EVALUATING THE GROWTH PERFORMANCE OF SMALL RUMINANTS AND THE QUALITY OF STORED FODDER AND MANURE IN ATEBUBU AND AMANTIN OF THE BRONG AHAFO REGION

By

Kwabena Owusu Ansah

A Thesis submitted to the Department of Animal Science,

Kwame Nkrumah University of Science and Technology

In partial fulfilment of the requirements for the degree

of

MASTER OF SCIENCE

(Animal Nutrition)

Faculty of Agriculture

College of Agriculture and Natural Resources

June, 2015

DECLARATION

I, Kwabena Owusu Ansah, hereby declare that this submission is my own work towards the award of a Master of Science (MSc.) degree in Animal Nutrition and that no previous submission has been made here or elsewhere for the award of any other degree. However, all references made herein are fully and respectfully acknowledged in the text.

Kwabena Owusu Ansah (PG4238010) ....

(Student's Name and ID) Signature Date

Certified by:

Prof. E.L.K. Osafo ....

(Project Supervisor) Signature Date

Dr. Christopher Antwi ....

(Project Co-Supervisor) Signature Date

Dr. (Mrs.) Victoria Attoh-Kotoku ....

(Head of Department) Signature Date

DEDICATION

This work is dedicated to the almighty God, my parents, Mr. and Mrs. Kwankye, My wife, Mrs. Gifty Nancy Fuah, my daughter, Obaapa Naachiaa and my Siblings, Baffour, Nana Poku and Rachael.

ACKNOWLEDGEMENT

My greatest thanks go to Professor E.L.K. Osafo and Dr. Christopher Antwi, my able supervisors, for their guidance, constructive criticisms, technical and fatherly advice in the design and successful execution of this project. May the good Lord grant you more years to continue your good works at KNUST. I would be most ungrateful if special mention is not made of AusTrade and CORAFSIR-CRI for sponsoring this project. To Dr. Stella Enning, Dr. Stephen Amoah and the entire staff of Crop Research Institute, Fumesua, I say a very big thank you to you all. For service to mankind, they say, is service to God. To all the participating farmers in the CORAF-AusTrade crop-livestock integration project in the Atebubu-Amantin District, I say God bless you for assisting me throughout the study period.

My appreciation goes to the Head of Department and all the Lecturers of the Department of Animal Science, KNUST, for their care, support, constructive criticisms and encouragement.

My special thanks go to the District Director and staff of the Ministry of Food and Agriculture, Atebubu-Amantin, for their role in the selection of the farmers for this study. I also appreciate the efforts of Messrs Frank Manu and Samuel Acquah (Soil Science Laboratory, Crop and Soil Science Department, KNUST) for their assistance with the proximate analyses and throughout the trial.

My appreciation will not be complete if I fail to express my profound gratitude to my family, particularly my Wife and Mother for their financial support and encouragement.

ABSTRACT

The study was aimed at evaluating the liveweight performance of sheep and goats and the quality of stored fodder and manure at Atebubu and Amantin in the Brong-Ahafo Region of Ghana. Six farmers (three males and three females) were selected from each Community with each farmer providing six animals (three sheep and three goats). Feed resources used in the study areas contained 3.2-17.3% crude protein, 82-97.2% organic matter and 2.818% ash contents. The dietary treatments were Treatment 1 (basal diets of maize stover, cassava and yam peels), Treatment 2 (supplementation of treatment 1 with cowpea residues) and Treatment 3 (supplementation of treatment 1 with groundnut residues) in a completely randomized block design. Nutrient composition of the feed materials used in Atebubu ranged from 89.43-91.2 % (OM), 84.22-88.50 % (DM), 6.41-11.58 % (CP), 8.8-9.57 % (Ash) with that of Amantin having 83.5-89.40 % (DM), 85.62-88.97% (OM), 5.32-10.27% (CP) and 11.04-12.38% (Ash). Total feed intake (TFI) ranged from 519.55659.72g/day and 331.84-420.17 g/day for sheep and goats respectively, with their corresponding weight gain of 14.96-25.74g/day and 8.52-18.89g/day. Feed conversion ratio (FCR) ranged from 22.08-64.24 and 18.38-53.45 for sheep and goats respectively. Samples of groundnut and cowpea residues in open and closed storage systems, taken at 1, 4, 8, 12, 14, 20, 24 and 28 weeks, showed an insignificant decline in crude protein content with storage time. Manure produced by sheep weighed 319.17-423.33g/day and contained 20.74-29.01% C, 1.87-2.32% N, 0.77-3.00 K, 9.52-26.50% Ash with a pH of 0.44-0.77 and a C:N ratio of 10.98-15.53 while that of goats weighed 178.67-216.17g/day with 19.5830.61% C ,1.56-2.21% N, 0.82-8.33% K, 10.75-19.80% Ash with a pH of 0.37-1.47 and a C:N ratio of 9.49-19.92. The results from this trial suggest that locally available feed resources can significantly contribute to meeting the nutrient requirements of ruminants.

