PERFORMANCE OF YANKASA RAMS OFFERED COWPEA HAULMS AS SUPPLEMENTS AT DIFFERENT LEVELS AND FREQUENCY TO A BASAL DIET OF SORGHUM STOVER.

BY

ABUBAKAR MUSA

DEPARTMENT OF ANIMAL SCIENCE,

FACULTY OF AGRICULTURE,

AHMADU BELLO UNIVERSITY, SAMARU, ZARIA.

NIGERIA

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Abubakar MUSA

PhD/AGRIC/42551/2012-2013

B.Sc. AGRICULTURE, AHMADU BELLO UNIVERSITY, ZARIA (1985).

M.Sc. ANIMAL SCIENCE, AHMADU BELLO UNIVERSITY, ZARIA, (1990).

A THESIS SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES, AHMADU BELLO UNIVERSITY, ZARIA, IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF DOCTOR OF PHILOSOPHY IN ANIMAL SCIENCE.

DEPARTMENT OF ANIMAL SCIENCE,

FACULTY OF AGRICULTURE,

AHMADU BELLO UNIVERSITY, SAMARU, ZARIA. NIGERIA.

FEBRUARY, 2016.

DECLARATION

I declare that the work in this thesis entitled "**PERFORMANCE OF YANKASA RAMS OFFERED COWPEA HAULMS AS SUPPLEMENTS AT DIFFERENT LEVELS AND FREQUENCY TO A BASAL DIET OF SORGHUM STOVER**" has been carried out by me in the Department of Animal Science, under the supervision of Dr D.D. Dung, Prof. O.S. Lamidi. and Dr. S.B. Abdu. The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this thesis was previously presented for another Degree or Diploma Certificate at any University.

________________________ ________________________

MUSA, Abubakar Date

CERTIFICATION

This thesis entitled "**PERFORMANCE OF YANKASA RAMS OFFERED COWPEA HAULMS AS SUPPLEMENTS AT DIFFERENT LEVELS AND FREQUENCIES TO A BASAL DIET OF SORGHUM STOVER.**" by Abubakar MUSA meets the regulations governing the award of the Degree of Doctor of Philosophy (Ph.D) of the Ahmadu Bello University, Zaria and is approved for its contribution to knowledge and literary presentation.

______________________________ ______________________

Dr D.D. DUNG Date

Chairman, Supervisory Committee,

National Animal Production Research Institute,
Ahmadu Bello University, Shika-Zaria.

______________________________ ______________________

Prof. O.S. LAMIDI Date

Member, Supervisory Committee,

National Animal Production Research Institute,
Ahmadu Bello University, Shika-Zaria.

______________________________ ______________________

Dr. S.B. ABDU Date

Member, Supervisory Committee,

Department of Animal Science,
Ahmadu Bello University, Samaru-Zaria.

______________________________ ______________________

Prof. S.DURU Date

Head, Department of Animal Science,
Ahmadu Bello University, Samaru-Zaria.

______________________ ______________________

Prof. K.BALA Date

Dean, School of Post-Graduate Studies,
Ahmadu Bello University, Samaru- Zaria.

DEDICATION

This thesis is dedicated to my late friend, Colonel **Abubakar Garba AHMAD** who made a big impact on my life during his life time. May his gentle soul rest in perfect peace.

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ABSTRACT

Two experiments (survey and feeding trial) were conducted in this study. The first Experiment was a Survey carried out at the West African Pilot Learning Sites, of Kano-Katsina-Maradi Pilot Learning Site (KKM PLS), Under the Forum for Agricultural Research in Africa (FARA) Challenge Project. The Survey was carried out to investigate the opinions of 100 households selected by random sampling from 5 targeted villages of Faruruwa, Alajawa, Ishiyawa, Fanteka and Kututture with 20 respondents per village. Data collected on all the households were analyzed using Descriptive Statistics by the application of Excel Spread Sheet. The most common livestock owned by farmers in these villages were goats and sheep, with 90.7% of the respondents owning does with kids and over 80% ownership of bucks. Possession of sheep with lambs and local breeds of rams constituted over 70%. Most farmers (62%) commonly owned less than 5 goats, while over 67% owned less than 5rams. Cattle ownership was less as compared to small ruminants in all the villages. Bucks and rams were owned by 81.5% and 71.3% respondents, respectively indicating the potential for small ruminant fattening programs as a means of income. Twenty five (25) % of the small ruminants were sold due to a lack of feed. Cattle were mostly housed in open kraal while small ruminants were provided with mud houses and kraals with roofs. More than 95% of respondents reported collecting crop residues for feeding, with less than 5% stating that they grazed residues in the field. Seventy-four percent (74%) of respondents reported purchasing sorghum and millet stover while 61 and 63% reported purchasing cowpea and groundnut haulms, respectively. Average prices paid per bundle (averaged 12kg) were ₦71 for sorghum stover and ₦72 for millet stover, indicating similar value for the two types of residue. The price per bag (averaged 17kg) of cowpea haulms was ₦340 and for groundnut haulms was ₦475. Bags of groundnut haulms are often slightly heavier than those of cowpea but groundnut often brings a slightly higher price even on an equal weight basis. Purchases of crop residues were made from as far away as 4-5 km in most cases and as far as about 15-25 km on big market days in minor cases. Farmers purchased concentrate feeds throughout the year. Average price of cottonseed cake was ₦2364 per 50 kg bag, ₦2226 for 50 kg wheat bran and ₦140 for 20 kg local mineral salt called (Kanwa). Land and occurrence of drought are perceived to be major constraints to livestock feeding. Over 80% were also willing to invest in improving animal health. The second Experiment was carried out to investigate the effect of supplementation of cowpea haulms at different feeding frequencies to sorghum stover basal diet on performance, and carcass characteristics. It involved fattening Yankasa rams in a 90day growth trial. A Completely Randomized Design (CRD) was applied with groups of eight rams (22.82 kg ±0.01) average weight and age (1.5 to 2 years), balanced by weight and allocated to five treatments; Basal sorghum stover as (Control) (T1), Control + 300g cowpea haulms fed once daily(T2), Control + 600g cowpea haulms fed once daily(T3), Control + 300g cowpea haulms fed twice daily (T4) and Control + 200g cowpea haulms fed thrice daily (T5). At the end of growth trial 8 rams from each group were slaughtered to study the carcass characteristics. Cell wall constituents (NDF, ADF and ADL) were higher in sorghum stover and cowpea haulms compared to wheat bran. The crude protein of cowpea haulms (13.35%) is higher than that of sorghum stover (1.77%). The average daily weight gain (ADWG) of ram fed T2 –T5 were significantly ($P<0.05$) higher than those fed T1 (Control) diet. Total feed intake TFI (g/d) was significantly ($P<0.05$) higher in rams fed treatmentsT2 to T5 diets and had similar trends for DM, OM NDF and ADF intakes. Increased supplementation of cowpea haulms resulted in more profit up to treatment T4 while the non-supplemented resulted in a loss. Hot carcass increased significantly ($P<0.05$) for the supplements compared to the control treatment, while dressing percentage was highest with the rams that received split supplemented feeds. Higher Total N was found in the manure supplemented group of rams relative to the Control, while the reverse was obtained in Total P. The present study indicated that supplementation with cowpea haulms at 600g/day, fed

twice or thrice, with respective average daily weight gain values of 53.75g and 50.83g were found to be better in fattening Yankasa rams for profit in integrated crop-livestock farming systems

FEBRUARY, 2016

CHAPTER ONE

1.0 INTRODUCTION

Crop and livestock agriculture is important to lives of most farmers and non-farmers in Nigeria. Fifty to eighty percent of Nigerians are involved in either crop, livestock or crop-livestock agriculture (Akinola *et al*., 2015). Considering the increasing population of Nigerians, agricultural production system is becoming more dynamic such that farmers who were hitherto in crop production have adopted crop-livestock production. In the same pattern, more pastoralists are turning into agro-pastoralists (Agyemang *et al*., 1993).

This change is spontaneous and is based on the perceived reciprocal benefits that the system offers. For instance, in order to meet the rapidly increasing demand for food by the expanding human population (estimated at 2.5% annually), (Manyong *et al*., 2005), indicated that production of food from animal production must expand by more than 3% annually and that of crop must expand by 4% every year between now and 2025. Under these conditions, there will be intensification of land use, full integration of crop and livestock Agriculture which will offer a great potential for increasing agricultural productivity and reduction or minimization of migration and the multiple conflicts between the Fulani herdsmen and the settled agrarian communities in Nigeria (Ajaero *et al.,* 2015), especially in the wetter parts of the semi-arid zones (Aune and Bationo, 2008).

According to Kamuanga *et al.*,(2008), livestock rearing plays a key role in the economies of West African countries providing, at times, 44% of agricultural GDP. With 60 million heads of cattle and 160 small ruminants, 400 million poultry, the Sahel and West Africa is an exceptional region for livestock rearing. In numbers, and in comparison with the entire sub-Saharan Africa region, the Sahel and West Africa contain 25% of the cattle, 33% of the sheep, and 40% of the goats (Serigne *et al.*, 2006). These potentials are currently under-exploited and the region continues to be too dependent on imports in order to satisfy demand of certain animal products such as milk and meat.

It is pertinent therefore that livestock rearing should be one of the main economic activities on which the poorest populations depend on for food and income. It is also essential to ensure against vulnerability and risk related to climatic conditions for populations highly dependent on rain-fed agriculture for their livelihoods. The Sub-Saharan Africa (SSA) Challenge Program includes pilot learning sites in West, East and Southern Africa. This program was established to bring innovation to rural Africa and to test the concepts of Integrated Agricultural Research for Development (IAR4D), an integrated multi-stakeholder participatory approach to learning and change processes.

The West African Pilot Learning Site, known as the Kano-Katsina-Maradi Pilot Learning Site (KKM PLS) was set up in three agro-ecological zones of Nigeria and Niger Republic. These three zones, Northern Guinea Savannah, Sudan Savannah and Sahel, are broadly represented across West

Africa and are areas densely populated with mixed crop-livestock farmers. The crops raised vary with the varied precipitation patterns of the zones, but ruminant livestock are an important component across all the zones. A major constraint to improved incomes from livestock and livestock products in this area has been the need for improved availability and utilization of feed resources (Herrero *et al*., 2010).

Poor nutrition remains the most widespread technical constraint to good ruminant animal performance in the sub-Saharan Africa. This becomes more critical during the dry season when feeds availability is not only inadequate, but the quality becomes extremely poor. Various options have been advocated as possible solutions to these perennial problems. These include feeding of treated crop residues or integration of forage legumes into the feeding strategies (Nnadi and Haque, 1988). Although feeding of forage legumes has been easily adoptable, the practice is not attractive to most of the farmers. This perhaps may be due to their limited immediate benefits that do not go beyond soil maintenance and nitrogen fixation (Akinlade *et al.,* 2005).

Seasonal availability of good quality feeds in the Sub-Saharan Africa and particularly in West African countries, has driven the evolution of crop-livestock farming systems to become a typical characteristic (Mpairwe *et al.*, 2003). Growing of grain crops, such as maize, sorghum, millet, cowpea, groundnut and keeping of livestock are the main components of this type of farming system (Hassan *et al.*, 2014). In Nigeria, such type of mixed crop-livestock production system is a common feature of the smallholder farmers, with limited farmland resources. In most African countries, livestock farming systems wholly rely on grazing of natural pastures and crop residues for their dietary energy and protein (Williams *et al.*, 1997). The dietary energy (10.05MJ/kg DM) and protein (5.6%) obtained from these sources, particularly in the dry season are generally too low to meet the nutrient requirements of ruminants for maintenance (Birnin-Yauri and Umar, 2014). The recommended nutrient requirements for maintenance and production are (11.30 MJ/kg DM 11.6% CP) and (12.14 MJ/kg DM 26.2% CP), respectively (NRC, 2008). The quality and quantity of feed resources are the major constraints of increasing ruminant productivity under tropical conditions. Existing feedstuffs in the tropical countries often provide inadequate energy, protein, minerals and vitamins to support optimum animal productivity (Tripathi *et al.*, 2006).

The increase in cropping of arable lands in West Africa has led to a greater utilization dependence of cereal stovers as the main feeds for both large and small ruminants. In the sub-humid and semi-arid regions of West Africa, millet and sorghum stovers are commonly fed as a basal diet and this is often supplemented with high protein cowpea haulms (Tarawali *et al.,* 2002).

The development of improved dual purpose cowpea varieties has raised the potential for increasing the livestock performance in sub- humid and semi- arid areas (Singh *et al.,* 1997). From the production of cowpea, rural families variously derive food, animal feed and cash, together with spillover benefits to their farmlands through various means such as *in situ* decay of root residues, use of animal manures, and ground cover from cowpea's spreading and low growth habit. (Singh *et al.,* 2003).

Cowpea (*Vigna unguiculata* [L.] walp) is a leguminous crop found to be very important in the dry savanna of Africa because of its lower water requirement (Hall, 1990); it is also known to be a superior source of protein. The dried seed, green pods and leaves are consumed as food while the dried haulms are very important as ruminant feeds.

In the West African sub-region, cowpea is an important crop because it provides an inexpensive source of protein for both the urban and rural poor farmers. Nigeria accounts for 70% of the world's cowpea production (Alghali, 1991). The grain is valued for its flavour and the plant is generally accepted by farmers especially as a supplementary feed for their animals during the critical time in the dry season. Cowpea haulms have been found to increase microbial nitrogen supply in ruminants when used as supplement to Teff straw (Abule *et al.,* 1995). Cowpea haulms also promote intake of maize stover, improve rumen ammonia concentration and degradation of maize stover (Chakeredza *et al.*, 2002).

Almost all the farmers in the dry savanna own ruminant livestock and intercrop two types of local cowpea cultivars (Dan- Ila and Kanannado) in alternate rows with millet and/or sorghum in the same field, one for grain and the other for fodder. The grain type of cowpea is first harvested together with millet while the late cowpea is left in the field until the onset of dry season. In case there are late rains the fodder type cowpea produce some grain as well and the fodder is cut and rolled into bundles and kept on rooftops and tree forks for feeding and income (Singh, 2000).

However, farmers'crops and fodder yields are low because the local cultivars are shaded due to intercropping and drought due to early cessation of rains and inadequate capital resources for purchasing inputs such as insecticides and intercropping to minimize risk which characterized the practice of most West African poor resource farmers (Singh *et al*., 2003). This therefore led to a search for an ideal dual purpose type of cowpea cultivar such as (IT90K-277-2) with intermediate maturity that produce both substantial grain and fodder after millet harvest in the intercrop fields as practiced by farmers.

Justification

Previous studies (Singh *et al*., 2011) have shown that there is little improvement in sheep performance when supplemented with about 300g cowpea haulms per day. In all of the trials, cowpea haulms were only fed once daily. With regards to Nitrogen degradability of cowpea being very rapid, it is likely that the extra protein provided when fed greater amounts of cowpea are lost as ammonia in the rumen and is expelled as urine, resulting in an energy cost to the animal. Therefore, if greater amounts of cowpea haulms were fed in smaller amounts during the day, this may improve animal intake and performance. Also chemical composition, *in vitro* gas production and *in situ* disappearance of some improved varieties of cowpea haulms indicated higher CP, readily soluble DM and CP, lower NDF and ADF. This could serve as a source of nitrogenous supplement to improve the productivity of ruminants fed poor quality diet (Antwi *et al.,* 2014). Cowpea haulms also are cheaper than that of groundnut and hence farmers may find it cheaper to use and could be more profitable in feeding with the aim of the targeted production (fattening or milk).One of the defined activities for the SSA Challenge Program was the development and dispersal of livestock feeding strategies.

The main objectives were therefore to:

A) Define appropriate feeding strategies by a thorough understanding of both the livestock and feed resources available to farmers
B) To evaluate the nutritive value of cowpea (*Vigna unguiculata*) haulms as supplement to sorghum (*Sorghum bicolor*) stover fed to Yankasa rams at different levels and frequencies.

Specific objectives were to:

i. Survey livestock production system, feeds and feeding strategies by the local farmers in the study area

ii. To determine the nutritive value of cowpea (*Vigna unguiculata*) haulms and sorghum (*Sorghum bicolor*) stover.

iii. To determine the effect of inclusion levels of cowpea (*Vigna unguiculata*) haulms in the diet and feeding frequency on growth performance of Yankasa rams fed a basal diet of sorghum (*Sorghum bicolor*) stover.

iv. To determine the effect of inclusion levels of cowpea (*Vigna unguiculata*) haulms in the diets and feeding frequency on nutrients digestibility in Yankasa rams fed a basal diet of sorghum (*Sorghum bicolor*) stover.

v. To evaluate the carcass characteristics of fattened Yankasa rams and economics of production on feeding sorghum (*Sorghum bicolor*) stover supplemented with cowpea (*Vigna unguiculata*) haulms at different levels and frequencies.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Importance of Ruminant Animals.

2.1.1 Importance of Small Ruminants in the Developing Countries

Small ruminants play important roles and functions in different categories. Rangnekar (2006) in India identified an output function, an input, risk coverage or asset function and socio-cultural functions of the small ruminants. In a study carried out in Kenya, Kosgey *et* *al*. (2008) differentiated between tangible and intangible benefits against emergencies and display of status. Devendra and Chantalakhana (2002) also mentioned that goats are sold when smallholders are in need of cash to pay fees for children's education, clothes and books, and as such, goats provide a medium-term of savings for smallholder ruminant farmers.

Boyejo and Adedoyin (1994) also reported that rearing of sheep and goats is a common feature in most rural households in Nigeria and are important items in meeting socio-cultural obligations. Also they contribute to the economic, food security, family income and risk mitigation (Hooft *et al*., 2008). They are associated with the poorest of the poor, often in marginal and harsh environment (Devendra, 1992; Devendra, 2000). Ruminants contribute in fulfilling multiple functions, such as meat and milk production, manure, insurance, religious rites, bride wealth and ceremonies are well acknowledged, because of their small size, off take cost (initial investment), ease of management and wide acceptability (Peacock, 2005). Certain breeds of sheep such as Djallonke goats and West African Dwarf are tolerant to trypanosomiasis and other diseases, and permit most of the animals to graze on land not available to other domestic livestock.

Iyayi and Tona, (2004) observed that small ruminants constitute a good source of family income and livelihood, assets and agricultural resources for smallholder farmers. Small ruminants play a significant role in the food chain and overall livelihoods of rural households, where they are reared largely by women and their children (Lebbie, 2004). Goats have been used for certain services and products, such as payment for the service of traditional healer, agricultural labour and products (Boogaard and Moyo, 2015). Also, Boogaard and Moyo, (2015) in their current study showed three pathways through which goats can contribute to food security: (i) consumption of goat meat (rather unimportant reason), (ii) sale of goats in times of food shortage to buy food (important reason), and (iii) exchange of a goat for agricultural labour on the crop fields. Haenlein (2004) has reviewed the importance of goat milk in human nutrition and emphasized two aspects. One concerns treating people afflicted with cow milk allergies and gastro-intestinal disorders. The other is the trend and market demand to meet the growing gastronomic needs of connoisseur consumers in the developed countries. Apart from the anti-allergy properties in goat milk, other important characteristics in goat milk are the presence of higher levels of six of the ten essential amino acids and also monounsaturated, polyunsaturated and medium chain triglycerides which are all known to benefit human health (Posati and Orr, 1976).

Furthermore, Grove (1991) and Shapiro (1991) describe manure as the most important contribution that livestock make to agricultural intensification. As components of mixed crop-livestock system, livestock have a critical place in the development of sustainable and environmentally friendly agricultural production system.

According to (FAO/IAEA) 2003, food balance sheets, in the developing world between 1982 and 2002 per-capita meat consumption increased from 14.9 to 28.5 kg/year and milk consumption from 24.8 to 45.6 kg/year. It is also predicted that aggregate meat demand will grow from 209 million tons in 1997 to 327 million tons by 2020 and milk consumption from 422 to 648 million tons. Delgado *et al*. (1999) labelled this trend the .livestock revolution. The market value of that increase in consumption totalled approximately $155 billion (1990 U$S)., more than twice the market value of increased cereals consumption under the better known .green revolution. in wheat, rice and maize. (Delgado e*t al*. 2001).

2.1.2 Small Ruminant Production in Nigeria

The importance of small ruminants for meat production in the tropics is well recognized (Williamson and Payne, 1978). Livestock production is also an instrument to socio-economic change to improved income and quality of life. In Nigeria, livestock provides about 36.5% of total protein intake (NISER/CBN 1991) but this still falls short of the minimum animal protein requirement recommended by FAO/WHO (1983). The level of domestic livestock production still falls short of demand, for example, in 1997, demand for beef was 554,000 tonnes, while it was 627,000 tonnes in 1998 but the domestic supplies were 376,000 and 391,000 tonnes in 1997 and 1998, respectively (NAERLS, 1999).

In Nigeria, small ruminants fit into the smallholder production system, as they require low initial capital investment and low operational cost (Pollot and Wilson, 2009). Majority of rural owners of small ruminants are farmers involved in arable food crop production, or women involved in food processing and marketing (Rivera *et al*., 2004). A large percentage of the rural people satisfy their subsistence needs through livestock production which involves the rearing and marketing of livestock (Oladele, 2004). Small ruminants therefore play an important social and cultural role for the households and communities that keep them. Small ruminant flock sizes in these communities are small, about two to six animals per household, with goats out-numbering sheep (Smith, 1992). Diseases and inadequate nutrition (in terms of quality or quantity) constitute serious constraints to small ruminant production in Africa (Tadesse, 2012). Good management practices in terms of adequate nutrition, disease prevention and control and breeding, are essential for improved small ruminant production. Nigeria's small ruminant resources are estimated at 34,453,724 goats and 22,092,602 sheep (Ajala *et al.,* 2008). Although the productivity of small ruminants in Nigeria is low (Rivera *et al.,* 2004), there is ample opportunity for improvement. Such improvement can be achieved through extension education and training of small ruminants producers

2.1.3 Small Ruminant Production Systems

Sheep and goats occupy an important place in the Nigerian livestock industry, representing about 63.70% of the total grazing domestic livestock in the country (Gefu and Adu, 1984). Small ruminant production systems in Nigeria are basically classified into three production systems extensive, intensive and semi intensive (Gefu, 2002). Also (Ahmed and Egwu, 2014) observed that sheep production system is predominantly extensive and semi-intensive. The most predominant system practiced in the rural areas (Gefu, 2002) is the extensive system. According to Mack *et al.* (1985), management of sheep and goat in Nigeria are under extensive and intensive systems. Also Alawa, (2002) reported that the bulk of sheep and goat in Nigeria is of traditional free–rang type. The semi intensive management system, the animals are allowed to graze pastures for some time and are later fed with concentrates as supplements, health care and other management practices are also provided (Lakpini, 2002). Also crop residues and agro-industrial by-product are effectively and economically combined with grazing (Aregheore, 2009). Intensive management system of small ruminant production involves high capital and labour but is usually very productive. This management system is becoming less common in Nigeria (Ademosun, 1985) although it still exists in some Government and Institutional farms and corporate farms (Nuru, 1985).

