	24	2.858	0.5405	0.1103	3.000
T8	24	3.196	0.4428	0.09039	3.150

APPENDIX VI

DMD% OF YANKASSA FED COWPEA HUSK AND GRASS WITH SUPPLEMENTS

ANOVA Table:

Source of variation	Degrees of freedom	Sum of squares	Mean square
Treatment (between columns)	7	529.27	75.609
Individual (between rows)	5	3.395	0.6790
Random (residual)	35	87.712	2.506
Total	47	620.37	

F = 30.171 =MStreatment/MSresidual

Summary of Data

Group	Number of Points	Mean	Standard Deviation	Standard Error of Mean	Median
T1	6	69.200	0.08944	0.03651	69.200
T2	6	62.600	3.119	1.273	61.000
T3	6	57.867	0.4412	0.1801	58.100
T4	6	61.767	2.582	1.054	60.100
T5	6	61.200	0.8532	0.3483	61.300
T6	6	60.567	0.4590	0.1874	60.700
T7	6	57.833	0.5750	0.2348	58.100
T8	6	61.867	0.5955	0.2431	62.200

APPENDIX VII.

CPD% OF YANKASSA FED COWPEA HUSK AND GRASS WITH SUPPLEMENTS

ANOVA Table:

Source of variation	Degrees of freedom	Sum of squares	Mean square
Treatment (between columns)	7	178.34	25.477
Individual (between rows)	5	10.422	2.084
Random (residual)	35	115.38	3.297
Total	47	304.14	

F = 7.728 =MStreatment/MSresidual

Summary of Data

Group	Number of Points	Mean	Standard Deviation	Standard Error of Mean	Median
T1	6	66.933	0.5086	0.2076	67.100
T2	6	66.633	0.5241	0.2140	66.400
T3	6	63.033	0.9395	0.3836	63.000
T4	6	63.067	1.603	0.6546	64.000
T5	6	66.200	4.570	1.866	69.100
T6	6	68.000	0.1549	0.06325	68.100
T7	6	67.367	0.4926	0.2011	67.100
T8	6	68.333	0.1366	0.05578	68.300

APPENDIX VIII

CFD% OF YANKASSA FED COWPEA HUSK AND GRASS WITH DIFFERENT SUPPLEMENTS

ANOVA Table:

Source of variation	Degrees of freedom	Sum of squares	Mean square
Treatment (between columns)	7	694.63	99.233
Individual (between rows)	5	18.692	3.738
Random (residual)	35	69.638	1.990
Total	47	782.96	

F = 49.875 =MStreatment/MSresidual

Summary of Data

Group	Number of Points	Mean	Standard Deviation	Standard Error of Mean	Median
T1	6	58.033	0.1366	0.05578	58.000
T2	6	53.713	0.2237	0.09131	53.600
T3	6	44.967	0.9564	0.3904	44.400
T4	6	52.733	2.655	1.084	52.000
T5	6	58.100	0.08944	0.03651	58.100
T6	6	53.100	0.08944	0.03651	53.100
T7	6	54.100	3.100	1.265	56.000
T8	6	53.200	0.08944	0.03651	53.200

APPENDIX IX

DMD% OF THE PERFORMANCE OF YANKASSA FED COWPEA AND GROUNDNUT HAYS WITH SUPPLEMENTS

ANOVA Table:

Source of variation	Degrees of freedom	Sum of squares	Mean square
Treatment (between columns)	7	393.07	56.152
Individual (between rows)	5	1.607	0.3213
Random (residual)	35	23.447	0.6699
Total	47	418.12	

F = 83.821 =MStreatment/MSresidual

Summary of Data

Group	Number of Points	Mean	Standard Deviation	Standard Error of Mean	Median
T1	6	63.300	0.6753	0.2757	63.200
T2	6	61.667	0.2582	0.1054	61.500
T3	6	59.500	1.183	0.4830	60.000
T4	6	53.967	0.1366	0.05578	54.000
T5	6	58.400	0.5441	0.2221	58.100
T6	6	62.433	0.1033	0.04216	62.500
T7	6	57.067	1.652	0.6746	56.000
T8	6	59.300	0.1789	0.07303	59.300