TABLE OF CONTENTS

Contents **Page**

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ADF	Acid detergent fibre
ADG	Average daily gain
ADIN	Acid detergent insoluble Nitrogen
AIBPs	Agro-industrial by-products
AOAC	Association of Official Analytical Chemists
BFI	Basal feed intake
BFILW	Basal feed intake per kilogram liveweight
C	Carbon
CIMMYT	International Maize and Wheat Improvement Center
CP	Crude Protein
DE	Digestible energy
DM	Dry Matter
DMI	Dry Matter intake

DOM	Digestible Organic Matter
FAO	Food and Agriculture Organization
FAOSTAT	Food and Agriculture Organization Corporate Statistical Database.
FCR	Feed Conversion ratio
FYM	Farm yard manure
g	Gramme
GLM	Generalized Linear Model
ILCA	International Livestock Center for Africa
IRRI	International Rice Research Institute
K	Potassium
Kg	Kilogram
Kg/LW	Per kilogram liveweight
KNUST	Kwame Nkrumah University of Science and Technology
Mcal	Megacalories
ME	Metabolisable energy
MOFA	Ministry of Food and Agriculture
MWT	Manure weight
N	Nitrogen
NDF	Neutral detergent fibre
NRC	National Research Council
OM	Organic matter
pH	Acidity level.
PPI	Potash and Phosphate Institute
PPR	Peste De Petit Ruminantes
SFI	Supplement Feed Intake
SFILW	Supplement Feed Intake Per kilogram liveweight
SSA	Sub Saharan Africa
TDN	Total digestible nutrients
TFI	Total feed intake
TFILW	Total feed intake per kilogram liveweight

TOTINT	Total feed intake

CHAPTER ONE

1.0. INTRODUCTION

Sheep and goats are a very prominent feature of the subsistence rural economy in most West African homes, even in places where cattle are not commonly kept (Tweneboah, 2000). Sheep and goats can be reared for various reasons such as income generation, religious purpose, household consumption, hobby and as a security against crop failure (Ozung *et al.*, 2011). In Ghana, the population of sheep (3.5 million) and goats (4.3 million) far exceed that of cattle (1.4 million) (VSD, 2009). Oppong-Anane (2011) reported small ruminant population in Ghana to be 13.3 million. Small ruminant production is mainly based on a low-input traditional extensive system where animals are supplemented on household waste e.g. peels of cassava, yam, plantain and cocoyam which are not always available in adequate amounts resulting in low levels of productivity (reduced growth and reproductive performance) and loss of animals especially lambs (Baiden and Obese, 2010). Small scale sheep and goat farmers in Ghana thus face a lot of challenges in generating income from their stock due to the slow growth rate, unstable weight gains related to seasonal imbalances of feed and reproductive inefficiencies (Annor *et al.*, 2007). The problems militating against livestock production in general have led to an average importation of 70% livestock and/or its products to satisfy Ghana‘s domestic requirements (Okai *et al.*, 2005). This situation may have worsened considering the fact that beef, mutton and chevon importation into Ghana increased to about 20 fold (943 to 18,491 metric tonnes) from 2000 to 2009 (MOFA, 2011). Some of these undesirable trends in sheep and goat rearing can be minimized if livestock owners adopt proper systems of production.