2.1.4 Economic Importance of Sheep

The economic importance of sheep in the developing nations cannot be over emphasized. Sheep with their small body size, high productive capacity and rapid growth rates are ideally suited to production by resource-poor smallholders. In sub-saharan Africa, sheep provide almost 30% of the meat consumed and around 16% of the milk produced. Sheep contributes about 50% of the total domestically produced meat in Nigeria. Nigeria possesses about 22.1 million sheep. They thrive in a wide variety of environments in the tropics and sub-tropics. It requires less capital as they can be completely maintained on pastures, browse and agricultural waste products.

2.2 Breeds of Sheep in Nigeria

A breed is a collection of individual within a species which share a certain number of morphological and physiological characters which are passed onto their progeny as long as they breed among themselves. The Nigerian breeds are mainly the hairy type and there are four breeds: the West African Dwarf, Yankasa, Uda and Balami. However, other breeds which are of less importance exist which include the Bororo and the Ara -Ara found in Niger and Anambra States (RIM, 1989). In a survey by RIM (1989), these two breeds were described.

Sheep are kept everywhere in Nigeria, with a broad distinction between their importance and ubiquity in the north, and the more dispersed populations of the humid zone. Sheep and goats are seen as having secondary importance in relation to crops. There are generally considered to be four breeds or races of sheep native to Nigeria, the Balami, Uda, Yankasa and West African Dwarf (WAD) (Adu and Ngere, 1979).

2.2.1 Yankasa

Yankasa is known in *Hausa as White Fulani,*or *Y'ankasa.* The Yankasa is a meat breed found in north and north central Nigeria. The Yankasa is a medium-sized breed of sheep. The tail is long and thin, the ears moderately long and somewhat droopy. Rams have curved horns and a hairy white mane and ewes are polled. They have white coat colour with black patches around the eyes, ears and muzzle. Yankasa rams stand 70 to 80 cm at the withers and weigh 45 to 50kg at maturity. Mature females could weigh 25 to40kg while male weighs between 35 and 40kg.

The Yankasa breed has been the most extensively studied in Nigeria. and recorded in all parts of Nigeria, though the populations attenuate towards the northern border and the sea-coast. Some tentative studies have been made of its ecological adaptations. Yankasa sheep do not need daily watering in the wet season and watering once a day suffices in the dry season (Aganga *et al*., 1988).

2.2.2 Balami

The Balami is the largest bodied native sheep in Nigeria. As a pastoral animal it is confined to the semi-arid north, but it is favoured as a stall-fed breed by Muslims throughout the Nigerian Middle Belt. It is white and hairy with pendulous ears and a long thin tail; rams have a throat ruff and are horned but ewes are normally polled. Another feature that makes the Balami distinctly recognisable is its Roman nose, a large bulbous nose that distinguishes it from the Yankasa (Adu and Ngere, 1979).

2.2.3 Uda

The Uda is slightly smaller-bodied than the Balami, although their size ranges overlap. It is easily recognised by a distinctive coat colour pattern; entirely brown or black forequarters and white behind. Uda sheep give their name to a Fulbe clan, the Uda'en, who herd large flocks of this breed between Niger and the northern reaches of the Nigerian Middle Belt. Studies on Nigerian Uda are lacking. Haumesser and Gerbaldi (1980) studied traditionally-managed Uda flocks in Niger Republic; Wilson and Durkin (1983a,b) and Wilson and Light (1986) report on related sheep production systems in central Mali.

2.2.4 West African Dwarf

The West African Dwarf is a small-bodied, compact breed which may be all white, black, brown, or spotted black or brown on a white coat. Its variation in colour and patchy distribution make it difficult to distinguish clearly from the Yankasa. Adu and Ngere (1979) say that different types exist, mentioning the 'Pagan' variety on the Jos Plateau, and the 'Umuahia' variety near the Confluence, but there is no published account of such varieties. Devendra and McLeroy (1982) argue that the WAD breed cannot be subcategorised on the basis of appearance, and no performance data is available.

2.3 Constrains to Small Ruminant Production in the Sudano-Sahelian Zone

Scarcity of forage during the dry season is a common problem limiting goat production in tropical areas (Malau-Aduli, 2003). Diego (1994) had stated that feed, whether purchased or produced on the farm; make up a large part of the expense incurred in ruminants production. The available feeds resources are low on nutritive value. The major feed resources for these animals are crop residues from cultivated fields and natural pastures from rangelands. According to Atta-Krah and Reynolds (1989), natural pastures consist of a mixture of grasses such as *Panicum maximum*, *Imperata cylindrica*, *Andropogon gayanus*, *Pennisetum* spp and *Hyparrhenia* spp. These grasses grow rapidly during the wet season, becoming fibrous and coarse, and are undergrazed because of the large amounts that become rapidly available. Their quality declines further during the dry season when they become standing hay and are subject to overgrazing. Coupled with high cost of supplementary concentrate diets has guided to the search for non- competitive alternative feedstuffs (Olorunsomo, 2008).

Daniel (2007) reported problems of small ruminant producers were disease, feeding problem, accommodation constraint, inadequate capital, destructive habit of the animals and predators, among others. Also Fasae *et al*. (2012) reported that production of small ruminants is limited among other factors by inadequacy of year round feed availability. According to Mucuthi and Munei (1996), helminths can be predisposing factors to respiratory infections. Consequently, the high percentage of the respiratory infections in the study could be caused by helminths which provoke diarrhea generally to the infested animal. Also Infestations of pest with significant importance are tsetse fly, flukes, roundworm and hookworms as well as ectoparasites like ticks, mange, mites and lice. Infestations of these parasites can cause major economic losses to producers because of the cost of treatment, production loss, and death of heavily infested animals (Fidelis and Tyrel, 2007).

2.4 Feed Resources of Ruminant Animals

2.4.1 Ruminant production on rangelands

Performance of animals grazing tropical pasture during the dry season without supplementation shows that they lose weight and body condition (Adu and Adamu, 1982). Ademosun (1993) and Zemmelink (1973), reported protein is the most critical nutrient for animals grazing poor quality pasture especially in the dry season. During the dry season, the crude protein of natural pasture falls to about 1.5 and 3% (Adamu *et al*., 1993) with attendant reduction in voluntary dry matter intake and animal performance. Adamu *et al.,* (1993) noted that native forage resources of the Savannah zones of the country can meet requirement of the animals for maintenance and low levels of production for only about two to three months of the year.

2.4.2 Cereal Crop Residues as Feed Resource

Crop-residues are materials generated after the crop has been harvested (Dixon and Egan, 1987). These include fibrous aftermath of farm crops grown for human consumption (Simbaya, 2002) and probably rank as the second most important feed resource for tropical sheep and provide the chief source of feed for smallholder flocks during the much of the dry season (Smith, 1989). Crop residues are of two general types— those of the cereals (millet, sorghum, rice and maize) and those of the legumes (cowpea, groundnut, and soybean). In addition, crop residues of cotton, cassava, and other types of beans may also be available for use by the farmer (Adamu and Odion, 1998).

The crop residues of cereals may be left in the field as grazing material for livestock and/or as mulch, or transported to the homestead for stall feeding or for use as fencing, building, or roofing materials or as fuel (Adamu and Odion, 1998) or left on the field to be attacked by termites. The major crop residues which are grazed or stockpiled for ruminant feeding are millet, sorghum, cowpea vines, cowpea husks, maize stover, maize husk, and groundnut haulms (Adamu and Odion, 1998). Sorghum crop residues are by far the most abundant of the cereal residues.

The leguminous crop residues, on the other hand, are harvested and conserved either for dry-season feeding to the farmers, animals or for sale to other farmers during the critical period of feed scarcity in the mid-to-late dry season (Singh and Tarawali, 1997). Legume crop residues, such as groundnut haulms, cowpea vines, and cowpea husks, are high in protein and are generally used as supplements to ruminants grazing ranges and cereal crop residues.

The potential of cereal crop residues as animal feed is enormous if all the different types of cereal crops are considered and if appropriate methods of improving their nutritional value are employed. Because of the importance attached to crop residue as feed resource, price is normally attached to it. The pricing of crop residues differs from place to place depending on animal population and between season, type of crop residue and time of the year. In drought years, they may cost as much as the grain while in favorable years they may cost as much as 25% of the grain values (Singh and Tarawali, 1997).

2.4.2.1 Origin, Distribution and Spread of *Sorghum bicolour*

Sorghum bicolour (L) Moench is widely grown in the semi-arid and arid savannah regions of Nigeria. Maunder (2002) reported that sorghum is a traditional crop of much of Africa and Asia and an introduced and hybridized crop in the western hemisphere. It specialises from an ability to tolerate drought, soil toxicities and temperature extremes effectively than other cereals like maize.

The most abundant variety of sorghum in Nigeria is *Sorghum guineense*; other varieties include *Sorghum durra, Sorghum caudatum* and *Sorghum margaritiferum* (Irvine, 1953; Busson, 1965). Several cultivars have, however, been developed through sustained breeding. Maunder (2002) reported that the single most important technology change in sorghum since the 1950's has been the development and use of hybrid seeds. Several improved varieties have been developed and released to farmers in Nigeria since the 1970's mainly by the Institute of Agricultural Research (IAR), Ahmadu Bello University, Zaria and the International Centre for Crop Research for Semi -Arid Tropics (ICRISAT), Kano centre. Some of these cultivars have been developed from the local varieties, namely Fara-fara, Farida, Kaura and from the ICRISAT lines of the Sudan zone. [IAR, 1999; National Centre for Genetic Resources and Biotechnology (NCGRB), 2004]. Among these are the ICSV 111 and ICSV 400 released by ICRISAT in 1996, SAMSORG series developed and released in the 1970's and 1980's; others are the NR series developed from the Sudan zone ICRISAT line (NCGRB, 2004), L-187, L-243 and L-333 and SK-5912, which have pale yellow to yellow grains and L-1499, which have white coloured grains (Ega *et al.*, 1992).

2.4.2.2 Production of *Sorghum bicolour*

In the past 50 years, the area planted with sorghum worldwide has increased by 60% and the yield by 233% (Maunder, 2002). Total annual production ranges from 40 –45 million tonnes from approximately 40 million hectares making sorghum one of the most important cereals in terms of production (ICRISAT, 2000). Between 1992 –1994, Africa produced 27% of the world's total sorghum and the annual growth rate of area planted with sorghum was 3.7%, production 2.9% and yields 0.8% between 1980 –1977 (Maunder, 2002). This indicates the importance of the crop in Africa, including Nigeria.

Recent yields in Nigeria indicated values of 2.5 tonnes/ha, 2.6 tonnes /ha and 1.5 tonnes/ha on ploughed, ridged and surface hoed tillage methods, respectively (Abimiku *et al.*, 2002). This encouraging yield is not unconnected with the introduction of high yielding varieties of sorghum and continuous development of these high yielding varieties.

2.4.2.3 Importance of *S. bicolour* in Ruminants Nutrition

The use of conventional feedstuff such as maize, soybean cake, fish meal and others as supplement to low quality feed may not be cost effective in present day Nigeria to intensify production, owing to their high cost, irregular supply (Akinmutimi, 2004) and the competition both with humans and animals (Adama, 2008; Ajayi *et al,* 2008; Ukpabi and Abdu, 2009). It is in this respect that non-conventional energy and protein materials of farm and agro-industrial wastes origin are presently being utilized for livestock production in Nigeria (Ndubueze *et al.,* 2006; Okonkwo *et al,* 2008). Such feed resources should be cheap, have high nutritive value, non-toxic, readily available, should have low or no demand by both human and other livestock species and without industrial usage (Egbo*et al.,* 2001; Amaefule, 2002; Ndubueze *et al.,* 2006).

Sorghum stover is one of such usable crop residues as ruminant animal feed. Sorghum stover consists of the leaves and stalks after harvest and has been used mostly as roughage for cattle, sheep, goats and horses (Alawa and Umunna, 1993). As sorghum stover is fibrous, its usage is limited mainly to cattle, sheep and goats which can convert in excess of 60% of the crude fibre component (Alhassan *et al.,* 1984). The mean voluntary consumption of supplemented sorghum stover has been found to be about 1.1% of body weight for intensively fed goats and cattle and 1.4% for sheep (Alhassan *et al.,* 1984; Alhassan, 1985).

It has been reported that 51% of sorghum crop is used to feed livestock while 49% is for human food and other uses (Maunder, 2002). Also, 48% of sorghum grain production is fed to livestock which according to Dowling *et al*. (2002) is often compared to maize for which it is a close substitute. Carter *et al*. (1989) reported that sorghum is used primarily as feed grain for livestock in USA and that the feed value of the grain is similar to maize. Smith (1995) agreed and indicated that sorghum compares well with other feed grains in total carbohydrate, indicating its suitability as a feed grain. Similarly, Purseglove (1972) reported that sorghum is a valuable feedstock; the smaller seeded varieties and bran afford excellent protein than maize but is lower in vitamin A. The grain is palatable and the feeding value ranges from 90% to nearly equal to maize (Carter *et al.*, 1989). Sorghum is often grown for forage or silage. The dried leaves and stems constitute useful roughage for ruminant animals and horses. The well matured plant can be used as green fodder or silage. It is, however, unsafe to feed the young green plant since they contain dhurrin, a cyanogenic glycoside which on hydrolysis yields hydrogen cyanide (HCN) (Oyenuga, 1968; Purseglove, 1972; Adamu and Alhassan, 1993). The kernel of sorghum is somewhat similar to maize though smaller in size. Whole sorghum grains can be given to sheep, pigs and even poultry but are usually ground for cattle (McDonald *et al.*, 1987; Carter *et al.*, 1989; Atteh, 2002). Brand *et al*. (1990) observed comparable live weight gain (799 g/day vs.809 g/day), feed conversion ratio (FCR) (2.87 vs.98) and feed intake (2.20 kg vs.2.38 kg) between pigs fed low tannin sorghum and maize meal, respectively. Similar results were also obtained by Kemm *et al.* (1984) but with slightly depressed live weight and FCR for pigs fed high tannin sorghum. According to Maunder (2002), sorghum may well offer the best opportunity to satisfy the doubling of meat demand in the developing world by 2020, as food for the poor, and as an alternative to maize. This is perhaps in line with Conolly (2012) who opined that feed cost is expected to continue in the upward swing while broiler meat consumption increased by 43% between 1999 and 2009.

Abubakar *et al.* (2006) reported that rabbits fed diets containing malted sorghum recorded a significantly higher weight gain of 25.72 g than those fed unmalted sorghum with a corresponding gain of 22.37g. The weight gain of rabbits fed unmalted sorghum was also higher than those fed maize based diet (25.72 g vs.23.00 g). Feed efficiency, feed cost and feed cost per kilogramme weight gain were also lower for rabbits fed sorghum based diets thus producing cost savings of N18.80 and N24.19 for rabbits fed unmalted and malted sorghum, respectively. Olorunnisomo *et al*. (2006) concluded that sorghum brewer's grains stimulated a better weight gain and FCR in WAD sheep than maize offal (46.9 g vs.27.2 g) and (0.14 vs 0.12), respectively in a low protein diet including a reduction in feed cost. However, when protein content was adequate, sorghum brewer's grain and maize offal had similar effect.

2.4.2.4 *S. bicolour* and other crop residues as supplementary feeding in ruminants

Cereal residues (maize, rice, millet, sorghum and wheat) residues are low in nitrogen and one way of improving their nutritive value is to feed them to animals together with a variety of forage supplements that are potentially valuable to ruminants (Adebowale, 1988). Some of these forages include cowpea (*Vigna unguiculata*), groundnut (*Arachis hypogea*), *Gliricidia* leaves (*Gliricidia sepium*) and *Leucaena leucocephala etc*. The beneficial effects of feeding these forages to ruminant animals are many such as increased metabolisable energy and nitrogen intake, improved palatability, increased available minerals and vitamins, better rumen function and a laxative influence on the alimentary system.

Alhassan (1985a, b) in a comparative study of maize residues with other crop residues fed Red Sokoto goats with various cereal or legume residues and found that dry matter intake (DMI) ranged from 0.7% of body weight for maize stover to 2% for sorghum leaves, while legume crop residues intake ranged from 0.8% for cowpea vines to 3.4% for groundnut haulms. When feeding maize residues was compared with other cereal or legume crops, it was found that live weight gain compared favourably. Highest feed consumption was recorded for the maize residue, although this was not significantly higher than the sugar-cane tops. However, this high consumption did not produce better live weight gain, except with sorghum stalks.

2.4.2.5 Limitation to feeding cereal crop residues

The feeding value of cereal crop residue is, however, limited by major deficiencies of protein, metabolizable energy and minerals (Dutta *et al.,* 1999). Kabaija and Little, (1988) reported that in general, ruminants fed solely on Maize Stover are unlikely to have adequate sodium intake. Crop residues are also deficient in several minerals particularly calcium, phosphorus, sulphur, cobalt, copper and iodine (Verma and Jackson, 1984).

2.4.2.6 Supplementation to cereal crop residue basal diets

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 (Herrero *et al*., 2010). Preston and Leng (1987) have suggested that to optimize the utilization of crop residues, nutritional supplements should be provided to meet the nutrients that are deficient in the crop residue.

Supplementation of a ration of rice straw with protein, energy and/or minerals has been reported to optimize rumen function, maximizing utilization of the rice straw and increasing its intake (Sarnklong *et al.,* 2010). Supplementation as suggested earlier will improve crop residue utilization by goats and sheep. The choice of supplement must tilt towards the more readily available and less costly alternatives (Smith, 2002).

2.4.2.7 Leguminous crop residues as supplement

Legume crop residues are higher in CP compared to the cereal residues (Alhassan *et al.,* 1985), but low in ADF. The CP content of cowpea haulms range from 5.9 to10.4 percent while that of cowpea husk ranges from 6.9 – 7.1 %, while crude protein content of groundnut haulms range between 11.40 and 16.70 (Alhassan *et al.,* 1983). Studies have indicated that groundnut hay could meet the maintenance energy requirements of adult goats even at increasing levels of dietary inclusion (Malau-aduli *et al.,* 2003). Adu and Lakpini (1983) recorded live weight gains of 90.20g/day and 130.7.0 g/day from Yankasa sheep when unchopped and chopped groundnut haulms was fed as sole protein sources. In a feeding trial, Ikhatua and Adu (1984) compared groundnut haulms and *digitaria smutsii* hay and concluded that the groundnut haulms is a better quality roughage with adequate protein to maintain ruminants than *digitaria smutsii*.

Ndlovu and Sibanda (1996) had similar results when sheep fed lablab as a supplement to Zimbabwe scrub land herbage gained a total of 3.1kg in two months while unsupplemented sheep only gained 1.0 kg. In another study where lablab was used as a supplement to oat hay, average daily gain in sheep fed the supplement was almost double than that of sheep fed solely the basal diet (Umunna *et al.,* 1995). Also Makembe and Ndlovu (1996), reported that maize stover diets supplemented with lablab resulted in better body weight changes of the does, higher kid birth weights, faster growth rates and more milk as compared to traditional small holder practices in which no supplementation was used.

2.5 Description, Origin and Distribution of *Vigna unguiculata* (Cowpea)

The cowpea (*Vigna unguiculata* (L.) Walp.) is an annual herbaceous legume cultivated for its edible seeds or for fodder. It may be climbing and erect, as well as prostrate and creeping depending on the cultivar. Prostrate varieties grow to about 80 cm and climbing cultivars up to 2 m. It has a well developed root system. The leaves are trifoliate with oval leaflets, 6-15 cm long and 4-11 cm broad. The papillonaceous flowers can be white, yellowish, pale blue or violet and are distributed along axillary clusters. Pods occur in pairs forming a V, mostly pendulous but they can be erect. They are cylindrical, 6 to 20 cm long and 3-12 mm broad, and contain 8 to 20 seeds. Seeds can be white, pink, brown or black (Singh *et al.*, 1997).

The cowpea is one of the most popular legume grains in Africa and is also cultivated in some parts of America and Asia. Cowpea is called the "hungry-season crop" because it is the first harvested crop, before the cereal crops. Its seeds, pods and leaves are commonly used as human food. Cowpea has great flexibility in use: farmers can choose to harvest it for grains or as forage for their livestock, depending on economic or climatic constraints (Gomez, 2004). Dual-purpose varieties have been developed to provide both grain and fodder while suiting the different cropping systems encountered in Africa (Tarawali *et al*., 1997).

Cowpeas *(Vigna unguiculata* [L.] Walp.) are grown for fodder (haulms) and food (leaves, immature pods, and seeds) in a wide range of environments, from 40^0N to 30^0S and in lowland and highland ecologies, principally in West Africa, but also in Asia, Latin America, and North America (Rachie, 1985). They are especially important in the sub humid and semiarid lowlands of West Africa, between latitudes 7 and 14^0N. Cultivars adapt to these diverse environments through considerable plasticity in phenology (i.e., time from sowing to maturity) and morphology (growth habit), the main determinants of which are responses to temperature and photoperiod (Summerfield *et al*., 1974; Wien and Summerfield, 1980).