APPENDIX X

CPD% PERFORMANCE OF YANKASSA FED COWPEA AND GROUNDUNT HAYS

ANOVA Table:

Source of variation	Degrees of freedom	Sum of squares	Mean square
Treatment (between columns)	7	387.72	55.389
Individual (between rows)	5	0.6467	0.1293
Random (residual)	35	4.380	0.1251
Total	47	392.75	

F = 442.60 =MStreatment/MSresidual

Summary of Data

Group	Number of Points	Mean	Standard Deviation	Standard Error of Mean	Median
T1	6	68.133	0.1862	0.07601	68.200
T2	6	68.133	0.1366	0.05578	68.100
T3	6	63.467	0.6470	0.2642	63.100
T4	6	68.133	0.1366	0.05578	68.100
T5	6	63.833	0.6831	0.2789	64.000
T6	6	68.233	0.05164	0.02108	68.200
T7	6	64.067	0.1033	0.04216	64.000
T8	6	60.267	0.1862	0.07601	60.200

APPENDIX XI

CFD% PERFORMANCES OF YANKASSA FED COWPEA AND GROUNDNUT HAYS

ANOVA Table:

Source of variation	Degrees of freedom	Sum of squares	Mean square
Treatment (between columns)	7	306.59	43.799
Individual (between rows)	5	1.682	0.3363
Random (residual)	35	11.105	0.3173
Total	47	319.38	

F = 138.04 =MStreatment/MSresidual

Summary of Data

Group	Number of Points	Mean	Standard Deviation	Standard Error of Mean	Median
T1	6	54.067	0.2251	0.09189	54.100
T2	6	59.267	0.2582	0.1054	59.100
T3	6	51.000	0.1789	0.07303	51.000
T4	6	56.067	0.1033	0.04216	56.000
T5	6	59.100	0.1549	0.06325	59.000
T6	6	57.100	1.032	0.4211	57.000
T7	6	56.933	0.1033	0.04216	57.000
T8	6	56.833	1.140	0.4652	56.200

APPENDIX XII

DMI OF YANKASSA FED COWPEA HUSK AND GRASS WITH SUPPLEMENTS

ANOVA Table:

Source of variation	Degrees of freedom	Sum of squares	Mean square
Treatment (between columns)	7	4.008E+07	5725640
Individual (between rows)	5	1.149E+07	2298548
Random (residual)	35	8.033E+07	2295070
Total	47	1.319E+08	

F = 2.495 =MStreatment/MSresidual

Summary of Data

Group	Number of Points	Mean	Standard Deviation	Standard Error of Mean	Median
T1	6	924.00	0.8944	0.3651	924.00
T2	6	3688.7	4285.3	1749.5	923.00
T3	6	937.00	0.8944	0.3651	937.00
T4	6	930.00	0.8944	0.3651	930.00
T5	6	929.33	1.366	0.5578	929.00
T6	6	932.00	0.8944	0.3651	932.00
T7	6	914.00	1.549	0.6325	915.00
T8	6	914.00	2.366	0.9661	915.00

APPENDIX XIII

OMI OF YANKASSA FED COWPEA HUSK AND GRASS WITH SUPPLEMENTS

ANOVA Table:

Source of variation	Degrees of freedom	Sum of squares	Mean square
Treatment (between columns)	7	24716	3530.8
Individual (between rows)	5	6290.7	1258.1
Random (residual)	35	48989	1399.7
Total	47	79996	

F = 2.523 =MStreatment/MSresidual

Summary of Data

Group	Number of Points	Mean	Standard Deviation	Standard Error of Mean	Median
T1	6	799.33	104.83	42.798	866.00
T2	6	858.00	1.789	0.7303	858.00
T3	6	804.33	0.5164	0.2108	804.00
T4	6	833.00	1.789	0.7303	833.00
T5	6	808.67	6.772	2.765	812.00
T6	6	858.00	1.789	0.7303	858.00
T7	6	849.00	2.683	1.095	849.00
T8	6	818.00	1.789	0.7303	818.00