Crop residue is an important feed resource in Sub-Saharan Africa. Crop residues in these regions are becoming a dominant feed resource as rangelands are being converted into crop land. However, the level of incorporation of crop residues in the complete diet is influenced by the quality of crop residue (Anandan *et al*., 2010). In Sub-Saharan Africa (SSA), crop residues are sometimes left on the field as standing hay or stacked on traditional structures or on trees exposing them to losses due to the effects of the weather. Crop residues like groundnut, cowpea haulms, bean vines, maize, sorghum and millet stover, constitute the bulk of ruminant feed during the dry season in Ghana (MOFA, 1998). Household wastes, combined with cassava peels or other crop by-products of small-scale commercial food processing, are important feed resources available to livestock owners having no direct access to land or to fodder crops.

Majority of crop residues generated during the rainy season is destroyed during the dry season by bush fires and the effects of weather as they are left in the field after crop harvest. The use of crop residues in Sub-Saharan Africa is becoming a dominant feed resource as more and more rangeland is converted into crop land (McIntire *et al.*, 1992). Crop residues are sometimes stored, but most are left on the field after harvest, opportunistically grazed, under-utilized and often spoiled. Some practical and low cost storage methods such as box-baling, room storage and bag silage of maize stover, fodder legumes, bean residues, and grasses have shown considerable potential for spill-overs across feed resources and throughout SSA (Suttie, 2000). These fodder conservation methods could be promoted in small-scale crop-livestock systems so as to alleviate the seasonal fodder shortages and undesirable growth patterns of livestock, resulting from dry season feed shortages. As crops and their residues are harvested, considerably high amounts of soil nutrients are removed without replacing them in most cases in Ghana. Almost all the nutrient balances in

Ghana show a nutrient deficit, i.e. the difference between the quantities of plant nutrients applied and the quantities removed or lost (FAO, 2004) since nutrient depleting cultivation practices are still used extensively (Gerner *et al.*, 1995). This represents a loss of potential yield and progressive soil impoverishment. According to the estimates, cassava and yams account for almost 20 percent of the cropped area, but 37 percent of the nitrogen deficit in Ghana (FAO, 2005). These crops remove large quantities of nutrients and their soils are prone to erosion during harvest. Low cost soil fertilizers like farm yard manure (FYM) could be used in soil fertility maintenance. In Ghana, cow and poultry manure are the commonly used inorganic fertilizers. Sheep and goat manure can also be used as they have been found to contain C: N ratio below the critical level of 20 as reported by PPI (1983) indication role in Nitrogen mineralization.

The study forms part of a 3-year Australia-Aid (AusAid) funded project purposed to develop and strengthen the crop–sheep and goats value chain in the sub-humid (Ghana, Benin), and semi-arid (Gambia and Mali) tropics of West Africa to increase agricultural productivity for poverty reduction and enhanced food security. Activities cover value chain and market development; development of crop management technologies for sheep and goats integration; selection and dissemination of dual-purpose cowpea and groundnut varieties; crop residue and manure management options for soil fertility improvement and increased crop and livestock productivity; modeling and capacity building along the crop-sheep and goats value chain. Small and mediumscale actors along the value chain, especially women are the target. Two districts in each participating country were selected on the basis of their high sheep and goat density, high potential for integration of crop-sheep and goats systems, market access, high poverty index and proximity to existing good sheep and goats practice centers. This study focused on two towns

(Atebubu and Amantin) in the Atebubu-Amantin District in the Brong Ahafo region of Ghana. Six farmers (three males and three females) from each of the two towns were selected for the study on storage and management of residues, animal (sheep and goat) feeding and manure management assessment.

Although feeding of residues and other agro by-products is very common amongst most of our farmers, evidence on the feeding value with respect to liveweight changes and other parameters such as manure produced from feeding these crop residues and by-products is scanty. The main objectives of the study were therefore to find the effect of two storage methods on the nutrient quality of stored residues and the effect of feeding these crop residues on the liveweight performance of Sheep and Goats raised on traditional feeding practices. The specific objectives were to:

- ✓ Find the effect of open and closed/shed storage methods on the crude protein content of cowpea and groundnut residues
- ✓ Determine the nutrient composition of crop residues and other feed resources in the study areas
- ✓ Evaluate the effects of feeding various crop residues and agro by-products on the growth performance and manure quality of sheep and Goats.