Cowpea originated in Africa and it became an integral part of traditional cropping systems throughout Africa, particularly in the semiarid region of West African savanna (Steele, 1972). Cowpea moved to Asia much earlier than America, but it has been entrenched in the cropping systems of both continents, even if it is less important than in Africa (Ng and Marechal, 1985). Of the world total of about 8 million ha, Africa accounts for 6 million ha. Cowpea is adapted to warm weather and requires less rainfall than most crops; therefore, it is primarily cultivated in the semiarid regions of lowland tropics and subtropics, where soils are poor and rainfall is limited. The crop is often grown without inputs. Consequently, the yields are poor. Whereas the way cowpea is cultivated in different continents depends upon the agro-climatic conditions, its use has depended upon the socioeconomic conditions, ethnic culture, and traditions of the people who grow it.

2.5.1 Production of *Vigna unguiculata* (Cowpea) in Nigeria

Cowpeas are grown extensively in 16 African countries, with the continent producing two-thirds of the world total. Two countries – Nigeria and Niger – produce 850,000 and 271,000 metric tonnes respectively annually or 49.3 percent of the world crop (Winrock, 1992). Cowpea in Africa is cultivated under diverse soil and climatic conditions and is traditionally intercropped with cereals. The bulk production comes from smallholder farmers in semiarid zones of the region (Winrock, 1992). Cowpea can sufficiently satisfy the tripartite need of providing (i) food for the farmer (ii) fodder for livestock especially during the critical period of the year (dry season) and (iii) fertility replenishment for the soil (through nitrogen fixation) which will ensure sustainable use of the farmer's limited land (for a longer period without much depletion of its nutrients).

Though, Africa grows the largest hectrage at 8.9 of the 9.1 million ha worldwide (FAOSTAT, 2007), cultivation is mainly under traditional systems and it therefore has the lowest average yield. In a general survey of cropping systems in West and Central Africa conducted from 1988 to 1990 covering: Nigeria, Benin Republic, Niger Republic, Togo, Cameroon, and Burkina Faso, Singh (1993) identified 15 major cropping systems, in addition to several others which vary from farmer to farmer. The traditional inter-cropping system involves little or no application of fertilizers and chemicals. Such practices lead to decreasing soil organic matter contents, increasing populations of chronic parasitic weeds (eg. *Striga s*pp.), reduced soil biological diversity and enhanced erosion risk (Mortimore *et al.*, 1997; Singh and Ajeigbe, 2002). Due to the increasing population in the region and resulting reduction in arable land per capita, there is a need to increase yields per unit area. Improving cowpea yields under these intercropping systems, and minimizing the biotic and abiotic constraints in such a way as to increase cowpea yield without reducing cereal yields is the challenge of agricultural scientists. Thus, the challenge is to maximize the benefits of small amount of purchased inputs like fertilizer and chemicals and use of manure from the existing livestock to enhance organic matter in the soil and increase and sustain crop productivity. On-station trials by International Institute of Tropical Agriculture (IITA) in Kano, Samaru and Bauchi, in northern Nigeria (Ajeigbe, 2003; Singh *et al.*, 2004) have shown that overall farm yield could be increased in a sustainable manner through adoption of improved varieties and cropping pattern and crop-livestock integration. This has been demonstrated by on-farm trials of 'best-bet options' involving improved dual purpose cowpeas by IITA, International Crop Research Institute for Semi-Arid Tropics (ICRISAT) and International Livestock Research Institute (ILRI) in collaboration with national partners (IITA, 1999). A combination of improved varieties and improved cropping systems for higher productivity and profitability with selective use of insecticides and fertilizers have been developed for the moist and dry savannas of West Africa (Ajeigbe, 2003; Ajeigbe *et al.*, 2006; Singh *et al.*, 2003, 2004). These improved varieties and cropping systems (2 cereal: 4 cowpea row to row strip cropping system) with selective use of fertilizer and pesticides, feeding of crop residues to small ruminants in permanent enclosures on the home compound and returning of the manure to the field holds great promise for increasing the food production in West Africa without affecting the environment or degrading the soils.

A farmer participatory on-farm validation and dissemination of the improved cowpea-cereal intercrop systems in the Northern Guinea Savanna zone of Nigeria, was started in

2002, to speed up the adoption of the improved system and cowpea varieties, and to improve the productivities of the small scale farmers in the region.

2.5.2 Fodder production and utilization

Whereas in eastern and southern Africa, cowpea is grown for human consumption of its leaves and beans, in West and Central Africa and particularly in their drier areas, in addition to food use, cowpea fodder plays a major role in animal feed and in many areas of the world, cowpea is the only available high quality legume hay for livestock feed (Coulibaly *et al*., 2009). In the semi-arid zones of Nigeria, all the above ground parts, except pods, are harvested for fodder and the take-off of the fodder contributes to feed supplies for large and small ruminants. Traditionally, farmers choose two main types of cowpea: early maturing varieties grown for grain and late maturing varieties grown for fodder production. However, because during the dry season, good quality fodder is scarce, there was a need to develop dual-purpose varieties that would give reasonable grain and fodder yields, thereby maximizing the output from land and labour.

The use of dual-purpose cowpea is attractive in mixed crop/livestock systems where land and feed are becoming increasingly scarce (Tarawali *et al.* 1997) especially in the dry season. In many areas of the world, cowpea is the only available high quality legume hay for livestock feed. Digestibility and yield of certain cultivars have been shown to be comparable to alfalfa (Davis *et al.* 1991). In Niger, the haulm of the plant is consumed as dietary habits and traditions, and cowpea plants are widely used for animal fodder. In Southern Africa, cowpea is at present planted primarily for fodder, although it is also used for grain production, green manure; weed control in forestry plantations and cover or anti-erosion crop (Coulibaly *et al.* 2009).

2.5.3 Development of Improved Dual-purpose *Vigna unguiculata* varieties

In the early 1990s, IITA, in collaboration with the International Livestock Research Institute (ILRI), initiated a breeding program to develop dual-purpose cowpea varieties that produce both grain and fodder to suit the diverse needs of farmers in the semiarid region. A recent breakthrough in cowpea breeding was the development of dry-season dual-purpose cowpea varieties adapted to the conditions of the semiarid zone. These varieties are dual purpose because they provide grain for human consumption and fodder for livestock. Several dry-season cowpea varieties were evaluated in irrigated and wetland areas in on-farm dry season trials. When planted at the end of January/February, they are harvested near the end of April to mid-May, when prices for cowpea grain and fodder are high. Fodder and grain yields of this improved variety are also higher than those of the local varieties. Data from farmers' fields showed that farmers obtained average yields of 1.3 t/ha of grain and 2.5 t/ha of fodder (Singh *et al*., 1997).

2.5.4 Nutritive and Feeding Values of *Vigna unguiculata*

Cowpeas are important legumes and sources of protein in livestock diets Giami, (2005). Compared to grasses, cowpeas have a relatively higher concentration of crude protein. Bressani, (1985) and Nielsen *et al.* (1997) indicated that the crude protein content ranges from 22 to 30% in the grain and leaves, and from 13 to 17% in the haulms with a high digestibility and low fibre level (Tarawali *et al.,* 1997).

The chemical composition and nutritional properties of cowpeas have been shown to vary considerably according to cultivar (Akinyele *et al.,* 1986; Longe, 1983). The chemical composition of cowpea is also influenced by environmental and genetic factors (Singh *et* *al.,* 2006). Evaluation of the nutritional characteristics of cowpeas is important because of the recent increase in the use of this material in ruminant livestock diets (Reed, 1995). Arora and Das (1976) reported that total soluble sugars, starch, and organic matter of cowpeas range from 179 to 275, 138 to 198, and 507 to 670 g kg^{-1}, respectively. Generally, it has been observed that cowpea leaves have less crude protein than seeds (Gohl, 1981).

The feeding value of cowpea hay has long been recognized, as it has been used extensively for all kinds of livestock in Africa (Thompson *et al.,* 1988). The aboveground parts of cowpea, except pods, are harvested for fodder. Cowpeas may be used green or as dry fodder. Digestibility and yield of certain cultivars are satisfactory and if cowpea hay is well-cured, it provides high nutritive value. The principal value of this hay lies in its high percentage of digestible protein. Leng *et al.* (1992) suggested that the role of cowpeas in ruminant diets can be seen as three fold, firstly, as a nitrogen and mineral supplement to enhance fermentative digestion and microbial growth efficiency in the rumen of ruminants on poor quality forage. It can be a source of post-ruminal protein for digestion. Mupangwa *et al.* (2000) indicated that dry matter digestibility was higher for legume hays. The organic matter digestibility ranged from 0.579 for cassia hay to 0.617 for stylo hay and there were no differences among the legume hays. Cowpeas are also total feeds, supplying almost all the biomass and other nutrients needed to support high levels of animal production.

Tarawali *et al.* (1997) found the cowpea species valuable after reviewing the literature on the use of cowpea haulms as fodder in different parts of the world. Several authors (N'Jai, 1998; Singh *et al.*, 2003; Singh *et al.*, 2006) have also described the use of cowpea residues as a supplement to low quality roughages in animal production. The level of supplement required will depend on the quality of the basal diet (Norton *et al.,* 1992). Singh *et al.* (2003) also found that incremental levels of cowpeas as a supplement to poor quality roughages indicate that they are valuable to animals. When cowpeas were fed to lambs under dry lot conditions the animals gained weight as well as those receiving an oat-hay-corn- soybean diet (Thompson *et al.,* 1988). Singh *et al.* (2006) found that there were differences in total dietary intake on sheep due to differences in the intake of the basal diet. On the value of legume hays for dairy heifers, Dvorachek (1929) found that cowpea hay was about equal to other leguminous hays (alfalfa hay) for producing body gains on dairy heifers, the tendency being to lay on more fat. Cowpeas are likely to be a significant source of minerals when fed in high amounts but animals are likely to require supplementation where dry feeds deficient in minerals make up 20–30% of the total dry matter intake (Goodchild and McMeniman, 1994).

2.6 Nitrogen content of *Vigna unguiculata* fodder as feed

High levels of neutral detergent fibre (NDF) and lignin plus low levels of nitrogen (N) result in restricted digestibility, poor intakes and depressed microbial protein production when cereal crop residues are offered alone (Abule e*t al*., 1995; Tolera and Sundstøl, 2000; Akinlade *et al*., 2005). Supplementation of cereal crop residues with legume forages increased concentration of ammonia-N, microbial-N and volatile fatty acid (VFA) in rumen fluid and stimulated degradation due to an increased supply of N, fermentable carbohydrates, sulphur and other essential nutrients (Abule *et al*., 1995; Tolera and Sundstøl, 2000). Bartholomew *et al*. (2003) and Savadogo *et al*. (2000) suggested that for smallholders to improve the feed self-sufficiency and enhance animal production through optimised feed utilisation, the adoption and production of legume feeds with a high N content is required. Cowpea is a grain legume utilized as human food and its haulm as livestock feed (Singh and Tarawali, 1997).

The haulm of cowpea contain more nitrogen than cereal straws and have been shown to improve intake of low quality forages (Smith *et al.,*1990; Abule *et al*.,1995), average daily gain and carcass dressing percentage of sheep (Koralagama *et al.,* 2008), as well as the supply of microbial nitrogen (Osuji and Odenyo, 1997). The cowpea haulm is available after grain harvest and is obtained at little or no cost hence its cost effectiveness as feed supplement. In a study by Antwi *et al.* (2009), an improved dual purpose cowpea cultivar IT93K-2045-93 was reported to have recorded a high agronomic and nutritive characteristics among the other cultivars assessed namely, SORONKO, IT93K-2309 and IT86D-710. The authors reported that cultivar IT93K-2045-93 had a grain yield of 2.26 t ha and a haulm yield of 13.35 t ha with 68.6% degradable DM fraction disappearing at a rate of 6.6% h^{-1}. It is important to know how the haulm of this cultivar would influence the intake and degradability of maize stover when used as a supplement.

Deficiencies of protein, energy and minerals are the main nutritional factors limiting productivity of sheep in tropical regions (Thomson *et al.,* 2000) Moreover, insufficient nitrogen supply for ruminal microbes result in low microbial protein synthesis and intestinal amino acid absorption which can limit forage intake and impair animal performance (i.e. growth, capacity for maintaining live weight and reproduction) (Osuji *et al.,* 1995). Therefore provision of appropriate supplementary feedstuffs would be an important step to enhancing the productivity of sheep under smallholder and pastoral production systems.

2.6.1 Degradability of *Vigna unguiculata* (cowpea) haulms

Agriculture in the Sub-Saharan African countries is intensifying in response to increasing populations of humans and livestock. Ignoring crop residues as a feed resource will ultimately result in serious feed shortages. As a result, increased productivity demands are placed on integrated crop-livestock systems with more emphasis on legumes such as cowpea (*Vigna unguiculata* L. Walp). Cowpea has the potential to function as a key integrating factor in intensifying systems through supplying protein in human diets, and fodder for livestock, as well as bringing N into the farming system through fixation (FAO, 2000). Residues of cereal crops are generally nutritionally inadequate to produce high yields of meat and milk. The greater nutritional quality of legume residues allows them to be used as a supplement to livestock diets based on cereal stover and other low-quality forage. One benefit of the use of cowpea and other legume fodders as a supplement is the provision of nitrogen to the rumen microbes, allowing them to improve utilization of the low quality forage. Leng *et al.,* 1992) suggested that the role of cowpeasin ruminant diets can be seen as a nitrogen and mineral supplement to enhance fermentative digestion and microbial growth efficiency in the rumen of ruminants on poor quality forage. It can be a source of post-ruminal protein for digestion.

Energy intake is improved by both the addition of a higher energy feed (cowpea) and by increasing the availability of energy through increased digestibility of the lower quality forage. At some level of supplementation, nitrogen becomes surplus to available carbohydrates for microbial growth and additional nitrogen may be wasted. Therefore, it is important to optimize ruminant diets to maximize digestibility with minimum nitrogen wastage (Grings *et al.,* 2010).

An example of this diet development is found in the study of Koralagama *et al.,* (2008) who fed either 150 or 300 g/d haulms from either a forage- or dual purpose-type cowpea to Ethiopian sheep fed a basal diet of maize stover. Dietary nitrogen was increased by cowpea haulm addition and higher levels of cowpea feeding resulted in higher nitrogen intakes. Total feed intake increased with increasing levels of cowpea supplementation but, while diet digestibility was greater for diets containing cowpea haulms, it did not differ between the levels or types of cowpea. The results of the study indicated that nitrogen level for the lower levels of cowpea supplementation likely matched the needs of the rumen microbes for the type of carbohydrate found (fiber) in these diets. This is also supported by increased urinary nitrogen excretion in sheep fed cowpea at 300 g/d compared to 150 g/day, indicating that some nitrogen was likely leaving the rumen as ammonia nitrogen rather than being incorporated into microbial cells. Sheep in these studies gained about between 32 and 51 g/d when supplemented with cowpea. Chakeredza *et al.,* (2002) found a 22.7% increase in microbial protein supply when cowpea haulms were added to a diet of maize stover which also illustrates how cowpea improves nitrogen supply for rumen microbes.

This hypothesis supports the results of the study reported by Singh *et al.,* (2003), in which additions of about 200 g cowpea haulms were shown to be the most economically viable level in feeding systems based on cereal stover compared to feeding either 400 or 600 g of supplemental haulms. Although increasing amounts of cowpea in a diet based on sorghum stover resulted in increased gains, the amount of increase diminished with each subsequent increase, resulting in the lowest level of cowpea addition (200g) being the most economical.

Going beyond its importance for food and feed, cowpea can be regarded as a fulcrum of sustainable farming in regions characterized by systems for farming that make limited use of purchased inputs (Anele *et al*., 2010) and the use of an in vitro gas technique in evaluating feedstuffs (through the measurement of variables like methane, microbial mass and short chain fatty acids (SCFA)) is a very effective and robust way of estimating energy loss from diets, microbial and feed nitrogen supply to ruminants.

2.7 Integration of *Vigna unguiculata* (Cowpea) in Crop-livestock

Adamu and Odion (1998) reported that fifty to 80% of Nigerians are involved in crop, livestock, or crop–livestock agriculture. Integration of crop and livestock production offers the greatest potential for increasing agricultural productivity, especially in the sub-humid and wetter parts of the semiarid zones (Powell and Williams, 1995).

In crop-livestock farming systems, manure from the animals is collected in two ways, either on the field (corralling) or around the homestead (Agyemang *et al.,* 1993). Corralling the animals on the field means that only the residue eaten by the animals can be used as manure while the other residues may be incorporated or burnt. Where crop residues are partially grazed, the rest are used as mulch or are fully grazed to return the manure to enrich the soil (Adamu and Odion, 1998).

Also Adamu and Odion (1998) reported that in many areas in the arid and semiarid zones of Nigeria, animal draft power has been utilized for plowing and ridging the land for planting crops. This activity is very common in these areas and it assuming more importance in the wake of the increasing price of tractors and tractor implements and fuel scarcity. Livestock is used for hauling goods to the market, from the farms, to draw water from rivers and streams, and even for transporting people.

The crop–livestock system of production is also important for many reasons which include soil fertility maintenance, prevention of environmental degradation, increased production of better or higher quality foods for all resulting in a healthier population.

Crop and livestock integration helps in maintaining soil fertility by the use of manure and increases farm efficiency by providing traction and transport and also it increase the farm income and human nutrition through milk and meat (Smith *et al*., 1997). The major constraint to crop-livestock integration in West Africa is the limited availability of livestock feed with high nutrient quality (Latham, 1999). In this region, farmers mostly feed their livestock with sorghum, millet and maize stovers as basal diet, while cowpea and groundnut haulms are fed as protein supplement (Russo, 1991). Other agricultural by-products such as brans, oilcakes, etc, which are generated when crops are processed (de Leeuw, 1979) are also fed to livestock as energy and mineral supplement. Cereals crop residues are low in nutritive value because of their relatively low digestibility, low crude protein content and low content of available minerals and vitamins (Owen, 1994). Efforts to improve the nutritive value of the cereals residues through treatment with urea and other chemicals have not been very popular because technologies are often at the "high tech", for application by small holder subsistence farmers (Owen and Jayasuriya, 1989). These limitations coupled with the fact that urea is very expensive in Africa, it would be more profitable to use the urea to increase grain and stover yields instead of using it to upgrade crop residues. Carangal and Calub (1987) noted that while the feeding value of cereal stovers are very low, the haulms of leguminous crops like cowpea and peanut are very high owing to higher protein contents ranging from 13 to 19% in these legumes. The leguminous haulms are therefore, good supplement to improve the feeding value of cereals straw. Cowpea and groundnut are the major legumes and maize, millet and sorghum are the major cereals in West Africa and their residues constitute a major source of livestock feed (Singh *et al*., 2003)

2.7.1 *Vigna unguiculata* (Cowpea) Contribution to mixed Crop-livestock Production Systems

As a legume, cowpea can contribute to soil fertility, mainly through its nitrogen fixing abilities. Part of the nitrogen fixed will remain in the soil in the roots, and thereby contribute to the soil fertility for subsequent crops. Some fixed nitrogen will eventually return to the soil as manure after residues are fed to livestock. In terms of the direct effects of cowpea in rotation with cereals, Manu *et al*. (1994) report a comparison of on-station and on-farm studies in Niger where cowpea–millet intercrop and cowpea–millet rotations were used. Their results on farmers' fields, rotation with cowpea gave 2.6 times more millet grain and 3.3 times more residue than the intercropped, non rotated treatment. Bagayoko *et al*. (1998) reported that cowpea can supply 35–40 kg N/ha in a cowpea–millet rotation, and Carsky and Berner (1995) presented similar figures for cowpea rotations with maize.

Cowpea residue is an important fodder resource for ruminant livestock (Tarawali *et al*., 1997). Farmers in the dry savannas deliberately grow varieties and use management practices that will ensure some cowpea fodder is available for harvest at the end of the growing season, even at the expense of grain production. Harvesting at the end of the wet season, before the dry season becomes severe, gives the best quality, and this is preserved throughout the storage period. If the fodder is harvested late, when the dry season is already underway, quality is poor (Tarawali *et al*., 1997). Recognition of the importance of fodder from cowpea led to the initiation of joint IITA–ILRI research in 1990 when fodder quantity and quality parameters were included in the breeding and selection program.

These efforts resulted in the identification of promising dual-purpose cowpea varieties suitable for the dry savannas such as IT90K-277-2 and IT89KD-288 (Singh and Tarawali, 1997).

Cowpea fodder as a feed supplement increases animal live weight gain during the dry season. Schlecht *et al*. (1995) report an experiment where Zebu cattle (bulls of about 250 kg, equivalent to 1 TLU–Tropical Livestock Unit) were supplemented with 1 kg cowpea hay at night and 0.5 kg fresh rice feed meal in the morning per animal/day during the second half of the dry season. The animals were allowed to graze as usual for the rest of the day. From February 1988 to September 1989 the supplemented group gained 95 kg compared to 62 kg for the non supplemented group. Taking animal numbers into account, this worked out to be equivalent to a difference of 67 g/animal/day. In many regions, cowpea fodder is particularly valued as a supplement in the period leading up to Muslim festivals when sheep are traditionally slaughtered. Some farmers sell cowpea fodder during the dry season when feed shortage is critical, and there have been suggestions that income from fodder sales makes a substantial contribution to the annual income in such cases (ICRISAT, 1991). In addition to the direct benefits of improved livestock production and health that result from feeding cowpea fodder, the quantity and quality of manure from such better fed animals will be improved and therefore, when returned to the land at the beginning of the growing season, contribute more towards the maintenance of soil fertility.

In the same experiment referred to above, although not significant in this particular trial, the manure nitrogen, in g N/TLU/day was on average 25% higher in animals receiving supplements. Indications are that from 1 ha of improved cowpea, a farmer could benefit by an extra 50 kg meat per annum from better nourished animals, with over 300 kg more cereal grain as a result of improved soil fertility directly from the cowpea and more/better manure from the animals (Tarawali, unpublished). Of course, considerations of the time scale—increased crop yields—would be realized only the next year and the distribution of manure should be taken into account. It is, however, noteworthy that these preliminary calculations have not considered all the potential benefits, for example, better fed traction animals would work harder, meaning more timely land preparation and better crop yields; better fed ruminants would give more milk and are likely to be more productive (increased weight gains mean young animals come into oestrus earlier). Providing more nutritious fodder also means that the comparatively indigestible parts of cereals (stalks, etc.) that are used as fodder are likely to be better consumed—intake of more fibrous material usually improves with the addition of better quality material to the diet.