APPENDIX XIV

DOMI OF YANKASSA FED COWPEA HUSK AND GRASS WITH SUPPLEMENTS

ANOVA Table:

Source of variation	Degrees of freedom	Sum of squares	Mean square
Treatment (between columns)	7	10044	1434.8
Individual (between rows)	5	0.2317	0.04633
Random (residual)	35	8.195	0.2341
Total	47	10052	

F = 6128.0 =MStreatment/MSresidual

Summary of Data

Group	Number of Points	Mean	Standard Deviation	Standard Error of Mean	Median
T1	6	562.90	0.8944	0.3651	562.90
T2	6	557.70	0.8944	0.3651	557.70
T3	6	522.60	0.1789	0.07303	522.60
T4	6	541.57	0.1366	0.05578	541.60
T5	6	527.80	0.08944	0.03651	527.80
T6	6	557.77	0.1366	0.05578	557.80
T7	6	551.90	6.081E-17	2.483E-17	551.90
T8	6	531.70	0.08944	0.03651	531.70

APPENDIX XVI

NITROGEN CONTENT OF YANKASSA FED COWPEA HUSK AND GRASS

ANOVA Table:

Source of variation	Degrees of freedom	Sum of squares	Mean square
Treatment (between columns)	7	49.468	7.067
Individual (between rows)	5	0.01520	0.003040
Random (residual)	35	0.2664	0.007611
Total	47	49.749	

F = 928.45 =MStreatment/MSresidual

Summary of Data

Group	Number of Points	Mean	Standard Deviation	Standard Error of Mean	Median
t1	6	10.300	0.08944	0.03651	10.300
t2	6	10.100	0.08944	0.03651	10.100
t3	6	8.800	0.08944	0.03651	8.800
t4	6	7.600	0.08944	0.03651	7.600
t5	6	7.800	0.08944	0.03651	7.800
t6	6	9.600	0.08944	0.03651	9.600
t7	6	7.700	0.08944	0.03651	7.700
t8	6	9.020	0.01789	0.007303	9.020

APPENDIX XVII

DMI OF YANKASSA FED COWPEA AND GROUNDNUT HAYS WITH SUPPLEMENTS

ANOVA Table:

Source of variation	Degrees of freedom	Sum of squares	Mean square
Treatment (between columns)	7	3.994E+07	5706101
Individual (between rows)	5	1.140E+07	2280646
Random (residual)	35	7.981E+07	2280207
Total	47	1.311E+08	

F = 2.502 =MStreatment/MSresidual

Summary of Data

Group	Number of Points	Mean	Standard Deviation	Standard Error of Mean	Median
t1	6	915.00	0.8944	0.3651	915.00
t2	6	924.00	3.225	1.317	925.00
t3	6	916.40	0.4733	0.1932	916.20
t4	6	3677.1	4271.1	1743.7	920.20
t5	6	916.33	1.366	0.5578	916.00
t6	6	915.00	0.8944	0.3651	915.00
t7	6	916.00	1.789	0.7303	916.00
t8	6	929.00	0.8944	0.3651	929.00

APPENDIX XVIII

OMI OF YANKASSA FED COWPEA AND GROUNDNNUT HAYS SUPPLEMENT

ANOVA Table:

Source of variation	Degrees of freedom	Sum of squares	Mean square
Treatment (between columns)	7	106905	15272
Individual (between rows)	5	144.67	28.933
Random (residual)	35	288.67	8.248
Total	47	107339	