CHAPTER TWO

2.0. LITERATURE REVIEW

2.1. Small ruminant production

Small ruminants, including goats and sheep, play a significant role in the food chain and overall livelihoods of rural households (Lebbie, 2004) Sheep and goats can be reared for various reasons such as income generation, religious purposes, household consumption, hobby and as security against crop failure (Ozung *et al.*, 2011). The manure generated by sheep can also be used as fertilizer in crop production. Sheep and goats are a very prominent feature of the subsistence rural economy in most West African homes, even in places where cattle are not commonly kept (Tweneboah, 2000). Worldwide sheep and goat numbers have been increasing steadily over the past twenty years, unlike other livestock species. According to FAOSTAT (2008), sheep numbers were in excess of one billion (1,078,200,000) and goat numbers (861,900,000) were steadily approaching that number. In spite of the general neglect of both research and commercialization of their production, statistics show that the annual increase in sheep and goat population in most West African countries averages 18-20% and 10-20% respectively (Tweneboah, 2000). The distribution of sheep and goats in Africa is not even and numbers tend to be higher in the drier areas. Consequently, flock sizes are larger in drier than in the humid areas. Thus, in some areas (e.g. West Africa) flock sizes decrease from north to south (ILCA, 1979; Otchere *et al.*, 1985). Sheep and goats are a major part of livestock production in Ghana which accounts for 7% of the Agricultural Gross Domestic Product (Oppong-Anane, 2001).

2.2. General management, nutrition and health of small ruminants

Small ruminants have been an integral part of most urban and peri-urban households for a long time, and it is unlikely that their role, current production systems, and the resources used to support them will change substantially in the near future (Baah *et al*., 2012). According to Oppong-Anane (2011), urban and peri-urban dwellers raise approximately 25% of the 13.3 million small ruminants in Ghana. Animal production as an agricultural enterprise complements economic activities of food processing and brewing industries and makes use of agricultural byproducts as feed materials. It is difficult to describe the feeding and management of the sheep and goat industry around the world because of the many interacting factors such as production system, management system within each production system, the genetic potential of the breeds, biological constraints etc. (Economides, 1981). Economides (1984) identified four systems for managing small ruminants for meat and other dual purposes as follows;

1. Extensive (migratory, free range, pasture or range grazing).
2. Semi-intensive (pastures or range grazing, use of supplementary feeding mainly on crop residues and conserved roughage).
3. Intensive (grazing on improved pastures, zero grazing, conserved forage, crop residues and increased use of concentrates).
4. Tethering (small size flocks of 2–10 animals). This is a subsistence family system and the animals live on kitchen remnants crop residues, grazing near inhabited areas and other supplementary feed).

Small ruminant production in Africa is not well developed. The fact that holdings are small seems not to give owners incentives for improved husbandry practices. In wetter areas, where arable cropping is the practice, small stocks are tethered during the cropping season in an attempt to prevent crop damage (Adu and Ngere, 1979; Okello and Obwolo, 1985). Van Vlaenderen (1985) described sheep and goat husbandry in Togo as being casual rather than an organized activity for the following reasons: (a) animals have no benefit of prophylactic or curative treatment: (b) little or no supplementary feed is offered; (c) no good flock management is practiced; (d) poor housing (e) tethering of animals during the planting season so as to avoid crop damage.

2.2.1. Nutrition

It is extremely difficult to present data collected from all over the world on the nutrient requirements of sheep and particularly of goats. For this reason, recommended minimum requirements of sheep and goats are suggested. The energy requirements of sheep and goats are similar according to NRC (1981). For dry, non-pregnant animals the maintenance requirements are 0.42 MJME/kg$^{0.75}$. In most SSA countries, farmers either allow sheep to accompany cattle for grazing but tether their goats under shelter and these goats are fed cut-and-carry green forage in the rainy season, or tether their small stock in their compounds and feed them silage in the rainy season (Otchere *et al*., 1985; Adu and Ngere 1979). The general consensus is that, after crops have been harvested, small stock are let loose to feed on crop residues and fend for themselves (Otchere, 1985).