2.8 Protein metabolism in the Rumen of ruminants

Protein is considered a key nutrient in ruminant nutrition, not only by providing amino acids to the animal, but also as a source of nitrogen (N) for microbial protein synthesis (Oliviera Junior *et al.,* 2004). The final protein supply to the .small intestine is formed by dietary protein (rumen undegraded protein) and microbial protein (Caldas Neto *et al.,* 2008). Microbial protein synthesized in the rumen can supply more than 50% of the amino acids absorbed by ruminants, being considered a protein of high biological value (AFRC, 1993). Therefore, optimization of microbial synthesis is one of the main objectives sought by researchers in ruminant nutrition. Microbial growth is dependent on the rule of protein degradation and availability of ammonia ($N\text{-}NH_3$) in the rumen (Brooks *et al.,* 2012). These authors reported that the lack of rumen degradable protein (RDP) in the diet caused a decrease in microbial N production, microbial efficiency and degradation of peptides.

Besides the presence of N-NH_3 in the rumen, it is also necessary to have available energy. The inadequate supply of RDP in relation to fermentable carbohydrates causes negative effects on fiber digestion and, consequently, loss of energy and reduction of microbial efficiency (Klevesahl *et al.,* 2003).

Microbial protein synthesized in the rumen is the major source of N to the host animal accounting for 60-85% of the total amino acids entering the small intestine (Ørskov, 1982). The pattern of degradation, therefore, influences the choice of N source for efficient utilization of cereal residues. A rapid degradation of N not matched to the release of OM from the carbohydrate could lead to a high absorption of NH_3 from the rumen (Meggison *et al.,* 1979). The availability of suitable carbon skeletons and ATP from plant material is a requirement for the NH.3 released from dietary urea to be used for microbial protein synthesis (Czerkawski, 1986).

Feedstuffs consumed by ruminants are all initially exposed to the fermentative activity in the rumen prior to gastric and intestinal digestion. Dietary polysaccharides and protein are generally degraded by the ruminal micro organisms into characteristic end products, which in turn provide nutrients for metabolism by the host animal. The extent and type of transformation of feedstuffs thus determines the productive performance of the host. Fermentation of feedstuffs in the rumen yields short-chain volatile fatty acids (VFA) primarily acetic, propionic and butyric acids), carbon dioxide, methane, ammonia and occasionally lactic acid. Some of the change in free energy is used to drive microbial growth, but heat also is evolved. Ruminants use the organic acids and microbial protein as sources of energy and amino acids, respectively, but methane, heat and ammonia can cause a loss of energy and nitrogen (N). The quality and quantity of rumen fermentation products is dependent on the types and activities of the microorganisms in the rumen. This, in turn, will have an enormous potential impact on nutrient output and performance of ruminant animals (Ahn *et al.,* 1989).

2.8.1 Factors affecting utilization of poor quality roughages by ruminants

Several factors affect the utilization of poor quality roughages by ruminants. These include rumen environment (where conditions should be pH > 6.2, NH3 > 3.5 mmol/1), microbial adhesion, particle size reduction, passage rates of both participate and liquid digesta, roughage degradation rate and volatile fatty acid production, adequate supply of iso-acids for microbial protein production and the availability of by-pass protein.

ILR1 nutrition research has focused on how to enhance fibre degradation and microbial protein supply by rumen manipulation aimed at optimizing the above conditions. The use of herbaceous legumes and multipurpose trees as a means to correct nutrient imbalances and improve the conditions in the rumen has been a priority area of research (ILCA, 1995; Osuji, 1994).

2.8.2 Legume as Sources of Nitrogen

Ruminants depend on microbial protein production to meet their N requirements. In ruminant production systems where poor quality roughages constitute the principal source of feed there are two major objectives aimed at optimizing their use. There is need to enhance the fermentation of the roughage to ensure adequate energy supply, mainly as VFA. Secondly, given the scarcity of protein in such systems, there is a need to maximize the supply of microbial protein. Several strategies arc available to manipulate the rumen. The strategy of choice depends on the desired output. One strategy that has often been used, particularly when poor quality forages are fed, is supplementation. The principal objective of supplementation is to increase the supply of nutrients, mainly energy and protein, such as to create favourable conditions in the rumen which result in better fermentation and microbial protein supply (Osuji, *et al.,* 1995).

The major constraint to small-holder ruminant livestock production is the availability and quality of feed all year round. Ruminants survive on crop residues and unimproved swards deficient in nitrogen, energy, and minerals. This affects feed intake, feed utilization and animal productivity. The deficiencies in these roughages can be overcome partly by nitrogen supplementation. Leguminous fodders are promising and cheap source of nitrogen for use by smallholder farmers; among these is cowpea haulm. Cowpea haulm has been shown to increase microbial nitrogen supply in calves when used as supplement to teff straw (Abule *et al.,* 1995), and to promote intake of maize stover and improve rumen ammonia concentration and degradation of maize stover (Chakeredza *et al.,* 2002). Supplemental feeding is also a means to promote productivity by supplying limiting nutrients during deficient periods (Huston *et al.,* 1999).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Experiment 1: Feed and Livestock Resources Survey in the Sudano – Sahelian Agro-ecological Zone of Nigeria.

3.1.1 Location of the Study area

The Sudano – Sahelian study area covers Kano and Katsina States which are located in North-Western Nigeria. Kano State borders Katsina State to the North-West, Jigawa State to the North-East, Bauchi State to the South-East and Kaduna State to the South west. Similarly, Katsina State borders Niger Republic to the North, Zamfara State to the North-west, Jigawa State to the North-east and Kaduna State to the South. The inhabitants of two states predominantly practice agriculture while Kano additionally serves as a commercial state. The mean annual rainfall is about 850 mm for Kano and 680 – 750 mm for Katsina State. The rainfall is highest in August (single peak) with sharp decline in September and an abrupt end in early October (Olofin, 1984).

The survey tool was developed by International Livestock Research Institute (ILRI) with inputs from Kano Agricultural and Rural Development Authority (KNARDA), Katsina Agricultural and Rural Development Authority (KTARDA) and Institut Nationale de Reserches Agronomique du Niger (INRAN) personnel. The survey was tested by ILRI and KTARDA personnel by questioning 100 farmers from the target villages (20 per village). Based on a Focused Group Discussion (FGD) with farmers in the villages, namely Faruruwa, Alajawa, (Kano State) and Ishiyawa, Fanteka and Kututture (Katsina State). Farmers were stratified into very poor, mid poor and wealthy based on the degree of ownership of livestock and landed properties.

3.1.2 Questionnaire Administration

Livestock farmers within each of the five villages namely: Faruruwa, Alajawa, (Kano State) and Ishiyawa, Fanteka and Kututture (Katsina State), were questioned about their livestock and feed resources. All respondents were male farmers. The survey was conducted mostly on days best suitable and agreeable to farmers which mostly coincided with market free days. Also the interview was conducted between 8:00 AM and mid day or between 2:00 PM and 4:00 PM and 4:15 PM and 6:00 PM. The goal was to survey 20 households in each of the five villages

3.1.3 Data Analysis

Data collected on Livestock Feed Resources Survey in the Sudano – Sahelian dry lands were entered in Excel Spread sheet of Microsoft software. Data on all the households were analyzed using descriptive statistics (means, frequency and percentages).

3.2 Experiment II: Performance of Yankasa rams as influenced by feeding regime of Cowpea (*Vigna unguiculata*) haulms on Sorghum stover basal diet in the dry savanna of Nigeria.

3.2.1 Experimental diets and treatments

The experimental treatments consisted of:-

Treatment 1 – Basal Sorghum Stover only (Control) (T1)

Treatment 2 – Control + 300g cowpea haulms once daily (T2)

Treatment 3 – Control + 600g cowpea haulms once daily (T3)

Treatment 4 – Control + 300g cowpea haulms twice daily (T4)

Treatment 5 – Control + 200g cowpea haulms thrice daily (T5)

3.2.2 Experimental animals and management

Forty (40) Yankasa rams of 1.75 ± 0.4yrs of age, weighing 22.50 ± 0.20 kg were bought from different local markets. Before the commencement of the experiment, the animals were treated with a broad-spectrum anthelmintic (*Levamisole*) against lungworms. They were also vaccinated against sheep pox PPR, (*Pestes du Petits Ruminantes*) and external parasites (*Ivomectin®*) administered subcutaneously. The animals were housed in an open sided zinc roof and quarantined for (2) two weeks for adjustment period.

3.2.3 Feeding management

During the adjustment period, they were fed chopped sorghum stover of local variety (Kaura) and 300g of improved (IT90K 277-2) variety of cowpea haulms to adapt them to the feeding regimes. All animals were individually fed sorghum stover *ad libitum* and supplemented with cowpea haulms according to treatments. Also in addition, all animals received 300g wheat bran as supplement throughout the period of the experiment. The wheat bran supplement was first given at 7:00am for all animals; Sorghum stover at 8:00am for those receiving no cowpea haulms and at 12:00 for those supplemented; Cowpea haulms was offered at 8:00am for those fed once; 8:00am and 5:00pm for those fed twice; at 8:00am, 12:00 and 5:00pm for those fed 3 times. Fresh water was offered daily, at 10:30am and 4:00pm. And all animals had access to mineral block.

Feed refusals was collected at 7:00am the next morning (immediately before feeding) and weighed separately for cowpea and sorghum. The feeding trial lasted for a period of 90 days (excluding the quarantine and adaptation period). The animals were weighed for three consecutive days every two weeks throughout the experimental period and recorded. Daily feed intake (supplement and basal diet) and daily faecal output were recorded before feeding in the morning throughout the study period.

3.2.4 Digestibility trial

During the fifth week, six animals per treatment were fitted with canvas bags for faecal collection. The bags were emptied twice a day. After 10 days of adaptation faeces were collected at 7:00am and 5:00pm for 7 days. Ten percent of the faeces collected were sun – dried in a sample paper bag and preserved for analysis. During this period sub – samples of feed refusals were collected and stored for analysis. After the collection period, faeces and feed refusals were pooled by animals, sub-sampled ground to pass through a 1mm sieve and clearly labeled in preparation for chemicals analyses.

3.2.5 Carcass characteristics

At the end of the experiment all the animals were slaughtered to evaluate carcass characteristics and meat quality. After fasting for 18 h, all animals were processed by trained personnel using Standard Slaughter Procedures of Abdullah, *et al.,* (1998). Fasted live weight was recorded immediately before slaughter and hot carcass weight was recorded after slaughter. Cold carcass weight was recorded after chilling the carcass at 4°C for 24 h. Empty live weight was calculated by subtracting rumen contents from the fasted live weight. Viscera components (lungs trachea, heart, liver, spleen, kidney, kidney fat, mesenteric fat and testes) were removed and weighed directly after slaughter.

3.2.6 Cost benefit analysis

Cost benefit analysis was carried out to determine the profitability of feeding frequency of cowpea haulms to rams. Both inputs and products costs were based on cost at the prevailing producers market price of the commodities. The cost benefit ratio was determined by dividing the total cost of inputs (TC) by that of outputs or revenue (TR).

3.2.7 Chemical analysis

The dry matter (DM) contents of experimental feed materials (sorghum stover, cowpea haulms and fecal samples) were determined by drying the samples in the oven at $60^{o}C$ for 48 hours, nitrogen analysis by Kjeldahl method and crude protein (CP) was calculated as (N x 6.25), crude fiber(CF), ether extract (EE), ash and nitrogen free extract (NFE), according to the method of (AOAC, 2005). The fiber fractions, acid detergent fiber (ADF) and neutral detergent fiber (NDF) was determined according to the method described by (Goering and Van Soest, 1970). Hemicelluloses content was obtained by difference between NDF and ADF values (Church and Pond, 1982).

3.2.8 Statistical analysis

Data on intake, weight gain, digestibility manure quality and carcass from the feeding experiment were subjected to Analysis of Variance (ANOVA) according to General Linear Models (GLM) of the Statistical Analysis System (SAS®, 2002). Group treatment means where significant, were compared using Tukey's Method of means comparison.

CHAPTER FOUR

4.0 RESULTS

4.1 EXPERIMENT 1: Livestock and feed resource survey

4.1.1 Livestock resources:

Small ruminants constitute the major livestock owned by crop – livestock farmers in the study area (Table 4.1). Local breed of male and female goats with kids is owned by over 80 and 90 percent of the households respectively. Does without kids are found in 73 percent of the households while goats of improved breeds account for less than 1% in the households. Similarly, over 70% of the households own rams and ewes of local breed with lambs, while ewes without lambs are common in almost 68% of the households.

With regards to large ruminant holdings, draft bulls is owned in over 70% of the households followed by 50% and almost 44% cows with calves and dry cows owned respectively. Females within the households owned between 50 and 63% of the goats and sheep with or without lambs while rams are owned by 65% of the males in the area and about 85% of the draft bulls were owned by males.

Many of the households surveyed owned only a few (less than 5) of specific classes of livestock (Table 4.2). Female goats and sheep could be found in greater numbers. Two respondents owned more than 20 bulls.

Table 4.1. Livestock Ownership Pattern in the Sudan-Sahel Zone of Nigeria.

Specific Class of Livestock	Percent of specific class of livestock owned	Females with group ownership	Females with sole ownership
Draft bulls	71.3	15.6	0.0
Cows with calves	50.0	33.3	3.7
Cows without calves	43.5	44.7	8.5
Buck, local breed	81.5	51.1	10.2
Buck, improved breed	0.9	0.0	0.0
Doe with kid	90.7	61.2	11.2
Doe without kid	73.1	63.3	16.5
Ram, local breed	71.3	35.1	10.4
Ram, improved breed	1.9	50.0	50.0
Ewe with lamb	72.2	60.3	15.4
Ewe without lamb	67.6	56.2	19.2

Table 4.2. Ownership pattern of respondents classified by number of animals owned in Sudan-Sahel Zone of Nigeria.

	Few	Some	A lot	Many	Average number per HH
(%)	**(<5)**	**(6-11)**	**(12-20)**	**(>20)**	

Draft Bulls	67.3	0.9	0.9	1.9	2.2
Cows with calves	45.4	3.7	0.9	0.0	1.4
Cows without calves	36.1	6.5	0.9	0.0	1.5
Buck, local breed	74.1	6.5	2.8	0.0	3.4
Buck, improved breed	0.9	0.0	0.0	0.0	0.0
Doe with kid	62.0	22.2	8.3	0.9	5.6
Doe without kid	59.3	13.9	5.6	0.9	3.7
Ram, local breed	67.6	3.7	0.0	0.0	1.9
Ram, improved breed	1.9	0.0	0.0	0.0	0.0
Ewe with lamb	57.5	12.3	2.8	0.0	3.1
Ewe without lamb	57.4	7.4	1.9	0.9	2.6

One of these individuals did lease these animals out, providing an estimated 70 days of leasing at ₦1000 per day. Male goats were owned by 81.5% and male sheep by 71.3% of respondents, indicating the potential of small ruminant fattening programs as a means of increasing income.

4.1.2 Livestock marketing

Farmers' sales records of the previous 12 months indicated that sales are somewhat seasonal and the greatest numbers of livestock are being sold during the dry season (Figure 4.1). Livestock trade in these areas is based on live animals because most actors(crop-livestock farmers and traders) are less endowed financially. Sales of small ruminants were at their highest peak in May. This may correspond to the information provided about reason for sale (Figure 4.2). About 25% of the small ruminants were sold due to a lack of feed for these animals. Sales of small ruminants were greater in the dry season, naming ceremonies and at the festival seasons for both Muslim and Christian. A slightly greater number of farmers identified festival rather than feed scarcity as the reason of sale for sheep.

Cattle sales were fewer and, perhaps, less seasonal than small ruminant sales. Cattle were sold less frequently to obtain cash than other livestock, likely because of their higher value and their direct relationship to farming activities through the provision of draft power. In addition, more farmers identified good market price as a reason to sell cattle compared to other livestock classes but small ruminant sales were more frequent and important as they easily proffered quick solutions to family needs.

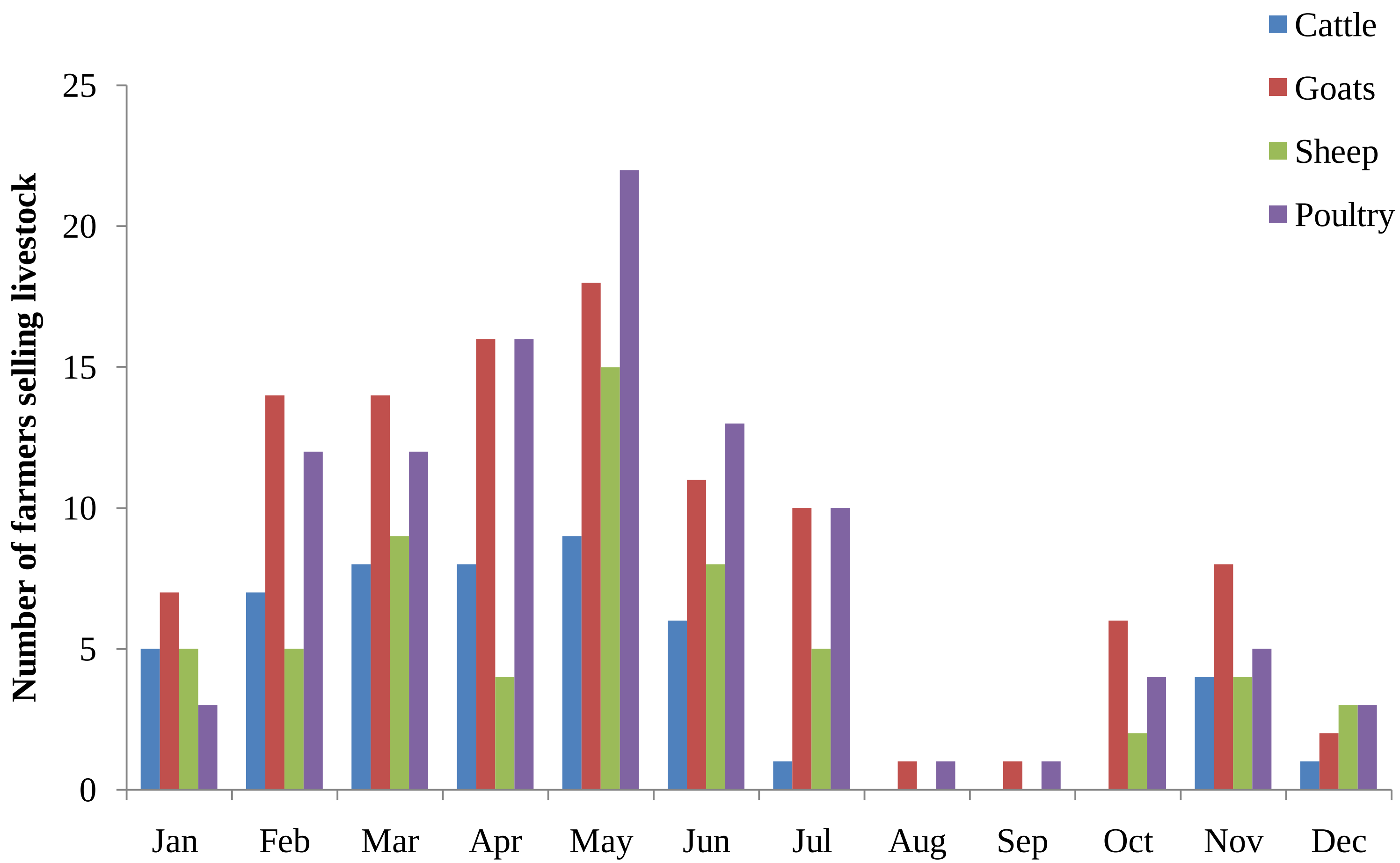

Figure 4.1: Number of livestock farmers selling specific classes of livestock during the previous 12 months of 2011 in the Sudan-Sahel Zone of Nigeria.