F = 1851.7 =MStreatment/MSresidual

Summary of Data

Group	Number of Points	Mean	Standard Deviation	Standard Error of Mean	Median
T1	6	874.33	1.366	0.5578	874.00
T2	6	817.00	0.8944	0.3651	817.00
T3	6	850.00	8.944	3.651	850.00
T4	6	818.00	0.8944	0.3651	818.00
T5	6	866.00	0.8944	0.3651	866.00
T6	6	828.00	0.8944	0.3651	828.00
T7	6	866.00	0.8944	0.3651	866.00
T8	6	718.00	0.8944	0.3651	718.00

APPENDIX XIX

DOMI OF YANKASSA FED COWPEA AND GROUNDUNT HAYS SUPPLEMENTS

ANOVA Table:

Source of variation	Degrees of freedom	Sum of squares	Mean square
Treatment (between columns)	7	45101	6443.0
Individual (between rows)	5	1.295	0.2590
Random (residual)	35	8.252	0.2358
Total	47	45111	

F = 27328 =MStreatment/MSresidual

Summary of Data

Group	Number of Points	Mean	Standard Deviation	Standard Error of Mean	Median
T1	6	568.07	0.05164	0.02108	568.10
T2	6	530.67	1.366	0.5578	531.00
T3	6	552.50	0.08944	0.03651	552.50
T4	6	531.70	0.08944	0.03651	531.70
T5	6	562.87	0.05164	0.02108	562.90
T6	6	538.13	0.1033	0.04216	538.20
T7	6	562.87	0.05164	0.02108	562.90
T8	6	466.70	0.08944	0.03651	466.70

APPENDIX XX

NITROGEN CONTENT YANKASSA COWPEA AND GROUNDNUT HAYS

ANOVA Table:

Source of variation	Degrees of freedom	Sum of squares	Mean square
Treatment (between columns)	7	46.246	6.607
Individual (between rows)	5	0.05167	0.01033
Random (residual)	35	0.3217	0.009190
Total	47	46.619	

F = 718.85 =MStreatment/MSresidual

Summary of Data

Group	Number of Points	Mean	Standard Deviation	Standard Error of Mean	Median
T1	6	10.067	0.1366	0.05578	10.100
T2	6	9.633	0.05164	0.02108	9.600
T3	6	7.500	0.08944	0.03651	7.500
T4	6	7.700	0.08944	0.03651	7.700
T5	6	8.800	0.08944	0.03651	8.800
T6	6	9.033	0.05164	0.02108	9.000
T7	6	7.400	0.08944	0.03651	7.400
T8	6	7.633	0.1366	0.05578	7.600