Improved animal nutrition appears to be a more critical factor in increasing small stock productivity. Native grasslands provide the cheapest source of nutrients for ruminants but it is however an established fact that for a greater part of the year, grasslands in the tropics do not supply sufficient nutrients to stock for greater productivity. Thus, the need for supplementation of natural forage with agro-industrial by-products cannot be overemphasized and this (supplementation) has been reported by Van Vlaenderen (1985) and Kolff and Wilson (1985) to enhance growth rate. Otchere *et al*. (1977) reported that West African Dwarf sheep, on the Accra Plains of Ghana, which received no supplementary feed during the dry season (December to February), lost about 15% of their body weight, while those receiving supplements made up of dried cassava peels fortified with urea and molasses gained 19g per head per day. Many crops discards like cocoa husks and corn cobs as well as brewery by-products like brewer‘s spent grains and most agro-industrial by-products have not been harnessed into small ruminant feeding even though they have been shown to be potentially useful (Adeyanju *et al*., 1975; Otchere *et al*., 1983). Initial indicators of research findings on the integration of forage legumes into cropping systems of small stock owners appear favourable and can be used to improve the productivity of animals (ILCA, 1982).

Studies on the foraging behaviour and the dietary habits of sheep and goats (type and parts of plants they eat, their tolerance to saline or bitter feed and saline water, the distance of travelling to find food, the frequency of drinking and their walking ability) can provide assistance to livestock managers for making the right management decisions and improving sheep and goat performance (Malechek and Provenza, 1983; Squires, 1984). Goats have been considered more efficient in the digestion of crude fibre and the utilization of poor roughages than sheep (Malechek and Provenza, 1983; Squires, 1984; Gihad *et al*., 1980). Possible physiological and behavioural factors for this ability of the goat have been indicated (Louca *et al*., 1982). However, with medium and good quality forage and adequate feed availability goats apparently are similar to sheep in nutrition (Malechek and Provenza, 1983; Huston, 1978).

2.2.2. Health care

Although small ruminants are widely distributed and are of great importance as a major source of livelihood of the small farmer in rural communities in tropical Africa, indications, however, are that their productivity is low but there is ample opportunity for improvement (Otchere *et al*., 1985). While goats are generally considered hardy animals and in many situations receive less medical care, sheep mostly fall victim to poisons (Simmons and Ekarius, 2001). Both species can be attacked by infectious diseases, physical injuries and can as well be a prey species (Simmons and Ekarius, 2001). Though some signs of illness can be hidden to avoid predator attack, some signs of ill health are obvious, with sick animals eating less, vocalizing excessively, and being generally listless (Wooster and Hansen, 2005).

Avoiding poisoning is also important. Common poisons are pesticide sprays, inorganic fertilizer, motor oil, as well as radiator coolant containing ethylene glycol (Simmons and Ekarius, 2001). Scarcity of feed in the dry season, especially in Africa, often forces animals to eat poisonous plants which they would normally avoid (Naude *et al*., 1996). Poisoning can be due to mineral imbalances tied to the consumption of certain plants or from contamination of food plants with pesticides, mycotoxin synthesizing fungi and other organisms, including insects, helminths and bacteria which can render them toxic to livestock (Botha and Penrith, 2008). Consumption of plants containing cardiac glycosides as well as other plants like *Lantana camara* and *Tribulus terrestris* have been reported to cause colic, jaundice, ruminal stasis, bloat (and usually diarrhoea), photosensitivity, photodermatitis and other gastrointestinal, nervous and respiratory disorders in ruminants (Kinghorn, 1979; Frohne and Pfander, 1983; Fourie *et al*., 1987; Kellerman *et al*., 2005). *Chromolaena odorata* (*C. odorata*) is another poisonous plant of importance in SSA (Moody *et al.*, 1984). It contains nitrate, which when converted to nitrite in the alimentary canal, converts haemoglobin into metahaemoglobin which cannot act as oxygen carrier. At a sufficient level of metahaemoglobin, animals may die of tissue anoxemia (a condition characterized by deprivation of oxygen at the tissue level) through consumption of tissues, young leaves and shoots of *C. odorata* (Pancho and Plucknet 1971; Waterhouse 1994).

Predators are a serious problem to sheep and goat production in Africa, Australia, the Americas, and parts of Europe and Asia. In the United States, for instance, over one third of sheep deaths in 2004 were caused by predation (NASS, 2010). Even if sheep and goats survive a predator attack, injuries and panic may lead to their death (Simmons and Ekarius, 2001). Worldwide, canids, including wolves, jackals, foxes, coyote and the domestic dog, are responsible for most sheep and goat deaths (MacDonald and Sillero-Zubiri, 2004). Other animals that occasionally prey on small ruminants include felines (cats), bears, birds of prey, ravens and feral hogs (Simmons and Ekarius, 2001). A variety of measures, including livestock owners‘ presence, penning sheep at night and lambing indoors, livestock guardian dogs, barns and fencing (both regular and electric) have been used to combat predation (Wooster and Hansen, 2005). More modern means such as guns, traps, and poisons have been used to kill predators, causing significant decreases in predator populations (Simmons and Ekarius, 2001).