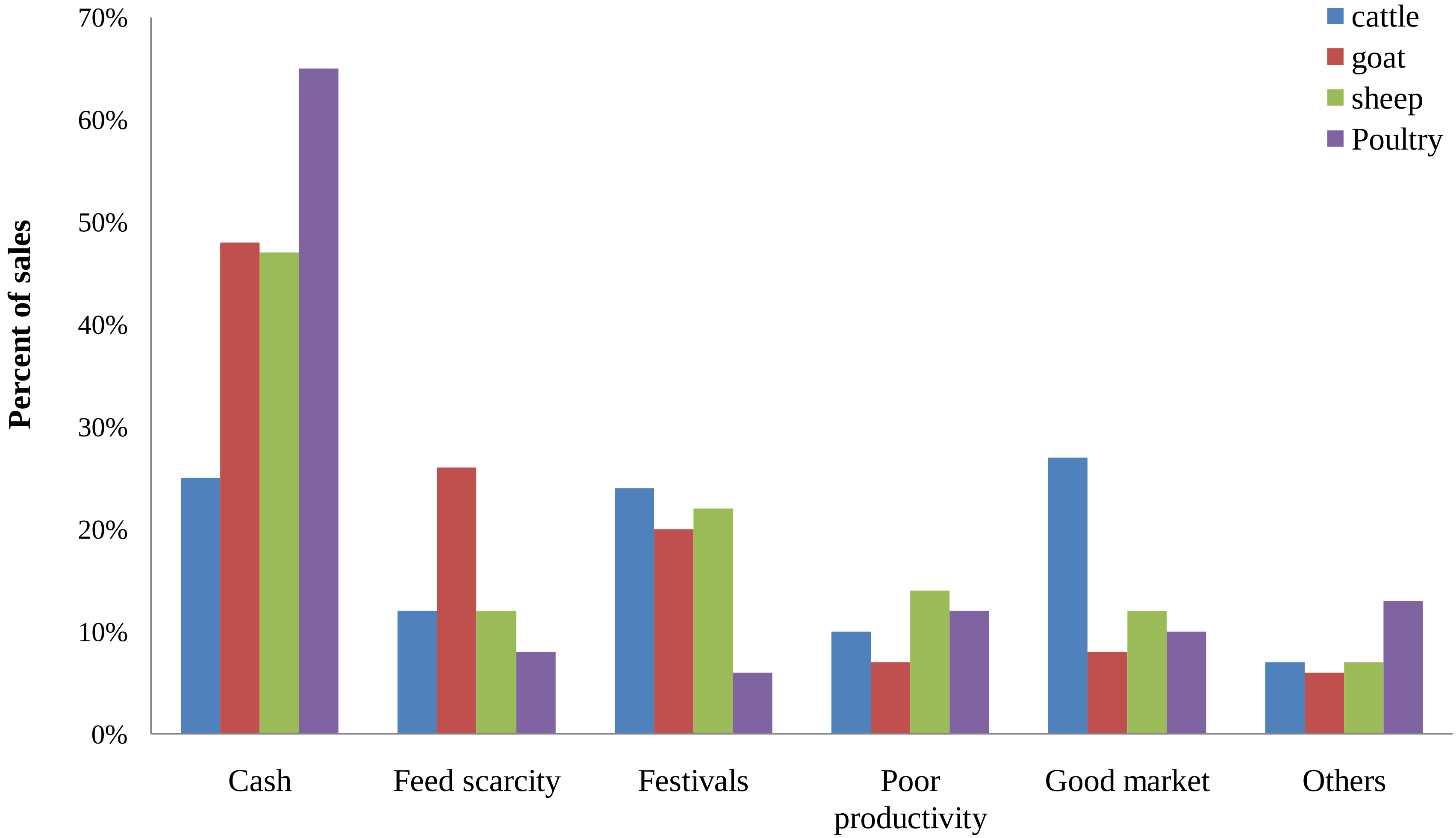

Figure 4.2:Reason for sales of different breeds/classes of animals within the previous 12months of 2011 for households in the Sudan-Sahel Zone of Nigeria.

Prices for cattle varied slightly throughout the year, with prices being highest just before the start of farming season when draft animals would be in high demand (Figure 4.3). No bulls were sold during the cropping season of July through October, largely due to reliance on them as draft power.

Prices fixed for sheep were higher than those of goats which varied little throughout the year (Figure 4.4), although they were slightly lower during the dry period when feed is scarce and slightly higher during September – October. Another likely reason for higher prices was that sheep generally have bigger mature sizes than goats. Income was derived from other livestock related activities including draft bull use and milk sales. Only one farmer reported selling manure, indicating the practice of integrated farming.

4.1.3 Draft power

Seventy-one percent of respondents owned adult male cattle (Table 4.1). Work bulls are used for a variety of tasks throughout the year. The most frequent use of bulls was for transporting manure to the fields, which occurred during the March through May period (Figure 4.5). In addition to work on their own farms, 31% of respondents leased their work bulls out for an average of 16 days/month and on an average price of ₦1, 000 per day.

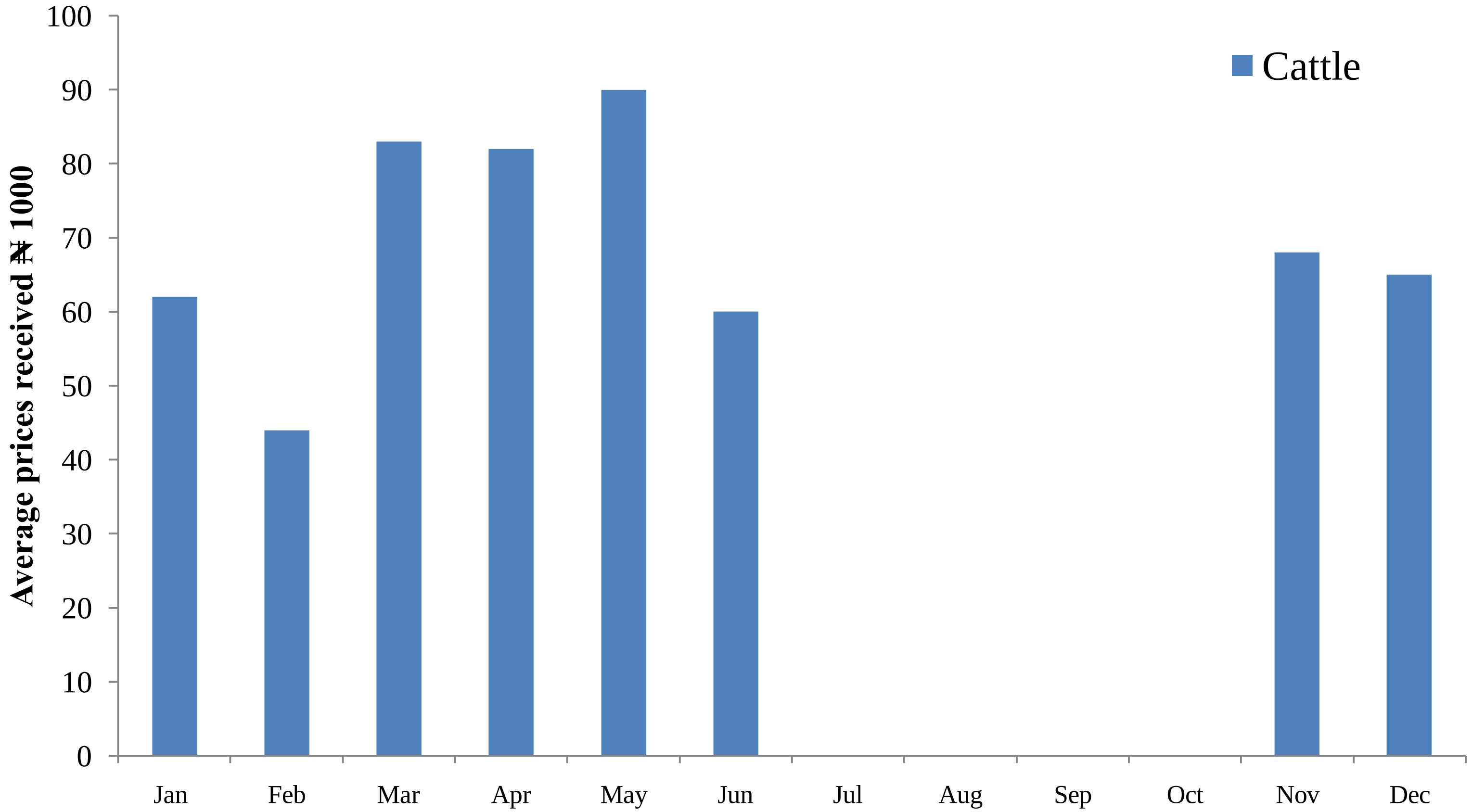

Figure 4.3: Fixed prices of cattle in the last 12 months of 2011 at the Sudan-Sahel Zone of Nigeria

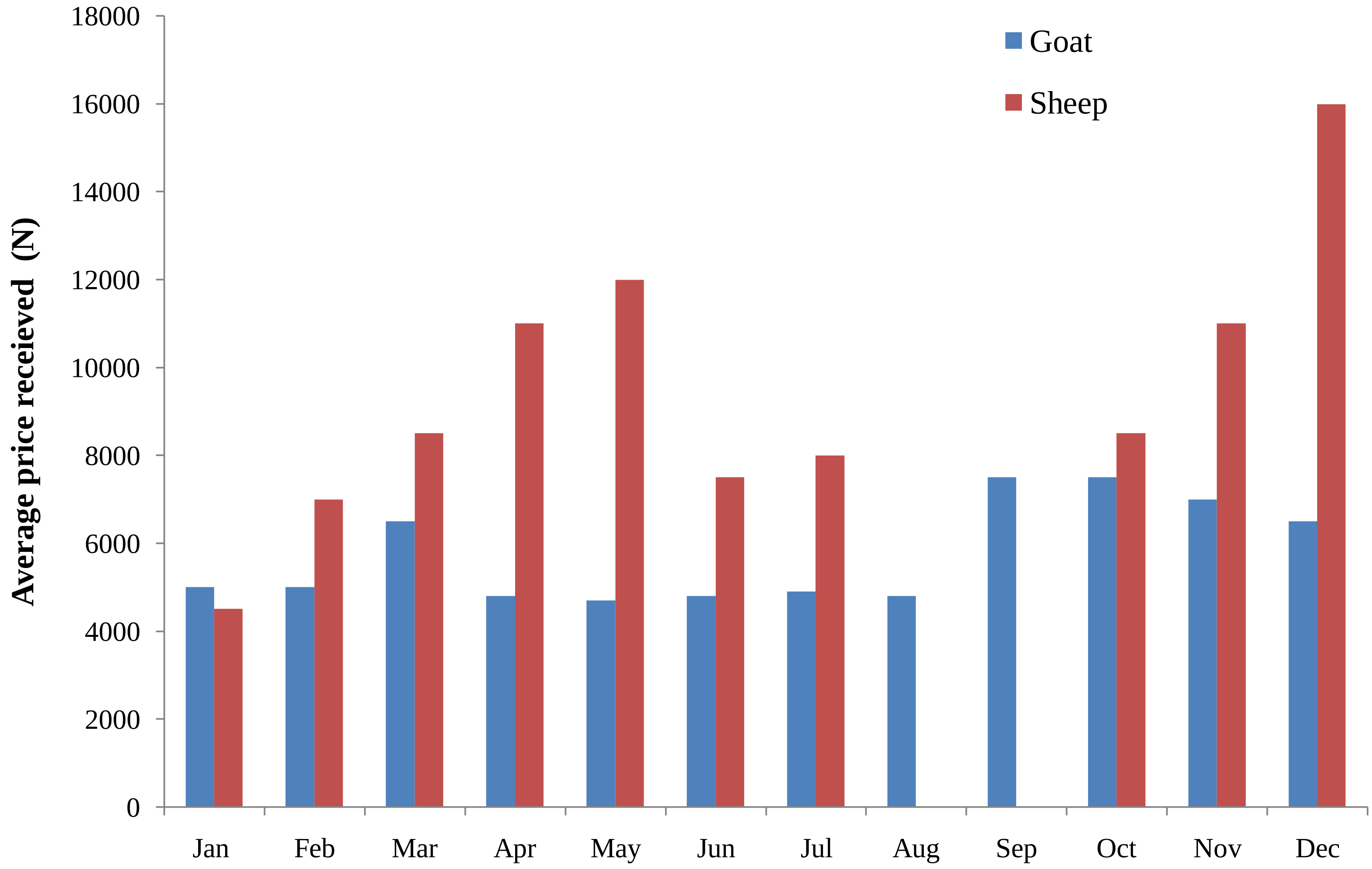

Figure 4.4: Fixed prices for small ruminants in the last 12 months of 2011 at the Sudan- Sahel Zone of Nigeria.

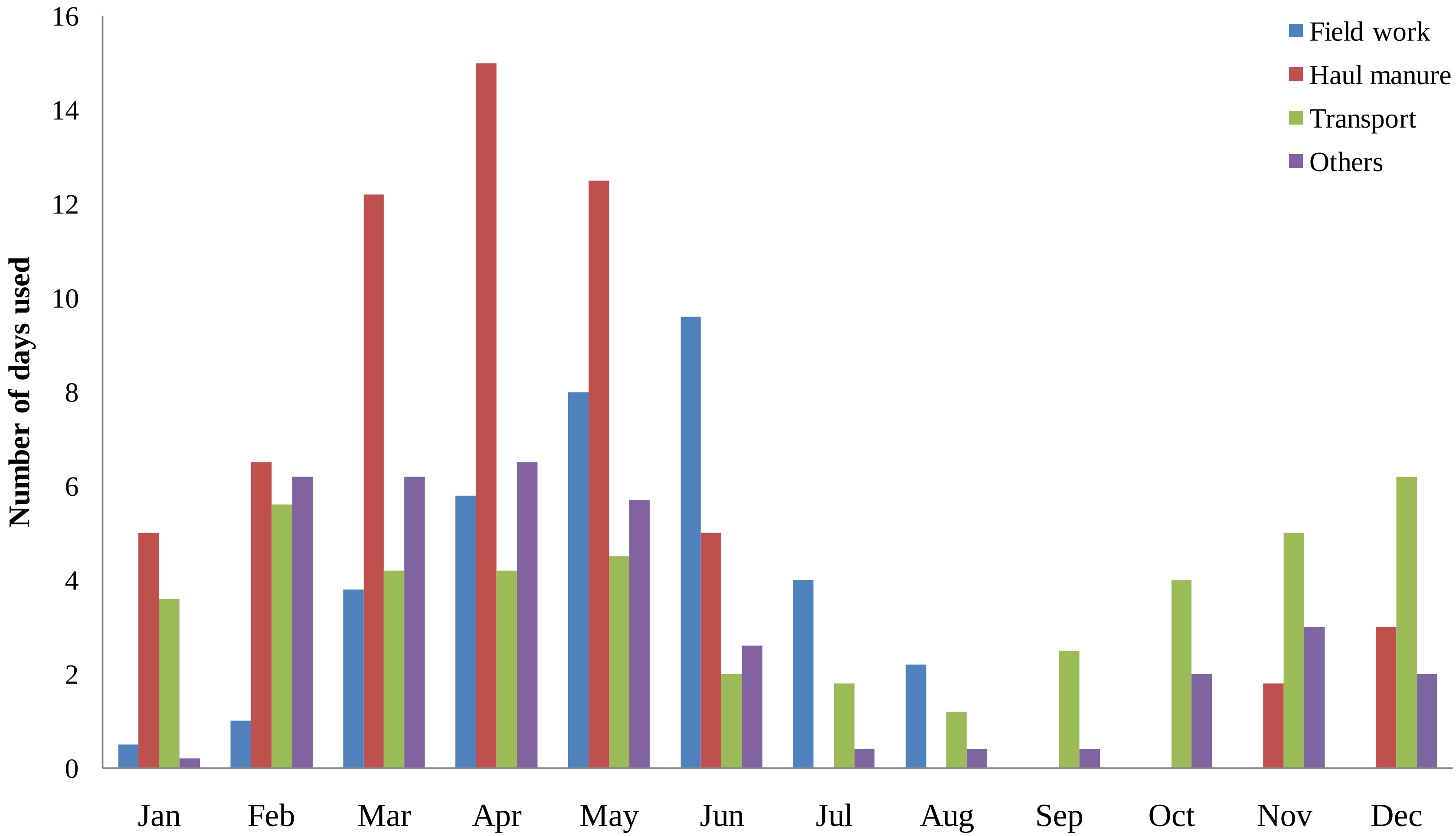

Figure 4. 5: Usage of work bulls (days) during the 12 months period of 2011 for households using draft bulls in the Sudan-Sahel Zone of Nigeria.

4.1.4 Milk sales

Milk sales were reported by 44.4% of respondents with an average daily sale of 2.3 liters. Sales of both cow and goat milk were reported. Milk sales are seasonal (Figure 4.6), with greatest number of days of sale occurring January through July even though milk yield is low during this period. The reason for this was that from July up to harvest period majority of the crop-livestock farmers are fully engaged in cropping their farmlands. In line with cattle ownership as discussed previously, sale of milk varied by village. Of the household reporting milk sales, 54% were from Fanteka (a predominantly Fulani setting), where 90% of the household reported selling milk.

4.2 Livestock Housing

Livestock were housed over 65% of the time throughout the year (Table 4.3). Of 9the livestock that were housed, the most common housing for small ruminants was roofing, although this could represent confinement within a walled area surrounding the entire household with open areas between structures (Table 4. 4). Cattle were mostly housed in open kraal while small ruminants were the class provided with the most of the roofing (Mud house and kraal with roof). Cattle generally withstand inclement weather more than the smaller ruminant species because of probably the thick skin coating.

4.3 Feed Resources

Crop-livestock farmers interviewed grew arable crops such as sorghum, millet, groundnut and cowpea. Not all sorghum residues were used as animal feed but farmers also produce other residues such as millet stover and legume haulms.

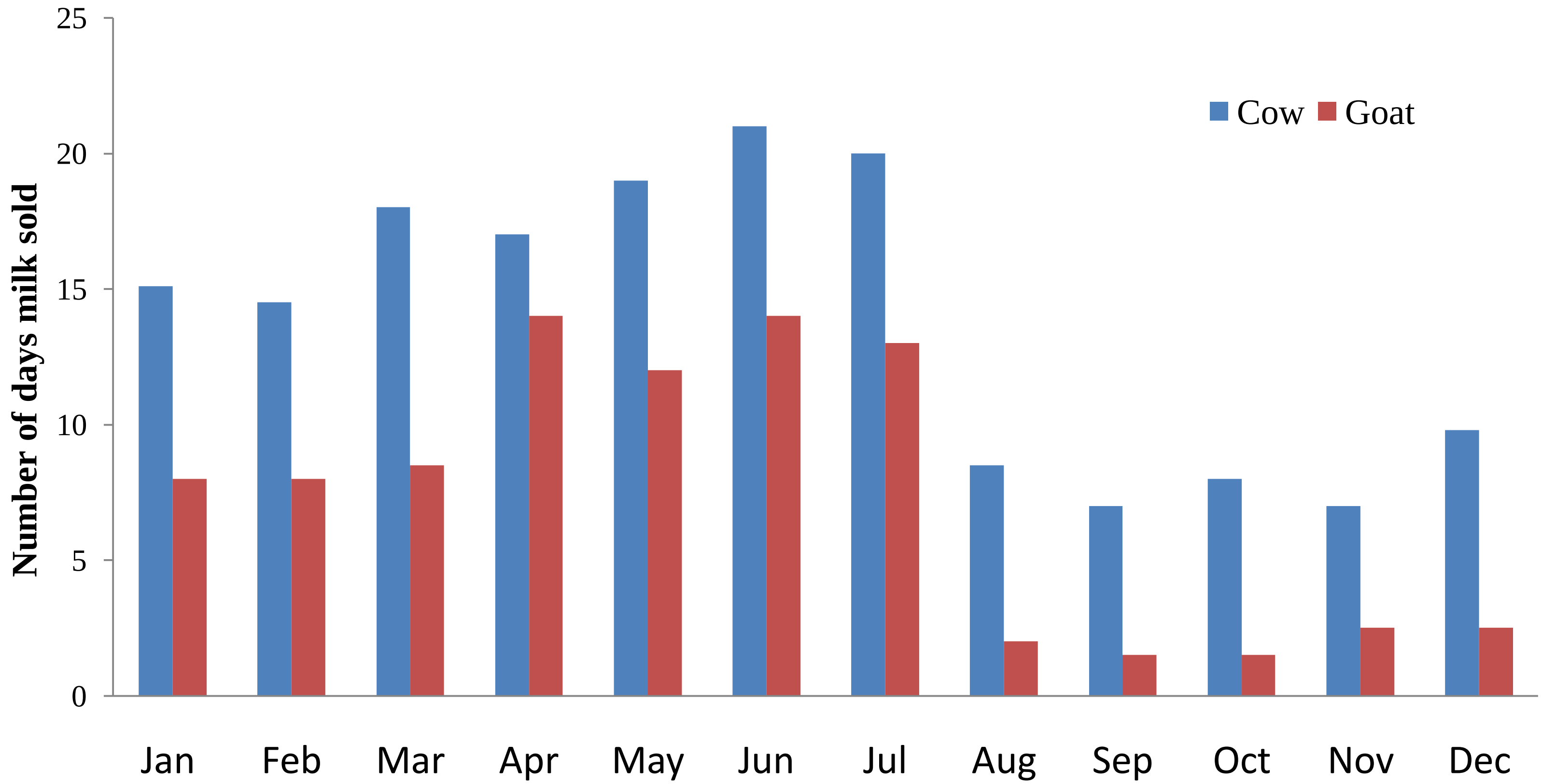

Figure 4.6: Milk sales during the 12 months period for Cows and does in the Sudan-Sahel Zone of Nigeria.

Table 4.3. Percentage of livestock being housed in the dry and rainy seasons in the Sudan-Sahel Zone of Nigeria.

Livestock Class	Dry Season	Rainy Season
Goat	80.6	89.8
Cattle	68.5	70.4
Sheep	78.7	81.5

Table 4.4. Mode of housing of livestock during dry and rainy seasons in the Sudan-Sahel Zone of Nigeria.