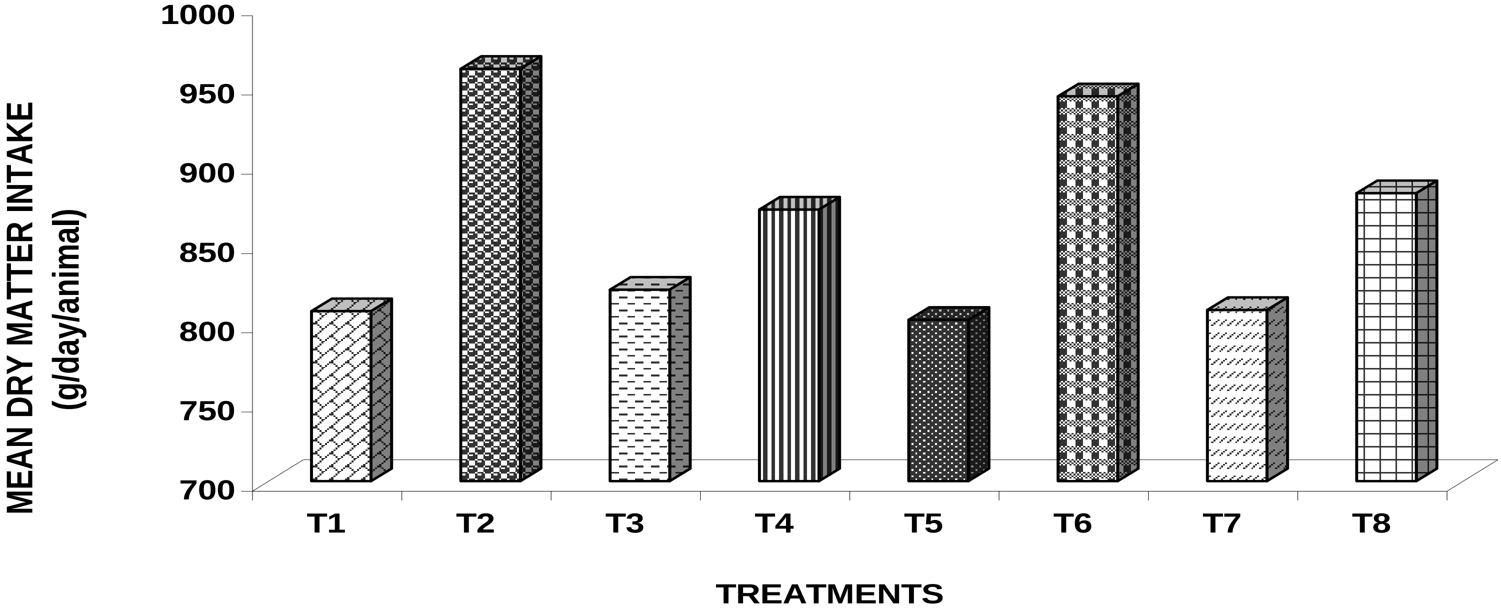

FIGURE 1. MEAN DRY MATTER INTAKE OF RAM FED COWPEA HUSKS AN GRASS WITH SUPPLEMENTS