Several factors, including season and type of birth (Peacock, 1982), parturition number (Fall *et al*., 1982) and disease (Mack, 1982) have been reported to affect mortality in small ruminants in various areas in tropical Africa. All of these effects are clearly related to nutrition, health and management. Many breeders quarantine new animals for about a month, maintain good nutrition and reduce stress in the animals as a preventive measure against diseases (Simmons and Ekarius, 2001). Restraint, isolation, loud noises, novel situations, pain, heat, extreme cold, fatigue and other stressors can lead to secretion of cortisol, a stress hormone, in amounts that may indicate welfare problems (Grandin, 2007; Gregory, 1998; Houpt, 2004; Moberg and Mench, 2000).

Helminthiasis and ectoparasitosis are widespread in tropical Africa and both seriously affect the productivity of small ruminants. Helminthiasis is a serious problem towards the end of the rainy season while ectoparasitosis inflicts heavy damage during the rains to early dry season. In West Africa, peste de petit ruminantes (PPR) is endemic (Otchere *et al*., 1985). According to Mack (1982), studies by International Livestock Centre for Africa (ILCA) scientists in south west Nigeria showed that dipping with gammatox against ectoparasites and annual vaccination against PPR dramatically reduced mortality and increased small stock numbers in village flocks. It was observed that mortality among sheep and goats in the ILCA studies decreased by 75%. A wide array of bacterial and viral diseases affects sheep. Some of these are foot rot, foot scald, Ovine Johne's disease, Bluetongue disease, Rinderpest (or *peste des petits ruminants*), Orf (also known as scabby mouth, contagious ecthyma or soremouth), Cutaneous anthrax, foot-and-mouth disease. Among the conditions affecting goats are respiratory diseases, including pneumonia, foot rot, internal parasites, pregnancy toxosis and feed toxicity. Goats can become infected with various viral and bacterial diseases, such as foot-and-mouth disease, caprine arthritis encephalitis, caseous lymphadenitis, pinkeye, mastitis, and pseudorabies. They can transmit a number of zoonotic diseases to people, such as tuberculosis, brucellosis, Q-fever, and rabies (Smith, 1994).

An efficient, well-planned animal health service, going hand in hand with an adequate improvement in the provision of feed, is a pre-requisite for increasing small ruminant production, which would directly improve the diet and the standard of living of the large number of rural smallholders in tropical Africa (Otchere *et al*., 1985).

2.3. The West African Dwarf Sheep

The West African Dwarf (WAD) sheep, commonly known as Djallonke, are widely distributed throughout the West and Central Africa. They are believed to have evolved from the ancient Egyptian sheep, *Ovis longipes palaeoaegypticus* (Yapi-Gnaore *et al.*, 1997). It is small in size, but physically and sexually strong. Their prolificacy in West Africa varies from 110% (Ginisty, 1976) to 161% (Dettmers and Hill, 1974). The WAD sheep is resistant to stress and diseases particularly trypanosomiasis. These adaptive features help the WAD sheep to reduce heat stress and to overcome the effect of rainfall and humidity of sub-equatorial and equatorial climates (Ryder, 1999). Apart from serving as a source of meat and income, the WAD sheep has significant social purposes including religious and funeral ceremonies in West Africa. In terms of value, the live animals have more value than its carcass and are thus used as gifts for strengthening human relationship, symbol of appreciation and payment of bride prices (Charray *et al*, 1992). Sheep rearing in Ghana is mainly for meat production using the Djallonke and Sahellian Sheep and their cross breeds (Ockling, 1986; MOFA, 2000). The Djallonke, also known as West African Dwarf (WAD) sheep according to Karbo and Bruce (2000) is the predominant sheep breed in Ghana.