Mode of housing	**Dry Season**			**Rainy Season**		
	Goat	**Cattle**	**Sheep**	**Goat**	**Cattle**	**Sheep**
Open kraal %	36.8	58.1	42.4	25.8	55.3	44.3

Kraal with roof %	25.3	2.7	11.8	38.1	3.9	11.4
Mud house %	47.1	48.6	49.4	42.3	47.4	47.7

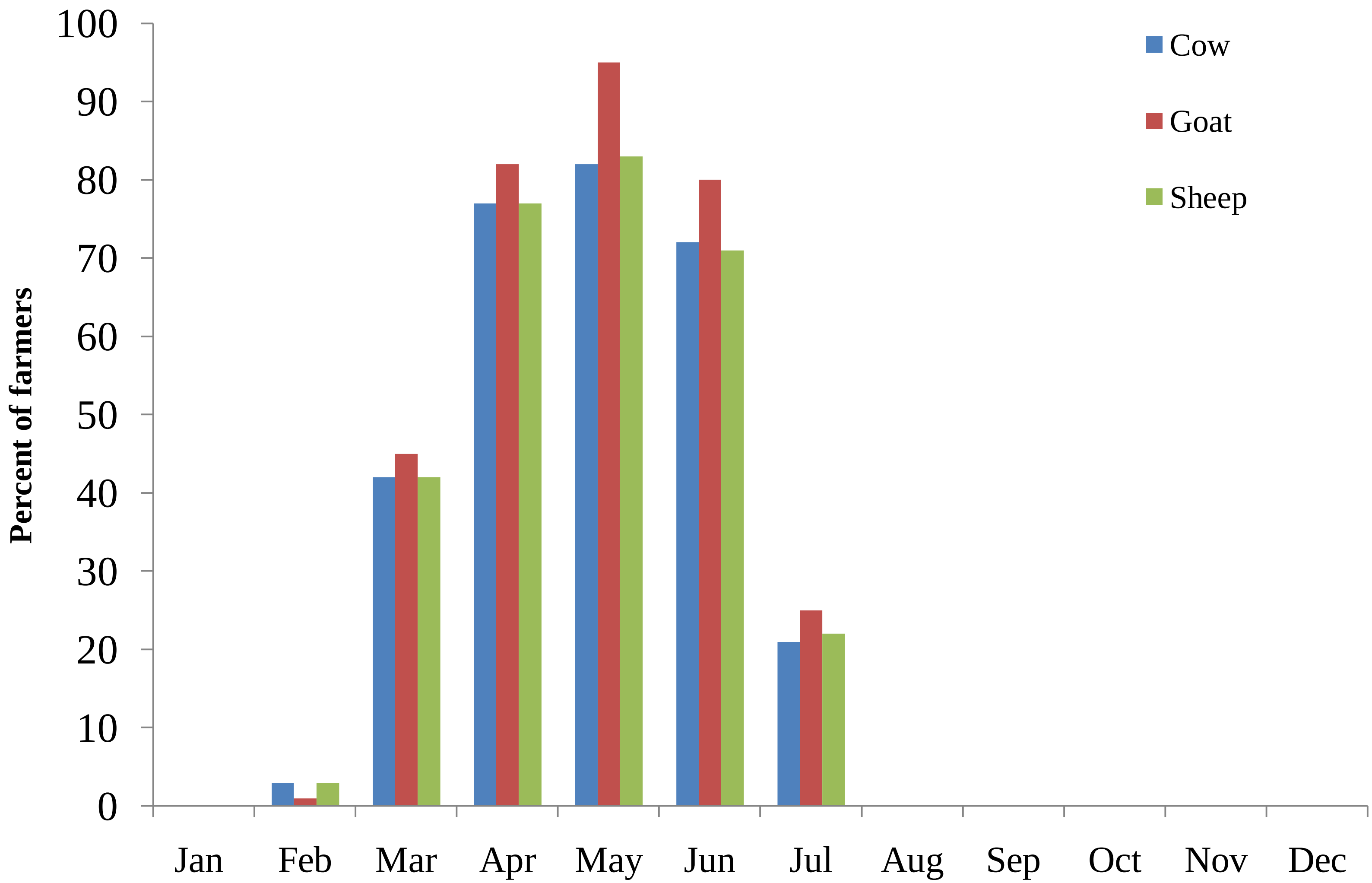

Figure: 4.7 Distribution of livestock farmers that experienced feed scarcity during the period of the year 2011 in the Sudan-Sahel Zone of Nigeria.

Even with the production of these feeds, farmers still experienced periods of limited availability of feed resources. Feed scarcity was reported by the majority of farmers for March through July, peaking in May (Figure 4.7). This coincided with the dry period, between harvest in September – November and the beginning of rains in June-July. Feed was limited for all classes of animals in a similar temporal pattern. As mentioned previously, farmers in this area reported selling goats because of feed scarcity during the dry season for salvaging other animals such as sheep and cattle.

A wider variety of feed resources were identified by farmers, including millet and sorghum stalks, cowpea and groundnut haulms, bran of sorghum, millet and wheat, cottonseed cake, tree leaves, salt, and minerals. More than 95% of respondents reported collecting crop residues for hand feeding, with less than 5% stating that they grazed residues in the field. Farmers did not list other feed resources when asked for a specific listing of feeds, however when asked open-ended questions about "what feeds do you like to use to make your rams grow faster? They included millet grain, sorghum grain, and ground maize. Many farmers measured feeds supplied to their livestock targeted for fattening.

All of the listed feeds above were traded or purchased to some extent. Bundles of crop residues (both cereal and legume) were, at times, purchased from neighbors. Seventy-four percent of respondents reported purchasing sorghum and millet stover and 61 and 63% reported purchasing cowpea and groundnut haulms, respectively. Average prices paid per bundle (averaged 12kg) were ₦71 for sorghum stover and ₦72 for millet stover, indicating similar value for the two types of residue. The price per bag (averaged 17kg) of cowpea haulms was ₦340 and for groundnut haulms was ₦475. Bags of groundnut haulms are often slightly heavier than those of cowpea but groundnut often brings a slightly higher price even on an equal weight basis. Purchases of crop residues were made from as far away as 4-5 km in majority cases and as far as about 15-25 km on big market days in minor cases.

Crop residues were purchased commonly both during October through December, which may represent purchases soon after harvest and again during the driest part of the year, March through June (**Figure 4.8**). This latter period coincided with the period of feed scarcity shown in **Figure 4.7**. This indicates that farmers do have access to feed resources that can help alleviate the period of scarcity of on-farm produced feeds as also discussed by (Grings *et al.,* 2012).

4.3.1 Purchase of concentrates and distance coverage

Farmers purchased concentrate feeds throughout the year (**Figure 4.9**). Purchases of both brans and cottonseed cakes peaked in July. This may represent feeds purchased for supplementing the majority of livestock in confinement. This coincides with the period when cropping is on and no animals can be allowed into the fields and moreover green grasses and other weeds were not fully established. Average price of cottonseed cake was ₦2, 364.00 per 50 kg bag, ₦2, 226.00 for 50 kg wheat bran and ₦140.00 for 20 kg local mineral salt called (Kanwa). The average distance traveled to purchase wheat bran and cottonseed cake was 5.8 km. Concentrates were purchased in markets with travel distances as far as 28-30 km being reported by crop-livestock farmers. Consistent sales and limited distances for feed purchase indicate the existence of input markets in the area that can be used to improve feed supplies.

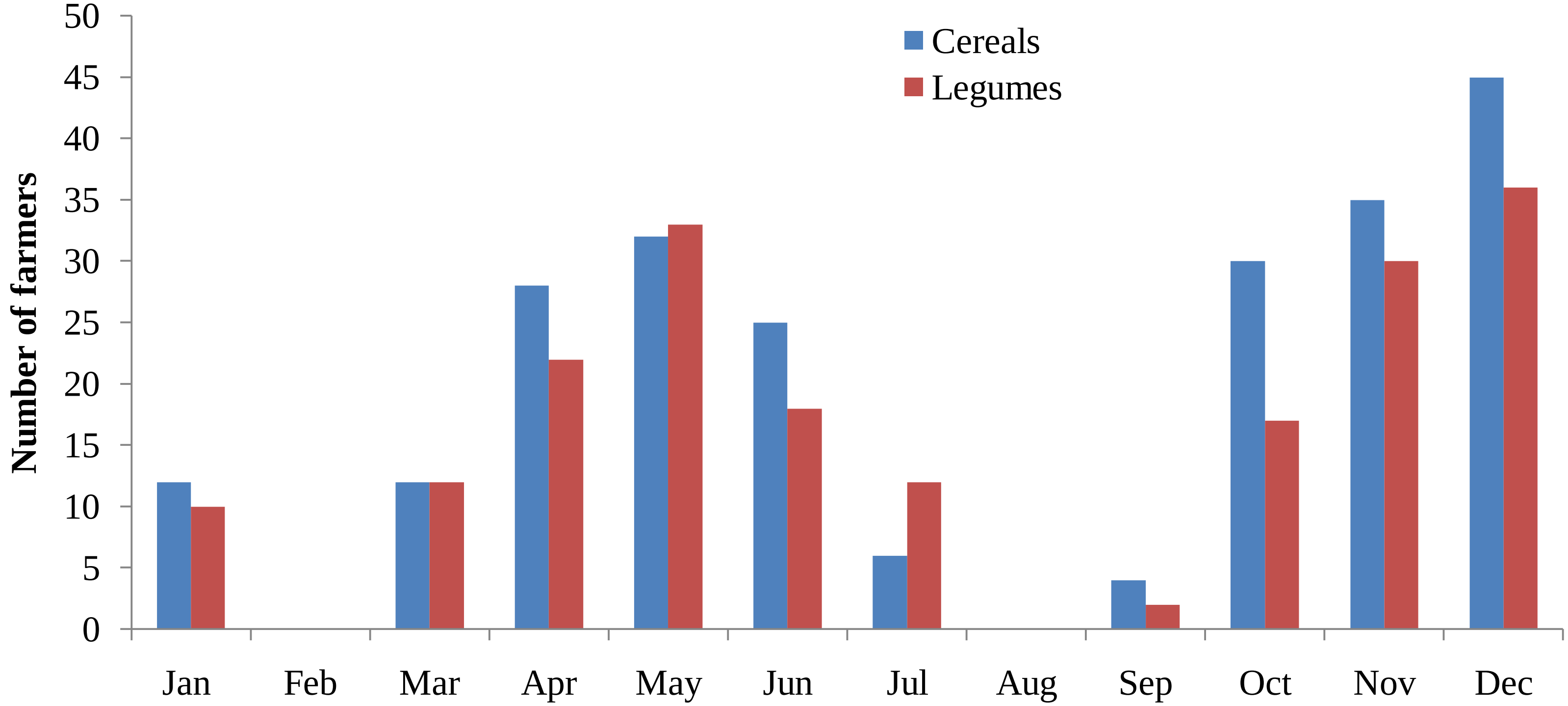

Figure 4.8: Months in which cereal and legume residues were purchased for livestock feed use by livestock owning households in the Sudan-Sahel Zone of Nigeria.

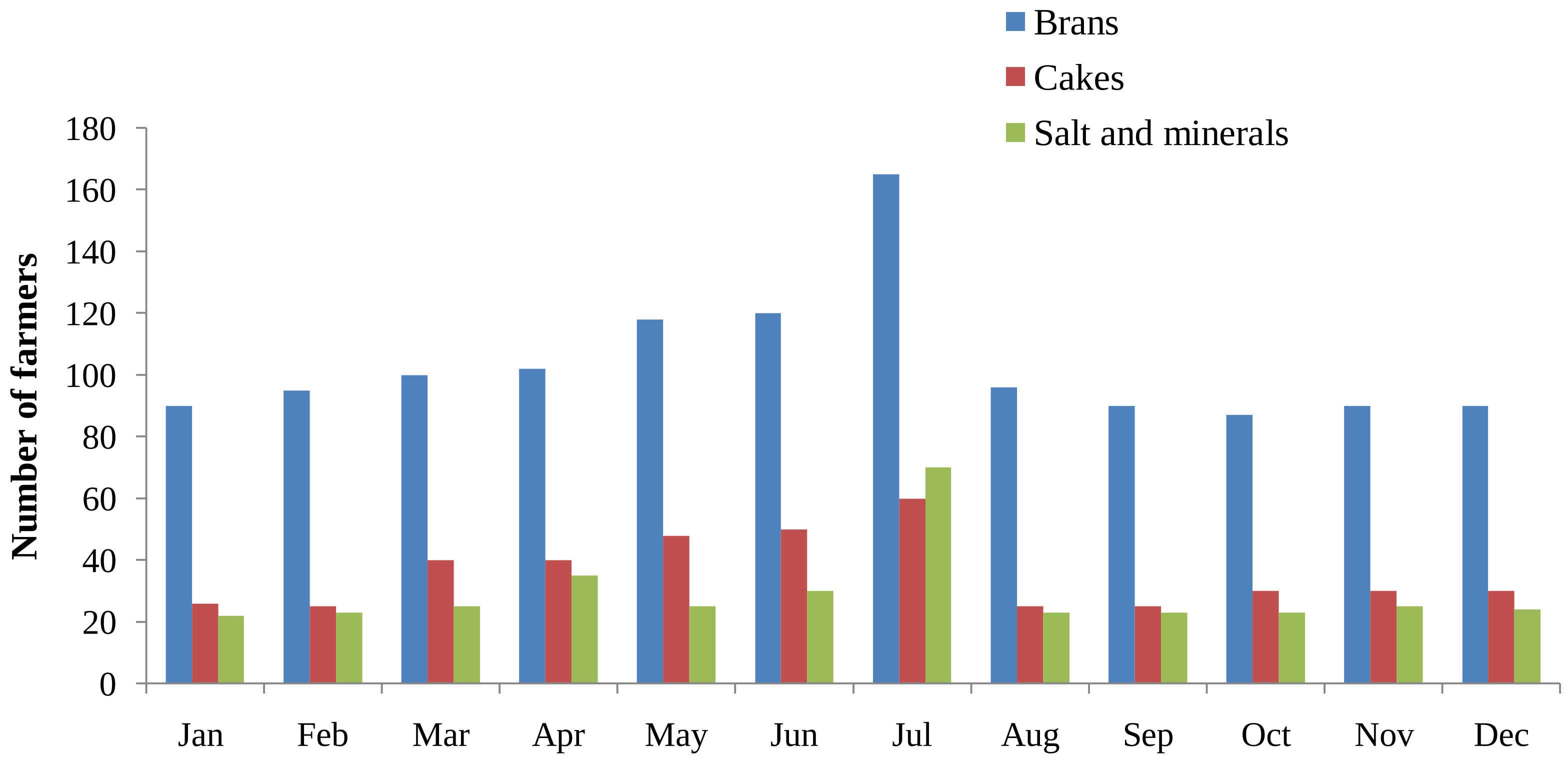

Figure 4.9: Period of concentrate feeds and mineral purchase by livestock farmers in the Sudan-Sahel Zone of Nigeria.

4.3.2 Feed usage by crop-livestock farmers

Competing uses of crop residues were reported and usage as livestock feed by most households (Table 4.5) was observed for both cereal and legume residues. Millet and sorghum residues were also used for fencing, housing and compost and legume residues for compost. A limited number of farmers cut and sold millet and sorghum residues and around 6% of farmers left cereal residues in the field for use by their own livestock but did not sell to others.

4.3.3 Crop residues feeding

Crop residues were offered to livestock unprocessed and only 10.2% of farmers reported that livestock ate all of the cereal residues offered and 37% stated that their livestock ate all legume residues offered. Farmers estimated that livestock consumed 98% of the leaves and only 47% of the cereal stalk. Crop residues, therefore, are the major feed resources for livestock, particularly during the dry season when the biomass of the natural grazing lands is very low. Leftover cereal stalks were used for both fuel and as compost. Leftover legume residues were trampled into the manure by livestock and thereby became part of the compost.

In this semi-arid environment, cottonseed cake was the most common ingredient fed to rams for fattening, draft bulls, and milking cows, with over 95% of farmers using it (Table 4.6). Legume haulms were fed by over 50% of farmers with the use of groundnut haulms being only slightly greater than that of cowpea. Wheat bran was another common feed resource used by more than 50% of farmers and this use was

Table 4.5. Uses of crop residues by households (%) in the Sudan-Sahel Zone of Nigeria

Crop residues	**Feed**	**Fencing**	**Housing**	**Compost**	**Sold**	**Left in field**
Millet	100.0	26.9	6.5	38.0	0.9	6.5
Sorghum	95.4	5.6	17.6	34.3	0.9	5.6
Cowpea	96.3	0.0	0.0	32.4	0.0	0.0
Groundnut	82.4	0.0	0.0	30.6	0.0	0.0

greater than for home produced brans such as those of millet and sorghum. Some grains were used in these production diets, especially for fattening rams where 25.6 and 21.8% of farmers reported using sorghum and millet grain, respectively. A small number of farmers (less than 10%) also reported grain use for draft bulls and milking cows.

4.4 Browse Plants Available in the Area

A variety of browse plants were used as livestock feed in these areas (Table 4.7). The farmers reported using 33 species of browse plants. The highest ranking plant was *Guiera senegalensis (*Sabara*)*, which received a rank of 74.1 out of a possible 100. Farmers reported using leaves of these species in both rainy and dry seasons, although the rainy season was more common (due to animal confinement at home). This plant can make use of underground water if available and start growth late in the dry season when other feeds may not be available. Another important browse species, which had leaves that appear before the end of the dry season, was *Piliostigma thonnigii* (Kalgo), with leaves and pods used in the dry season or both rainy and dry seasons.

Farmers did purchase tree leaves for use in livestock diets more especially in the drier areas such as Dargage in Zangon Daura area. The most common month of purchase was December and leaves were then purchased throughout the dry season (**Figure 4.10**).

Table 4.6. Use of specific feed ingredients for productive functions by farmers raising specific class of livestock in Sudan-Sahel Zone of Nigeria (%).

Specific feed ingredients	Ram Fattening	Draft bulls	Milking cows
Groundnut haulms	61.5	60.5	61.4
Cowpea haulms	51.3	50.7	58.9
Cottonseed cake	98.7	95.8	98.3
Millet bran	7.7	8.5	16.1
Sorghum bran	6.4	8.5	8.9
Wheat bran	51.3	56.3	57.9
Sorghum grain	25.6	8.5	5.4
Millet grain	21.8	9.9	3.6

Cowpea pod walls	10.3	8.5	0.0

Table 4.7. Usage of browse species by livestock farmers in 5 villages in the Sudan-Sahel Zone of Nigeria.

Browse species	Hausa name		Season of Use			Part used[1]
		Rank	Dry	Rainy	Both	
Guiera senegalensis	Sabara	74.1	27	47	26	L
Piliostigma thonnigii	Kalgo	55.3	42	9	49	L,P
Azadirachta indica	Bedi	21.8	36	41	23	L
Prosopis africana	Kirya	19.6	25	50	25	L
Lannea schimperi	Faru	16.9	37	42	21	L
Ficus vallis-chaude	Dundu	16.3	33	59	8	L
Ziziphus spina-christi	Yabo	15.1	29	24	47	L
Tamarindus indica	Tsamiya	9.8	54	27	19	L

Vitellaria paradoxa	Kaba	7.5	33	56	11	L

[1] L = Leaves, P = Pods

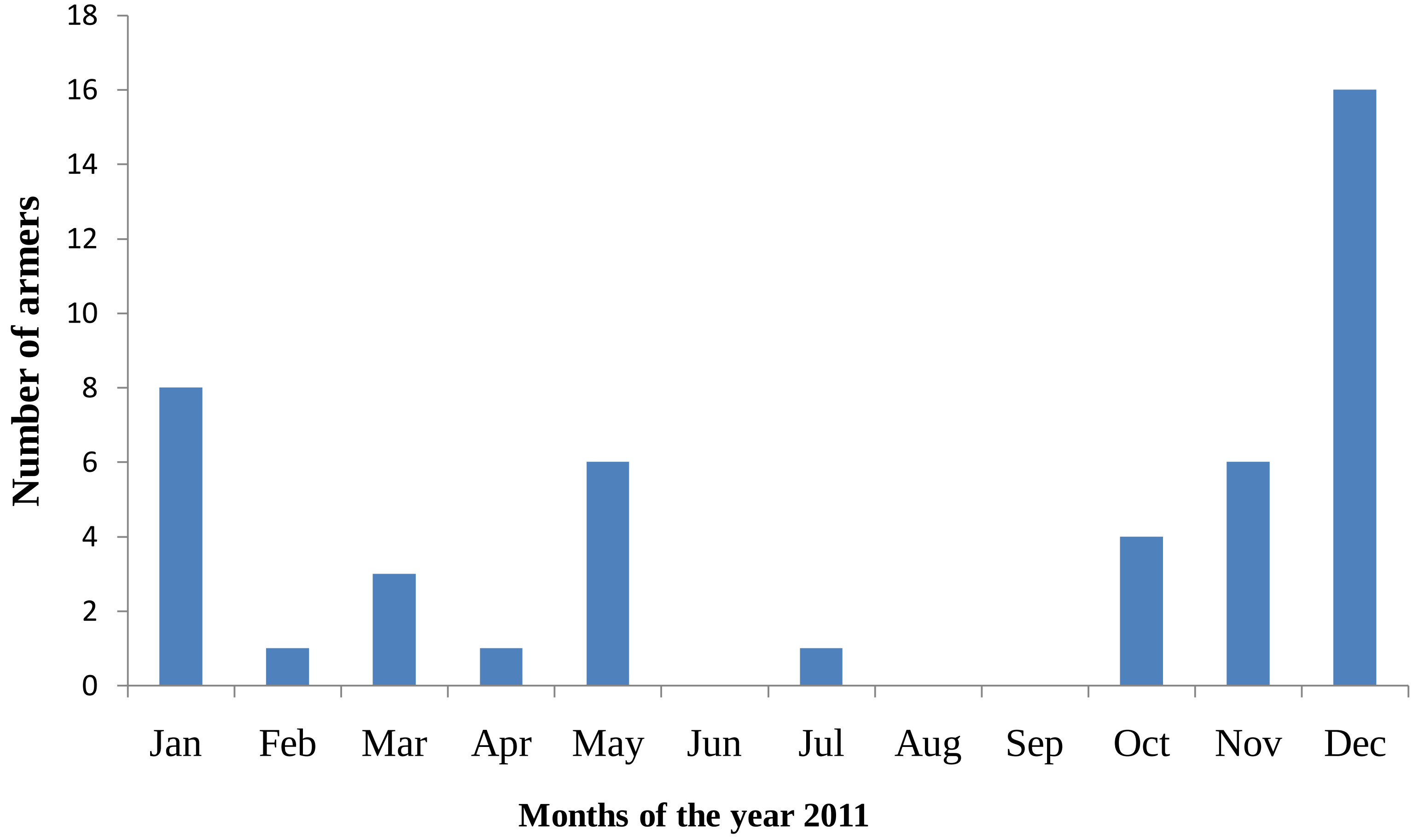

Figure 4.10: Distribution of browse plants purchase by livestock farmers in 2011 for the Sudan - Sahel Zone of Nigeria

4.5 Provision of Supplemental Feeds

The rationale for providing supplemental feeds was evaluated. “Better body condition” was a common response for rationale in supplementing livestock (**Figure 4.11**). Farmers were initially asked to provide their rationale for supplementation on a monthly basis but responses changed little throughout the year and data is presented as an average throughout the year. Adult males were also supplemented to some extent to increase market price, especially small ruminants. Some supplementation of adult males targeted improved draft power in cattle. This was likely a representation of small ruminant fattening operations targeting various festivals. Additionally small ruminants were sold for many year-round celebrations that might not be reflected in a question about sales for ‘festivals’. Although there were a limited number of farmers specifying “higher fertility” as a supplementation rationale, it was difficult to distinguish this from “better body condition”.