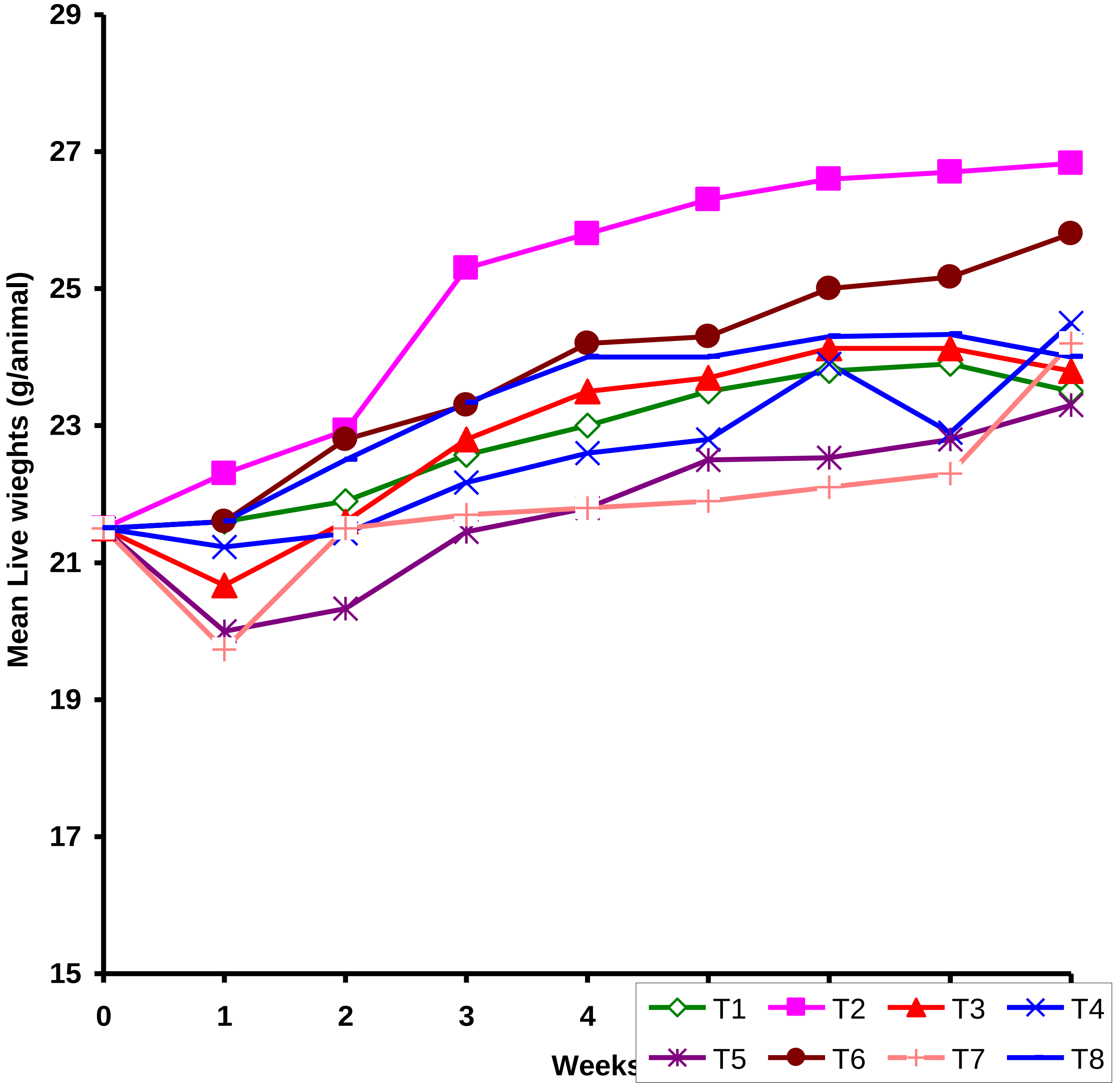

Figure 2. Mean weekly weight changes of Rams fed cowpea husks or grass with different supplements