2.4. The West African Dwarf Goat

The West African Dwarf goat (WADG) is believed to have originated from the wild Bezoar goat, *Capra hircus aegagrus* distributed in south west Asia, where the wild form still exists (DAGRIS, 2007). The WADG is small in size (15-21 Kg) with an average shoulder height not exceeding 50cm (Epstein, 1971; Devendra and Mcleroy, 1982). Years of adaptation and natural selection under humid tropical conditions made this breed highly adapted to the humid forest zone (Leak *et al*., 2002) thus their presence in all of humid Africa, where ambient temperature and relative humidity are notably high all year round (Gall, 1996; Oseni and Ajayi, 2014). WAD goats are highly prolific and can be bred all year round, with up to three parturitions in two years, even under backyard systems where they are raised almost with zero investment (Ademosun, 1993; Oseni and Ajayi, 2014). They are hardy, digest a broad range of diets, able to thrive under harsh environmental conditions of heat and humidity and resistant to high humidity pathogens, gastrointestinal nematodes and trypanosomiasis (Devendra and Mcleroy, 1982; Blench, 1999). WADG have the ability to maintain positive weight gain and record low mortality rates , in the face of parasitic challenge (Goosen, 1998) and this allows them to graze and thrive on lands in tsetsefly infested humid forests and guinea savannah zones (Ngere *et al.* , 1984; Rege, 1994; Bosso *et al*., 2007). They represent one of the predominant small ruminant breeds raised by resource-limited households in the humid west and central Africa (Oseni and Ajayi, 2014) and according to Tuah *et al*. (1992) are the commonest and most predominant breed of goat in Ghana.

2.5. Agricultural by-products as livestock feed

Agro by-products, which are derived in integrated crop-livestock systems (Thornton *et al*., 2002) have been described by El-Nouby (1991) as those materials obtained other than the main product for which the crop is cultivated. They include on-farm by-products or crop residues (straws, stubbles, leaves, tops, etc.) (El-Nouby, 1991) and Agro-Industrial by-products (AIBP) which are obtained from crop processing: cassava peels, cocoyam peels, yam peels, rice bran, cowpea husk, rice husk, maize husk, banana peels and plantain peels (El-Nouby, 1991; Adesomu, 1987).

2.6. Agro-industrial by-products (AIBPs)

Agro industrial by-products (AIBPs) are by-products derived mainly after processing of agricultural products for the production of a main product (Sindhu *et al*., 2002). They may be low and high in fibre (sugar cane bagasse, palm press fibre), rich in nitrogen (oil seed cakes, brewery and flour milling by-products), more concentrated (molasses), highly nutritious and less costly as compared to crop residues (Smith, 1988; Aguilera, 1989). The increasing human demands for several food types such as vegetables, wine and fruit juices has led to an increase in the availability of agro-industrial by-products (AIBPs) such as molasses, brewer‘s dried grains, palm oil cake, winery mash and so on, which are not fully utilized in livestock feeding (Amata, 2014).The difficulty of the use of AIBPs as fresh material for extended periods and the lack of efficient ways for their integration in feeding regimes may account for their under-utilization (Chadhokar, 1984).

The use of AIBP as a part of feed for livestock reduces the cost of production, improve the quality of feed, ensure regular feed supply even during the slump period and ultimately increase the profit margin of livestock farmers (Sindhu *et al*., 2002). Different agro-industrial by-products like rice straw (Otchere *et al,* 1977; Karbo *et al*, 2002) and cocoa husk (Otchere *et al,* 1986), cotton seed (Avornyo *et al.,* 2001), soya bean cake (Obese (1998), cassava and groundnut haulms (Wesseh, 1999) to feed ruminants have been certified as good supplementary feed for ruminants.

2.6.1. Classes and nutritive value of AIBPs:

Generally, agro-industrial by-products are listed as energy, protein and combined protein/energy sources (Aregheore, 1998). Energy sources are rich in fermentable carbohydrates and low in protein. Examples are cassava peels (Sekondi, 1991) and molasses, a by-product of the sugar industry, (75 % DM, 4.1 % CP and 12.7 GEMJ/kg DM). Protein sources are derived from animal by-products and oilseeds after oil extraction (Sindhu *et al*., 2002). The cakes and meals are valuable sources of protein in livestock diets. Examples are fish meal (55% CP), meat meal (5055% CP) blood meal (80% CP), soya bean meal (48% crude protein) groundnut cake (protein 4048%), palm kernel meal (18.0 % CP) and copra meal (18.8 % CP). The combined energy/protein is from cereal by products such as brewers' spent grains and bran from wheat, rice and maize (Cheeke, 1991). While some of these can be fed directly, others have to undergo processing to make their nutrients available to livestock.