4.6 Involvement in Livestock Feeding

To assist in targeting populations to be trained in livestock feeding activities, questions were asked regarding which specific household members were involved in making decisions about or conducting feeding activities. Male heads of household were the major decision makers, even though women owned some of the livestock (Figure 4.12). All household members were involved to some extent in the actual feeding of the livestock.

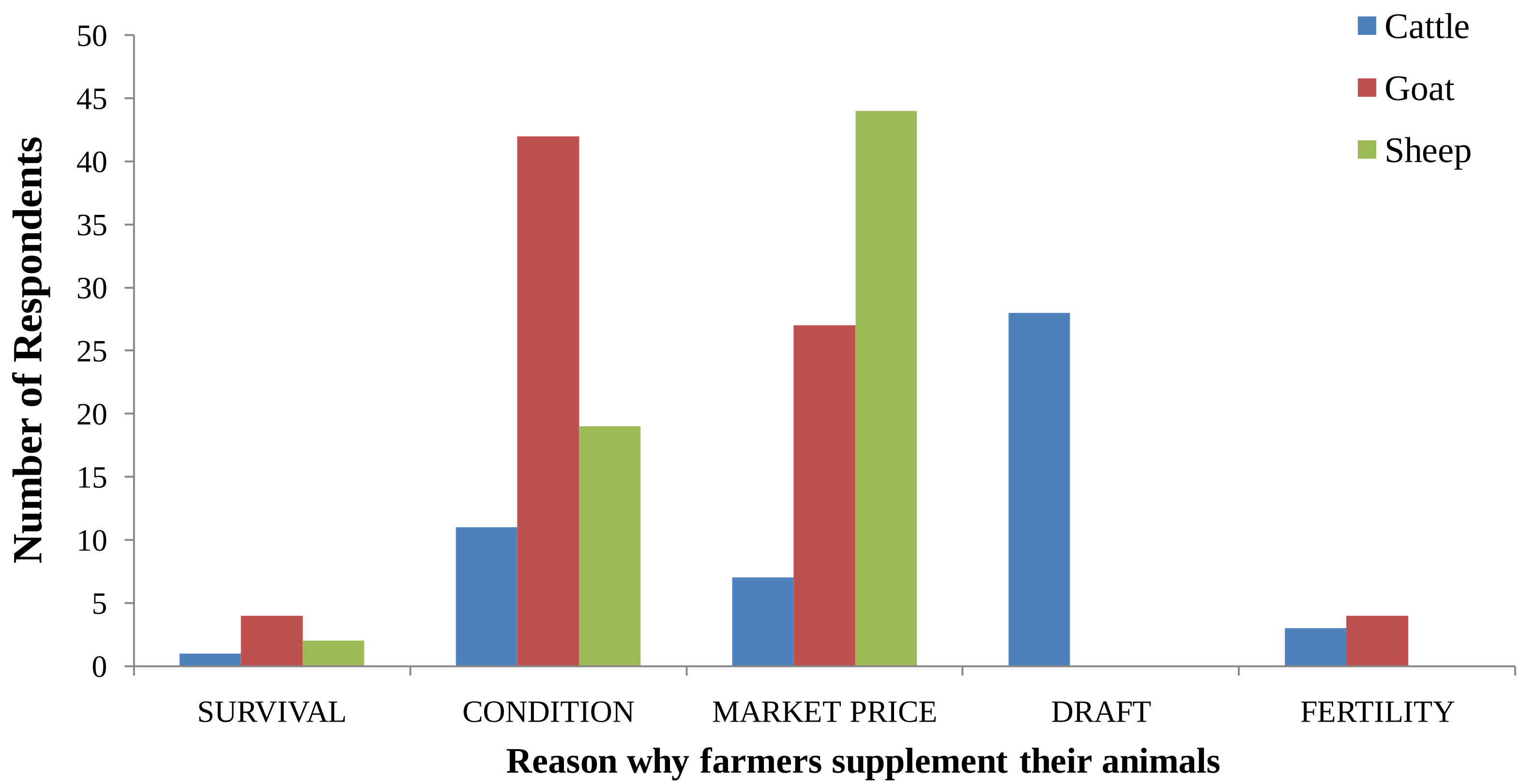

Figure 4.11: Number of respondents that supplemented adult male livestock during the year and the reason for supplementation in the Sudan-Sahel Zone of Nigeria.

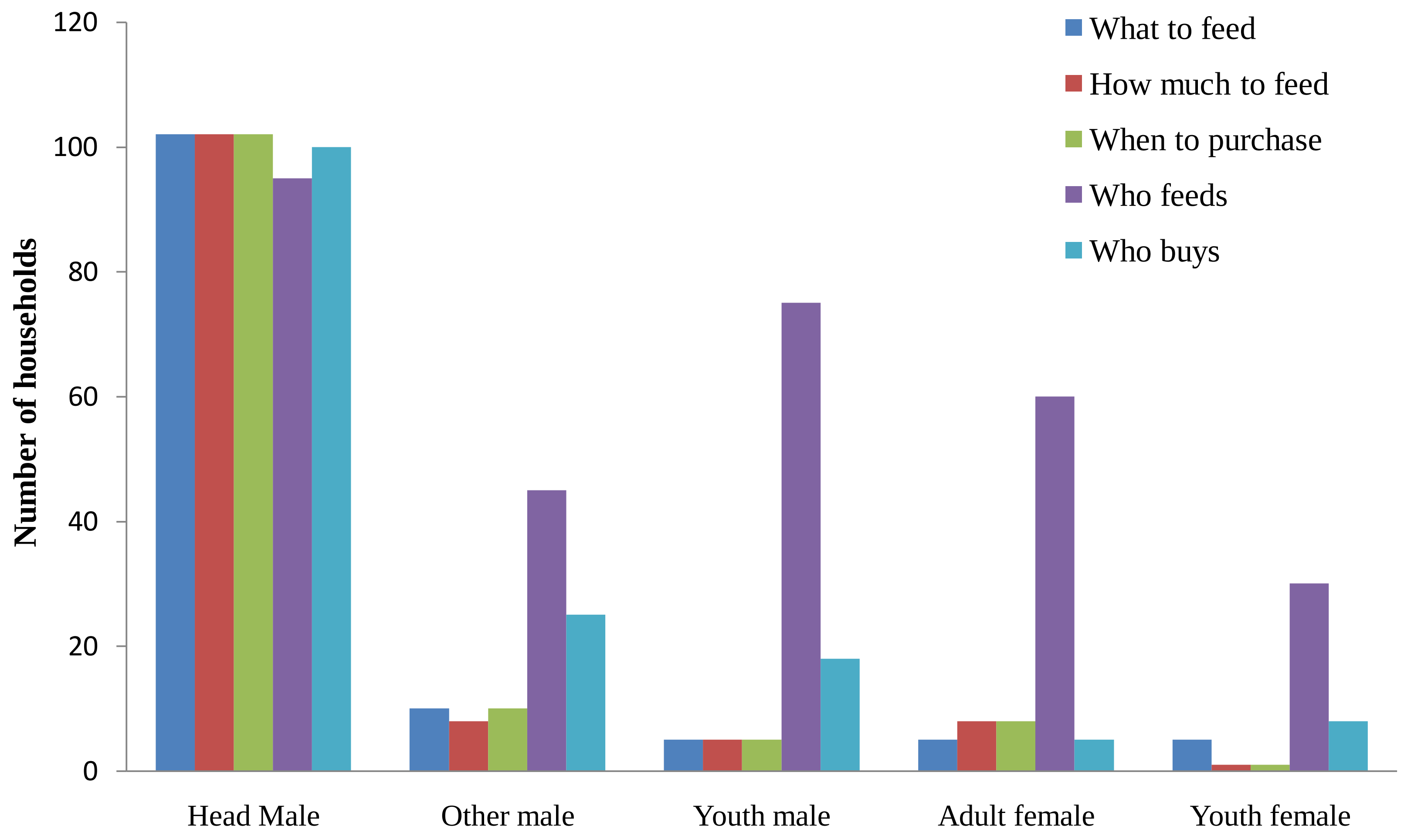

Figure 4.12: Household members and their involvement in livestock related activities in the Sudan-Sahel Zone of Nigeria.

4.7 Constraints to Livestock Feeding

Land and occurrence of drought are perceived to be major constraints to livestock feeding (Table 4.8). These are major issues for crop residues, tree leaves, and grazed forage. Drought is also considered a constraint for green fodder and distance is a constraint for tree leaves. Market access and high price are concerns for concentrate feeds. Poor quality was only considered a major constraint for crop residues by 6.4% of respondents, whereas poor quality of grazed forage was identified as a major constraint by 28.2% of respondents.

Farmers expressed a willingness to make some investments to improve feeding strategies, with improvements to cattle feeding ranking highest (Table 4.9). Over 80% were also willing to invest in improving animal health. Farmers expressed their willingness to invest in water facilities, improved animal breeding strategies, and housing, but these ranked below feeding and animal health in importance.

4.8 Experiment II: Performance of Yankasa Rams as Influenced by Feeding Regime of Cowpea (*Vigna unguiculata*) Haulms on Sorghum Stover Basal Diet in the Dry Savanna of Nigeria.

4.8.1 Feeding trial

4.8.2 Chemical composition of experimental feeds

Chemical composition of sorghum stover, cowpea haulms and wheat bran are presented in Table 4.10. Dry matter and cell constituents (ADF and NDF) of sorghum stover were higher than both those contained in cowpea haulms and wheat bran. NDF content was lowest for wheat bran (43.74 %) followed by

Table 4.8. Major perceived constraints to growing, purchasing and accessing livestock feeds in the Sudan-Sahel Zone of Nigeria.**(%)**

Livestock feeds	**Constraints**					
	Land	**Market**	**Price**	**Quality**	**Distance**	**Drought**
Crop residue	29.8	2.5	22.1	6.4	7.2	31.9
Green fodder	7.1	19.7	15.6	13.2	14.5	29.9
Tree leaves	30.8	0.4	3.5	17.8	25.4	21.4
Concentrates	2.0	26.9	32.2	17.3	19.1	2.4

Grazed forages	28.6	2.5	3.2	28.2	11.2	27.3

Table 4.9. Willingness of livestock farmers to invest in technologies for improving animal production in the Sudan-Sahel Zone of Nigeria.

	Feeding	**Animal Health**	**Water**	**Breeding**	**Housing**
Percentage of farmers willing to invest					
Cattle	96.3	95.4	92.6	92.6	91.7
Goats	83.3	84.3	82.4	80.6	80.6
Sheep	83.3	83.3	81.5	77.8	79.6
Priority of investment [1]					
Cattle	1.29	1.89	2.52	2.56	2.45
Goats	1.35	1.86	2.44	2.65	2.42
Sheep	1.36	1.89	2.42	2.68	2.52

1 = (Feeding) Highest priority, 2 = (Water, Housing and Breeding) lowest priority.

cowpea haulms while that of sorghum stover was highest. More cell wall constituents (NDF, ADF and ADL) were more in sorghum stover and cowpea haulms than wheat bran. The crude protein of both cowpea haulms and wheat bran 13.35%, 17.50% respectively, were higher than that of sorghum stover (1.77%).

4.8.3 Feed and nutrient intake

Sorghum stover intake was highest for the control although not significantly(P>0.05) different across the rest of supplemented treatments except for those fed thrice , followed by those fed 300g cowpea haulms and was lower for those fed in split doses. All cowpea haulms supplements offered were completely consumed and resulted in observed DM intakes (Table 4.11). Total feed intake was significantly (P<0.05) increased for cowpea haulms with increasing level of feeding. Animals fed 300g and 600g cowpea haulms supplement also had significantly (P<0.05) higher feed intake compared with the control. Rams fed 600g consumed more feed than those fed 300g cowpea haulms. There was however no statistical (P>0.05) difference between those rams fed 600g once or in split feeding. All other components of intake (OM, CP, ADF, ADL and Ash) were significantly (P<0.05) lowest in the rams fed the control diet and highest in the rams on the split feeding treatments.

Table 4.10. Proximate composition of experimental feed materials

Parameters (%)	Sorghum stover	Cowpea haulms	Wheat bran
Dry matter	94.35	93.27	92.17

Organic matter	88.94	82.46	87.41
Crude protein	1.77	13.35	17.5
ADF	46.61	42.95	12.9
NDF	79.60	55.67	43.74
ADL	5.09	5.51	3.18

ADF=Acid Detergent Fiber, NDF= Neutral Detergent Fiber, ADL= Acid Detergent Lignin.

Table 4.11. Total Feed and nutrient intake of fattening Yankasa Rams under different Cowpea haulms feeding levels and frequency.

Parameters (g)	Level of cowpea haulms incorporation					SEM
	Control	300g fed once	600g fed once	300g fed twice	200g Fed thrice	
Stover intake	455.16[a]	442.72[ab]	399.74[ab]	383.75[ab]	332.40[b]	34.26
CPH intake	0	284.53[b]	506.04[a]	542.42[a]	533.31[a]	14.35
Total feed intake	455.16[c]	727.25[b]	905.78[a]	926.17[a]	865.70[a]	32.42
Dry matter intake	429.44[c]	675.26[b]	849.14[a]	867.99[a]	811.03[a]	30.48
Organic matter intake	404.81[c]	621.30[b]	772.81[a]	788.59[a]	735.40[a]	28.67
Crude protein intake	8.06[c]	45.04[b]	74.63[a]	79.21[a]	77.08[a]	1.84
ADF intake	212.15[c]	324.86[b]	403.66[a]	411.84[a]	383.99[a]	15.02
NDF intake	362.30[c]	505.46[b]	599.91[a]	607.43[a]	561.48[ab]	25.62
ADL intake	23.17[c]	37.76[b]	48.23[a]	49.42[a]	46.30[a]	1.65
Ash intake	24.62[c]	53.40[b]	75.32[a]	78.31[a]	74.57[a]	1.97

[a,b,c,] Means within row with different superscript differ significantly (P<0.05) CPH= Cowpea Haulms, ADF=Acid Detergent Fiber, NDF= Neutral Detergent Fiber, ADL= Acid Detergent Lignin.

4.8.4 Live weight changes

Cowpea haulms supplementation improved average daily weight gain significantly (P<0.05) in all the cowpea haulms supplemented treatment groups compared with the control group that received only sorghum stover as shown in Table 4.12. Average daily weight gain of rams fed on sole sorghum stover was just 5.29g while those fed on 300g cowpea haulms supplementation was 45.78g. There were no significant (P>0.05) differences between the cowpea haulms supplementation across the treatments, however, rams offered cowpea haulms 600g once, twice and thrice daily showed the highest significant (P<0.05) weight gains.

4.8.5 Nutrient digestibility

There were significant (P<0.05) increases in the digestibility of DM, OM, CP, ADF and ADF in favour of rams supplemented with cowpea haulms compared to those on control as presented in Table 4.13. Although there were no significant differences (P>0.05) between the cowpea supplemented treatment groups, nutrient digestibilities of rams fed 300g supplement once, were generally lower except for CP (43.83%) than those fed 600g regardless of feeding regime. Similarly, DM, OM and CP digestibilities slightly increased in rams supplemented 2 times daily compared to the ones supplemented thrice daily while ADF and NDF increased slightly for rams on supplements fed thrice compared to those fed supplement fed twice a day.

Table 4.12. Weight changes in Yankasa rams on different feeding levels and frequency with cowpea haulms.

Parameters (days)	Level of cowpea haulms incorporation					
	Control	300g fed once	600g fed once	300g fed twice	200g Fed thrice	SEM

Initial Wt	22.82	22.83	22.83	22.82	22.83	0.68
15	21.66[b]	23.31[ab]	23.97[a]	24.42[a]	23.19[ab]	0.68
30	21.92[b]	23.65[ab]	24.16[a]	24.99[a]	24.21[a]	0.73
45	22.19[b]	24.44[a]	25.21[a]	25.67[a]	25.08[a]	0.76
60	22.42[b]	25.03[a]	25.54[a]	26.030[a]	25.78[a]	0.80
75	22.71[b]	26.09[a]	26.50[a]	26.82[a]	26.66[a]	0.86
Final wt (Kg)	22.71[b]	26.07[a]	26.50[a]	26.85[a]	26.65[a]	0.86
Total wt gain(Kg)	0.391[b]	3.388[a]	3.668[a]	3.978[a]	3.761[a]	0.82
ADWG (g)	5.29[b]	45.78[a]	49.56[a]	53.75[a]	50.83[a]	3.51

[a,b] Means within row with different superscript differ significantly ($P<0.05$).

Table 4.13. Effect of different feeding levels and frequency on nutrient digestibility of Yankasa Rams

Parameters (%)	Level of cowpea haulms incorporation					SEM
	Control	300g fed once	600g fed once	300g fed twice	200g Fed thrice	
DM Digestibility	25.96 [b]	55.01 [a]	63.22 [a]	64.77 [a]	64.97 [a]	4.70
OM Digestibility	36.62 [b]	57.79 [a]	65.57 [a]	67.09 [a]	67.47 [a]	4.21
CP Digestibility	39.60 [b]	56.13 [a]	43.83 [a]	51.20 [a]	52.76 [a]	20.09
ADF digestibility	38.85 [b]	57.47 [a]	66.96 [a]	65.86 [a]	64.70 [a]	4.31

NDF digestibility	46.42 [b]	61.13 [a]	67.48 [a]	68.52 [a]	67.75 [a]	3.92

[a,b] Means within row with different superscript differ significantly (P<0.05).

4.8.6 Slaughter parameters

Rams fed supplementary cowpea haulms had significantly (P<0.05) higher slaughter weight, hot weight, cold weight, dressing percent, mesenteric fat weight and kidney fat weight relative to the control treatment (Table 4.14). Cowpea haulms supplemented twice daily gave the highest weights 26.16 kg, 11.41 kg, 10.95 kg, 43.63%, 386.88g and 334.38, for weight after slaughter, hot weight, and cold weight, dressing percent, mesenteric fat weight and kidney fat weight, respectively. However, dressing percent was statistically similar for rams on the control group and those fed cowpea haulms supplements once daily. There was no significant (P>0.05) differences between the gastro intestinal tracts, head, skin and leg weights of rams across all the treatments.

4.8.7 Manure quality

Table 4.15 shows the total manure output and level of total nitrogen and total phosphorus in manure of rams fed on different treatments. Total nitrogen contents of the manure voided by rams fed supplementary cowpea haulms were significantly (P<0.05) higher than those fed on sorghum stover alone (control). Among those fed cowpea haulms however, they were not statistically different (P>0.05) even though rams offered 600g once had higher total nitrogen of 2.03%. The total phosphorus content of the manure produced by rams fed sorghum stover was significantly (P<0.05) higher than those supplemented with cowpea haulms. Animals on the cowpea haulms supplement fed 2 times (300g x 2) had significantly more total phosphorus (1.07%) than those fed thrice (0.73%). There was no difference between rams fed cowpea haulms once in terms of total phosphorus.

Table 4.14. Slaughter parameters of Yankasa rams fed cowpea haulms on different feeding levels and frequency.

Parameters	Level of cowpea haulms incorporation					SEM
	Control	300g fed once	600g fed once	300g fed twice	200g Fed thrice	
Slaughter weight (Kg)	22.25^{b}	25.34^{a}	25.50^{a}	26.16^{a}	25.69^{a}	0.82
Hot carcass weight (kg)	9.17^{b}	10.44^{a}	10.90^{a}	11.41^{a}	11.13^{a}	0.41
Cold carcass weight (kg)	9.03^{b}	10.16^{ab}	10.33^{a}	10.95^{a}	10.50^{a}	0.40
Dressing percent	41.31^{ab}	41.10^{b}	42.38^{ab}	43.63^{a}	43.61^{a}	0.79
Full GIT weight (kg)	9.420	10.05	10.21	9.71	9.07	0.57
Empty GIT (kg)	2.57	2.69	2.91	2.87	2.71	0.13
Head weight (kg)	1.94	1.96	1.99	2.06	1.95	0.07
Skin weight (kg)	1.70	1.69	1.77	1.83	1.88	0.10
Leg weight (g)	598.75	585.00	636.25	626.25	606.25	23.94
Mesentric fat weight (g)	212.50^{b}	302.50^{ab}	245.00^{b}	386.88^{a}	293.75^{ab}	38.85
Kidney fat weight (g)	240.00^{b}	281.88^{ab}	267.50^{ab}	334.38^{a}	269.38^{ab}	27.17

^{a,b} Means within row with different superscript differ significantly (P<0.05).

Table 4.15. Effect of feeding levels and frequency with cowpea haulms on manure output and quality.

Parameters	Level of cowpea haulms incorporation					SEM
	Control	300g fed once	600g fed once	300g fed twice	200g fed thrice	
Total manure output (Kg)	37.38	40.43	33.25	39.55	39.20	3.34

Total Nitrogen (%)	1.70[b]	1.90[ab]	2.03[a]	1.90[ab]	1.75[b]	0,07
Total Phosphorus (%)	1.46[a]	0.90[bc]	1.03[bc]	1.07[b]	0.73[c]	0.10

[a, b, c,] Means within row with different superscript differ significantly at (P<0.05).

4.9 Cost Benefit Analysis

The result of the cost benefit analysis on fattening of Yankasa rams on different cowpea feeding management presented in Table 4.16 shows an increase in total feed intake. Animals fed on sole sorghum stover recorded lower feed intake. Feeding cowpea haulms as a supplement increased total feed intake from 455.16g/d to 727.25g/d, while increasing the quantity of cowpea haulms also increased intake to 905.78g/d. Feeding frequency also affect total feed intake. Rams fed 200g 3 times a day had consumed 865.71g, while those fed 300g 2 times a day consumed the highest feed 926.17g/day.