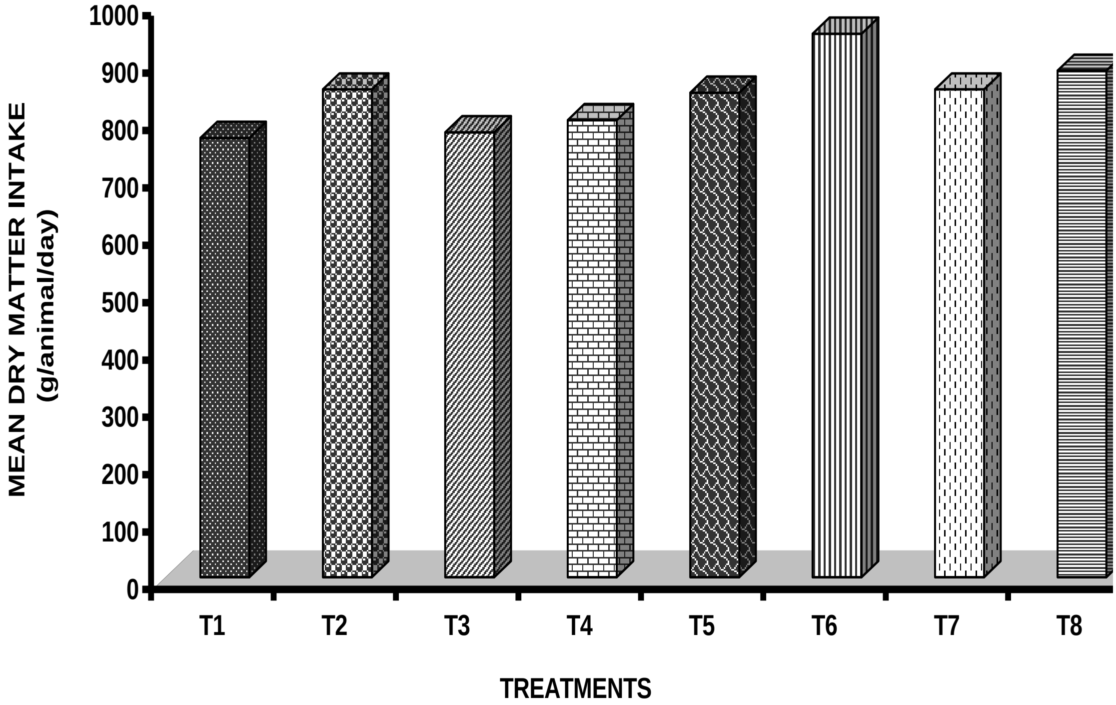

FIGURE 3. DRY MATTER INTAKE OF RAMS FED COWPEA AND GROUNDNUT HAYS WITH DIFFERENT SUPPLEMENTS

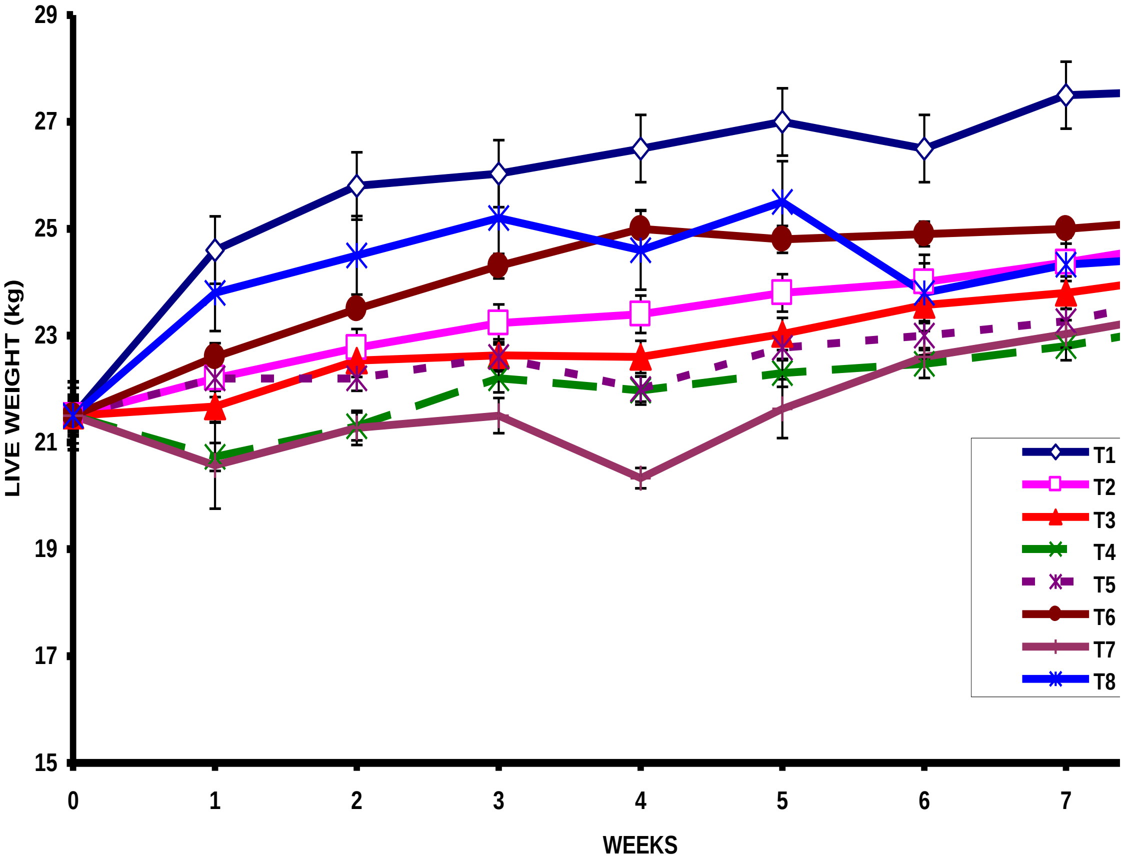

FIGURE 4. WEEKLY LIVE WEIGHT CHANGES OF RAM FED COWPEA AND GROUNDNUT WITH DIFFERENT SUPPLEMENTS FOR 56 DAYS