Income accruable as a result of the cowpea feeding management shows that least income was obtained from rams fed on no cowpea haulms (NCP) (₦ 102.12), while supplementation with cowpea haulms increased the income to (₦1003.45), resulting in a marginal increase of (901.33). Increasing the quantity of the haulms to 600g resulted in an increase in income (₦ 1166.51) and a marginal income of (₦ 163.06). Feeding cowpea haulms twice versus thrice a day resulted in an increased income (₦ 1247.76 and ₦ 1305.48, respectively), with a lower marginal increase in income (₦ 81.25 and ₦ 57.72, respectively) when compared with feeding same quantity of supplement once a day (₦ 163.06). Feeding rams with sole sorghum stover alone (Control), an apparent loss of (₦ 170.98) was incurred.

Table 4.16. Cost benefit analysis of fattening rams on different feeding levels and frequency with cowpea haulms.

Parameters	Level of Cowpea haulms incorporation				
	Control	300g fed once	600g fed once	300g fed twice	200g Fed thrice
Total Feed Intake (Kg)	455.16	727.25	905.78	926.17	865.71
Total weight gain (Kg)	0.34	3.26	3.67	3.99	3.82
Dressing percent	40.28	41.10	42.38	43.63	43.61
Cost of Total Feed consumed (₦)	273.09	436.35	543.47	555.70	519.43
Income accruable (₦)	102.12	1003.45	1166.51	1305.48	1247.76
Marginal increase in income		901.33	163.06	57.72	81.253
Apparent Profit/Loss (₦)	-170.98	567.10	623.04	749.78	728.34

Cost of stover = N3.00/Kg, Cost of Cowpea haulms = ₦5.00/Kg, Cost of meat = ₦750.00/Kg, Income accruable (₦) = Total weight gain (Kg) x Dressing percent x Cost of meat/Kg, Apparent Profit/Loss (₦) = Income accruable – Cost of total feed consumed.

CHAPTER FIVE

5.0 DISCUSSION

5.1 EXPERIMENT 1: Livestock and feed resource survey

5.1.1 Livestock resources

Livestock are an important component of the farming systems within the Sudan-Sahel zone of the KKM Pilot Learning Site and interventions and training have the potential to improve the livelihoods of resource-poor crop-livestock farmers in the zone. Livestock were often sold to provide cash when needed. Market prices seemed attractive to farmers, as livestock such as sheep were sold for festivals when market prices are good. It is particularly attractive to poor farmers because of the low investment and rapid turnover (Fernandez-rivera, *et al.,* 2008).Increased understanding of market conditions for livestock could potentially improve planning and income from sales.

Analyses of policies in the livestock sector all agree that demand for animal products will rise in line with population growth, especially in view of rapid urbanization. In the West African region, statistics also indicate a high demand for animal products both in the coastal countries described as consumption basins and in the Sahel countries described as production basins (Kamuanga *et al.,* 2008). This relative natural specialization with regards to animal production has advantages for the development of intra-regional trade in animal products and therefore for regional integration. This is especially apparent as small ruminants' fattening now, attracts income throughout the year due to increased urban demand for protein. However, this may also be a time that cash is required to obtain inputs for farming operations and may influence the decision to sell livestock.

5.1.2 Feed resources

The period of feed scarcity is at its peak at the dry season and this falls during the period of highest nutrient demand of livestock (during March through July, when farmers have difficulty providing feed). The judicious and economic use of supplementary feeds such as cowpea haulms at this time is very important for crop-livestock farmers to raise income and take care of other family and farm needs (farming inputs). Also, the use of crop residues for other uses than livestock feed has been well recognized in this zone. This means that the inclusion of left-over residues into compost for application to fields is an important part of the crop-livestock farming strategy. It is also important to consider the use of cereal feed refusals as a fuel source.

The use of concentrate feeds in the Sudano-Sahelien zone is a widely recognized and practiced phenomenon by livestock farmers and also distances to points of sales of these concentrates are within short coverage. However, considering the poor resource holdings of the crop-livestock farmers, this potentiality is limited to a wider extent across the zones.

One proposed feed intervention strategy for this study is the introduction of feed choppers to improve feeding value of cereal residues. In attempting to introduce this technology, care must be taken to ensure that materials are left for fuel use (about 25% of the residues). Lack of consideration of this residue use could lead to problems in adoption of chopper technology or increased use of alternate fuel resources, such as firewood, which could have negative consequences for the environment.

A willingness of farmers to utilize concentrates such as wheat bran and cowpea haulms for fattening programs was observed. This interest is being considered in developing feeding strategies to be tested as part of a ram fattening program. This aspect formed the basis for designing ram fattening experiment aimed at addressing a more economically viable and sustainable option for crop-livestock farmers to raise income from livestock.

5.2 Experiment II Feeding Trial

5.2.1 Chemical composition of feed ingredients

The result of the chemical composition of the feed ingredients shows that the stover had lower crude protein content. This agrees with Smith (1993), that most crop residues are low in crude protein (CP) which is below the minimum level of 7.0% CP required in forages to enhance voluntary intake, digestibility and utilization by ruminants. The high fiber fraction of the stover obtained in this study is in line with Alhassan *et al.* (1986), who reported cereal crop residues are available after the grain harvest when the crop plants mature and are highly lignified.

The chemical composition of the cowpea haulm (**IT90K-277-2**) was comparable to that reported by previous researchers (Ajeigbe, 2003; Mosimanyana and Kiflewahid, 2006). The variation in the chemical composition may be attributed to varietal difference as new early maturing and draught tolerant varieties are developed. The CP concentration and the DM reported are adequate for maintenance and growth of small ruminants (NRC, 2007). Residues of cereal crops are generally nutritionally inadequate to produce high yields of meat and milk, this implies that cowpea haulms can be used as supplement to poor quality cereal stovers such as sorghum, in feeding sheep (Anele *et al.,* 2012). Fibre fractions (ADF and NDF) were higher in sorghum stover than cowpea haulms; this indicates that fibre in cowpea haulm is easier to degrade in the rumen. This might stimulate ammonia-N utilization in the rumen to a greater extent than that contained in sorghum stover (Tylukti e*t al.,* 2008). Nitrogen utilization by rumen microbes is related to the supply of fermentable energy and therefore, the NFE in the cowpea haulms is likely to improve the efficiency of microbial CP synthesis thereby promoting a better utilization of rumen ammonia released from feeds with high content of rumen degradable CP (Cabrita *et al.,* 2006).

5.2.2 Feed intake

Total feed intake generally increased with increasing level of cowpea supplementation, for example components such as DM, OM, CP, Cellulose contents (ADF, NDF and ADL) and Ash intakes all increased from 300g cowpea haulm supplementation to 600g supplementation level. Koralagama *et al.* (2008) fed cowpea haulms (150g and 300g/day) to a basal diet of maize stover and reported a higher nitrogen intake. The intake of sorghum stover was highest for the control group which was not supplemented. This is expected because of the poor quality of the nutrient contents; animals tend to consume more in order to probably meet up the nutrient demands of the body. McDonald (1981) reported that roughages of low quality tend to be eaten more by the animals in order to satisfy their needs for energy and other nutrients. In contrast sorghum stover decreased in intake as cowpea haulm supplementation increases in this study. This agrees with Savadogo *et al.* (2000) who reported that sorghum stover intakes declined even with low levels of cowpea haulm supplementation. Significant improvement in feed intake and digestion of most nutrients in this study of the supplemented feeding frequency of cowpea haulms group could be justified by the relatively better intakes of CP. However, DM intake was affected when feeding frequency was reduced to once daily as observed and reported by Soto-Navarro *et al.* (2000).

5.2.3 Weight changes

Cowpea haulm supplementation significantly increased live weight gain and average daily weight gain across all levels of treatments compared to the control. When cowpea haulms was supplemented from 300g to 600g per day regardless of fed once or more, average daily weight gain increased nine times compared to the unsupplemented treatment or control (45.29 versus 5.29 grams). All rams fed 600g supplemented cowpea haulms had about 50 to 54 grams average daily weight gain which is comparable to that reported of Abil *et al.* (1992) who obtained a value of 53g/day when they replaced cotton seed cake and maize with wheat bran in the diet of sheep. Adu (1985) also reported an ADWG of 65 g when he replaced maize with brewers dried grains in the diet of growing sheep, although this value is higher than the ADWG obtained from animals supplemented twice daily (53.75g/day). Feeding frequency was observed by Gibson (1981) to increase feed utilization efficiency.

5.2.4 Nutrient digestibility

There was a significant difference in percentage digestibility of DM, OM, CP, ADF and NDF across the treatments in this study. Significant increase in dry matter and organic matter observed which coincided with the report of Koralagama *et al.* (2008) who reported increases in OM and DM digestibility with increase in cowpea level supplementation from 150g to 300g/day .All nutrients were higher in digestibility of diets of animals fed on the supplemented cowpea haulms relative to those on sorghum stover alone (control). Feeds with higher nutrient digestibility as in cowpea haulms improve the intake and performance of sheep (Singh *et al.,* 2011). Atkinson *et al.* (2010) reported that feeding frequency has a positive impact on DM, OM and CP digestibility, as shown to result in increased number of protozoa. Also, Abouheif *et al.* (2010) linked the positive effects of increased meal frequency to a more stable rumen environment and thereby leading to a more efficient digestion.

5.2.5 Slaughter parameters

The important slaughter parameters such as hot weight, dressing percent, mesenteric and kidney fat weights exhibited a similar pattern and were significantly enhanced by supplementation of cowpea haulms fed to the experimental rams. Koralagama *et al*. (2008) suggested that a portion of the live weight gain may be due to increases in gut fill rather than actual carcass weight gain and therefore proposed a range of measurements to assess diet quality such as removal of feed several hours before slaughter. Hot weights of 10.44 kg to 11.41 kg was attained in this study for animals supplemented with cowpea haulms which was significantly higher than 9.17 kg for those not supplemented, while dressing percent was not significantly different across all treatments even though it was higher for animals on twice and thrice split feeding on cowpea haulms. Shija *et al.* (2013) reported hot weights of sheep and goats of 9.43 and 9.68 kg for sheep and goats respectively which was lower than that of the supplemented rams and similar with the control in this study. Santos *et al.* (2008) when comparing carcasses and meat quality of Portuguese native goat and sheep breeds, found lambs to have greater dressing percentage than goat kids. Greater weights of non-carcass components and gut fill are known to reduce dressing percentage. Dhanda *et al*. (1999) reported significant differences between various goat breeds for dressing percentage based on full body weight and attributed these differences to variations in weight of GI tract contents. Moreover, breed differences in dressing percentage are also attributed to the degree of gut fill at slaughter (Kadim *et al*., 2003). Mesenteric fat and kidney fat weights also were significantly increased in the supplemented animals more than the control although values obtained in this study was higher than that reported by (Shija *et al.,* 2013).

5.2.6 Manure quality

The supplemented animals produced more total nitrogen and less total phosphorus compared to the control while the manure output were similar across all the treatments. An important benefit of cowpea haulm utilization in sheep and other livestock production systems is the improvement in subsequent crop yields as a result of the enhanced quality of manure when applied as organic fertilizer. Supplementation therefore offers a safer and more environmentally conducive way to enhance rural livelihoods in the context of crop-livestock system or integration.

5.3 Cost Benefit Analysis

It can be seen from Table 4.16 that increasing the cowpea haulms supplements led to increased income for rams fed 600g per day more than those fed 300g of the same supplement. Also income increase is more for those fed split (twice or thrice per day) than those rams fed 600g in a single dose. This shows that it is more profitable to feed cowpea haulms supplements in splits as also evident by the higher total and average daily weight gain recorded by the same treatment group. Split feeding also maximizes utilization of feed and reduces wastage.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATION

6.1 Conclusions

From the results obtained in this study, the following conclusions can be drawn;

- Livestock are an important component of the farming systems within the Sudan-Sahel zone of the KKM Pilot Learning Site and are often sold to provide cash when needed as market prices seemed attractive to farmers, as livestock such as sheep were sold for festivals when market prices are good.
- Almost all households in the Sudano-Sahelian zones possess at least 1-5 small ruminants indicating a practice of crop-livestock integration and this indicates the potentials for livestock production especially for small ruminants.
- The period of feed scarcity is at its peak at the dry season and this falls during the period of highest nutrient demand of livestock (during March through July, when farmers have difficulty providing feed) and farmers have to complement with supplements and concentrates which are expensive.
- Crop-livestock farmers in the Sudano-Sahelien zone use legume supplements like cowpea haulms a lot in fattening their small ruminants especially sheep to generate income for solving immediate farm and family needs.
- Labour as related to livestock production is not a problem in most households in the Sudano-Sahelien zone as all strata in the family contribute towards raising the livestock.
- Feeding rams with crop residues alone (Control) could lead to an apparent loss of weight income (₦ 170.98).
- Supplementation with cowpea haulms increased the income to (₦1003.45), with marginal increase of (901.33) and higher live weight gains.
- Increasing the quantity of the cowpea haulms to 600g resulted in an increased income (₦ 1166.51) and a marginal income of (163.06).
- Digestibility of nutrients is similar in rams fed diet supplemented with cowpea haulms and fed 3 times daily compared to those fed supplemented cowpea haulms twice daily.

- Production of quality manure is also another booster for the poor resource rural farmer in comparison to numerous problems of inadequate and very scarce, not readily available inorganic fertilizer that is beyond the reach of crop-livestock farmers.

6.2 Recommendations

From the results in this study, the following recommendations were made:

- As rural labour is not a problem in the farmer rural settings of the Sudano-Sahelien agro ecological zone, fattening rams on supplemented cowpea haulms fed more than once a day is beneficial to farmers.
- Rams fed on sorghum stover basal diet should be supplemented with cowpea haulms when fattening.
- When fattening with cowpea haulm as a supplementary feed, it should be fed at 600g/day and should be split and fed two times in a day.

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APPENDIX

Appendix 1: Feed Assessment Survey in the Sudano-Sahelian Zone of Nigeria

The following survey is collects information needed to make decisions about feeding options within the Sahel Livestock Innovation Platform. Questions are asked about

- the animals to be fed (type of animal, type of product being produced,etc),
- feed costs
- price (returns) that will be received if production is improved
- animal management activities that affect feeding decisions
- decision making
- farmers' ranking of investment opportunities to increased animal production.

Together these questions should assist in developing practical feeding options and training programs.

Village ___________________

Location _________________

Enumerator_______________

Date _____________________

Farmer ___________________

Gender_________________ __

Can you tell us about the livestock you now own?

TYPE	**Number (Code)**	**Present value**	**Purchased last year (include month)**	**Plan to sell this year (include month)**	**Owned by (tick off)**

					Male	Female
Draft bulls						
Cows with calves						
Cows without calves						
Male goat, local breed						
Male goat, improved breed						
Female goat with kid						
Female goat without kid						
Ram, local breed						
Ram, improved breed						

Female sheep with lamb						
Female sheep without lamb						

Number code F (few) = less than 5; S (some) = 6 – 11; A (a lot) = 12-20; M (many) = more than 20

Within the last 12 months, in which month(s) do you sell animals? Give the number and price of animals sold within each month.

Goat	**Number**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
	Price												
Cattle	**Number**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
	Price												
Sheep	**Number**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
	Price												
Poultry	**Number**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
	Price												

Why did you sell your animals?

Reason for selling	Type of animal sold for this reason (Tick box)					
	Goat	Cattle	Sheep	Poultry	Rabbit	Dog
Needed cash						
Not enough feed for all animals						
Festival						
Animal had poor productivity						
Market price was good						
Other (specify)						

Do you sell any manure? Y = yes/N = No _____________

If so, what is the unit sold, ie bag, kg, etc___________

Price received per unit_____________

Do you lease out your work bulls?

If yes, How many days? _________________

Price received per day _________________

Within the last 12 months have you sold milk? Y = yes/N = No _____________

If so, what is the unit sold, ie liter___________

Price received per unit_____________

	Number of days milk is sold each month.											
Goat	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec
Cattle	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec

	Within the last 12 months, how many days did you use your work bulls within each month for different activities?											
Plowing, earthing, other crop farming activity (except manuring)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Hauling manure	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Transport	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Other	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

	In which month(s) do you experience shortages in feed for livestock. Tick the month(s).											
Goat	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec
Cattle	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec

Sheep	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec

Do your animals graze rangelands?   No = 0, Yes = 1   ______

If yes, how many months in the dry season?______; How many months in the wet season?_______

Can you please tell us about the feeds available for your livestock?

				Sources of feed						
Type of feed	**Units of feeding**	**Method of feeding**		**Home produced**				**Purchased**		
		Hand fed	**Grazed**	**Number of hectares in this crop**	**Number of bundles/ bags put up at harvest**	**Units put up at harvest (bundles, bags)**		**Purchase price**	**Month and place of purchase**	**Distance from household**
Dry Fodder										
Sorghum residue										
Soyabean residue										

Maize residue										
Rice Straw										
Cowpea haulms										
Groundnut haulms										
Other										
Green fodder										
Tree Leaves and pods*										
Feeds										
Sorghum bran										
Maize bran										
Wheat bran										
Rice bran										
Cassava peels										
Salt										
Minerals										

Cakes										
Other										

*** NOTE: If tree leaves and or pods are identified as a feed source, please provide the following:**

Names of local browse trees most preferred by animals and time of harvest (dry season, wet season):

Name of browse plant	Plant part used: Leaves (L), Pods (P), Tops (T), Whole (W)	Season of use: Dry season (DS) or Rainy season (RS)
1.		
2.		
3.		
4.		

5.		

If more than one browse is used, please rank importance using numbers and letters above (example: 1 L for leaves of plant 1; 2 P for pods of plant 2 etc)

Most important ____________ Second most important __________ Third most important ____________

Fourth most important ___________ Fifth most important: ____________

Do you plant your browse trees or are they nataurally found in the bush/grazing land?

	When do you supply feed supplements to livestock and for what benefit?											
Goat	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Juy**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
Young stock												

Adult males												
Adult females												
Cattle	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Juy**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
Young stock												
Adult males												
Adult females												
Sheep	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Juy**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
Young stock												
Adult males												
Adult females												

FOR WHAT BENEFIT?

1=Survival 2=Better body conditions 3=Higher market price 4=Higher milk production 5=More draft power 6=Higher fertility 7=Other (specify)

Do you measure out the feeds given to your

Goats Y/N ____________

Ewes Y/N ______________

Fattening rams Y/N ____________

Work bulls Y/N_____________

Milking cows Y/N ______________

What feeds do you (would you) like to use to make your rams grow faster?

What feeds do you (would you) like to use to make your cows milk more?

What feeds do you (would you) like to use to get more draft power from your bulls?

Describe any special feeding strategies you use:

Who makes decisions about what feeds are given to livestock?

_____Male, adult, head of household

_____Male, adult, other

_____Male, youth

_____Female, adult

_____Female, youth

Who makes decisions about how much feed to give to livestock?

_____Male, adult, head of household

_____Male, adult, other

_____Male, youth

_____Female, adult

_____Female, youth

Who makes decisions about when to purchase feed?

_____Male, adult, head of household

_____Male, adult, other

_____Male, youth

_____Female, adult

_____Female, youth

Who feeds the animals?

_____Male, adult, head of household

_____Male, adult, other

_____Male, youth

____Female, adult

____Female, youth

____Male, youth

____Female, adult

____Female, youth

Who buys the feed?

____Male, adult, head of household

____Male, adult, other

What are your major constraints in growing/purchasing/accessing livestock feed? Choose 3 only and rank, 1 = greatest constraint, 2 = intermediate, 3 = lowest ranked constraint of the three.

	Constraint						
	Land	**No Market**	**High price**	**Poor quality**	**Long distance**	**Frequent drought**	**Other competing use for feedstuff**
Crop residue/dry fodder							
Green fodder							
Tree leaves							
Concentrates							
Grazed forages							
Other							

Identify management components in which you would invest to increase the productivity of your livestock herd?

		Feeding	**Animal health**	**Water**	**Breeding**	**Housing**
Goat	**Would you invest? (tick)**					

	If yes, level of importance (code)					
Cattle	**Would you invest? (tick)**					
	If yes, level of importance (code)					
Sheep	**Would you invest? (tick)**					
	If yes, level of importance (code)					

1= Highly important	2=Important	3= Somewhat important

What do you do with your crop residues after harvest? This can be any time after harvest.

	Animal feed	**Fencing**	**Housing**	**Compost (mix with manure and return to field)**	**Cut and sell**	**Leave in field for my livestock to graze**	**Leave in field and sell grazing to others**	**Other**
Maize stalks								
No = 0, Yes = 1								
If yes, what proportion, 1 (all), ½, 1/3, ¼								

Sorghum stalks								
No = 0, Yes = 1								
If yes, what proportion, 1 (all) = 1 ½, 1/3, ¼								
Cowpea haulms								
No = 0, Yes = 1								
If yes, what proportion, 1 (all), ½, 1/3, ¼								
Groundnut haulms								
No = 0, Yes = 1								
If yes, what proportion, 1 (all), ½, 1/3, ¼								
Sotabean haulms								
No = 0, Yes = 1								
If yes, what proportion, 1 (all), ½, 1/3, ¼								

Tell me more about the residues fed to the animals -

	Cereal	**Legume**
Do animals eat all of the crop residue? (Y/N)		

If not, what proportion do they eat		
Leaves, 1(all), ½, 1/3, ¼		
Stalks, 1(all), ½, 1/3, ¼		
What do you do with the leftovers?		
Fuel		
Mix with manure (compost)		

Are your livestock penned/housed at night? Tick if yes

Goats [   ]   Cattle [_______] Sheep [________]

If YES, provide information on mode of housing and frequency of housing during the dry and rainy seasons

	Dry season			**Rainy season**		
	Main mode of housing (code)	**Frequency of penning (code)**	*Category prioritized (code)*	*Main mode of housing (code)*	**Frequency of penning (code)**	**Category prioritized (code)**
Goat						
Cattle						
Sheep						

MODE OF HOUSING	FREQUENCY OF HOUSING	CATEGORY PRIORITIZED	
1= Open kraal 2=Kraal with roof 3= Brick walled	1=Daily 2=Every second day 3=Weekly	1=Milking female 2=Calf/kid 3=Draft animals	5=Breeding males 6=Breeding females 7=All

4= In the house 5=Other (specify)	4=When need arises 5=Other (specify)	4=Weak animals	8=Other (specify)