Other AIBPs such as oyster shells and bone meal are rich sources of minerals and remains the most regular source of calcium and phosphorus to various kinds of animals in developing countries

(Aletor, 1986; Verma, 1997). They are important in diets for young animals which require large amounts of calcium and phosphorus for bone development. Poultry excreta have been found to be a rich source of protein, calcium, phosphorus and minerals and can be used as a source of nitrogen in ruminant ration (Ranjhan, 1993).

2.6.2. Improving the nutritive value of AIBPs:

Constraints on the use of crop residues and agro-industrial by-products include bulkiness, poor nutritive value and the unsuitability of some for direct animal use (Aregheore, 2000). A wide variety of anti-nutritional factors, including various toxic compounds, which are deleterious to animal health and performance are found in AIBPs but a number of technologies and methods have been developed to detoxify or at-least minimize the effect of these toxins or anti-nutritional factors (Sindhu *et al*., 2002). For example, the high lignin content of unprocessed bagasse (Bhatti and Khan, 1996) which renders it lowly digestible has reportedly been improved by high pressure treatment. This treatment improved both palatability and digestibility of bagasse (Morrison and Brice, 1984). The level of phosphorus and high crude fiber (38%), the main limiting factor of groundnut straw, which may in warm periods of the year, inhibit feed intake has been found to be overcome by sprinkling a mixture of molasses and di-ammonium phosphate or preferably a balanced liquid supplement on chopped groundnut straw (Maglad *et al*., 1986). The inhibitors and toxins in feedstuffs and the deactivation process/method of some of the inhibitors and toxins are shown in table 2.1.

Table 2.1. Toxins/inhibitors in feedstuffs and their deactivation processes

Feedstuff	Inhibitor(s)	Deactivation process
[b,c] Linseed meal	Crystalline water soluble substance	Water treatment

[b,c] Groundnut meal	Aflatoxin, goitrogen, Protease inhibitors, saponins	Treatment with ammonia or ammonium hydroxide
[b,c] Soybean meal	Hemagglutinins, Goitrin, trypsin and Protease inhibitors, Saponins	Heat (autoclaving), Toasting
[a] Cassava peels	Hydrogen Cyanide (HCN)	Sun drying, ensiling, cooking, addition of methionine
[b,c] Cottonseed meal	Gossypol eyclopropene fatty acids	Adding iron salts; rupturing pigment gland
[b,c] Raw fish	Thiaminase	Heat treatment
[b,c] Sheanut cake	Saponings, tannings	PEG (polyethylene glycol) addition.
[b,c] Lucerne meal	Saponins: pectin methyl esterase	Limit amount feed

Sources: [a]Sekondi, 1991; [b]Benerjee, 1993; [c]Bhatti and Khan, 1996.

2.7. Crop residues as livestock feed

Crop residues are an excellent source of feed that can be obtained from the farm and are parts of plants that are left in the field following harvest and thrashing of the primary crop. Apart from being a source of animal feed, residues are used as building, roofing and fencing materials, as fuel, and as fertilizer or surface mulch in cropland (van Raay and de Leeuw, 1974). About 25% of Nitrogen (N) and phosphorus (P), 50% of sulphur (S), and 75% of potassium (K) uptake by cereal crops are retained in crop residues making them valuable nutrient sources (Chandiramani *et al.*, 2007). Crop residues include maize stover, cowpea haulms, cassava tops, maize cob, cassava peels etc. and are usually fibrous, low in nitrogen and form the basal or principal feed in small-scale farming systems during the dry season (Smith, 1988).

Kossila (1985), indicated that, on a global basis if all potentially available crop residues could be utilised for feeding, each herbivore would receive over 9 kg DM and about 17 Mcal ME /day, thus largely covering their requirements. Unfortunately, only a small fraction of the available residues is currently being used for livestock feeding because of problems of collection, transportation, storage and processing, alternative uses, seasonal availability, and perhaps most importantly, an apparently poor nutritional value (Sansoucy and Emery, 1982; Owen, 1985).

Cereal crop residues are of low nutritive value because of their relatively low digestibility (<500 g digestible OM per kg DM, low CP content (<50 g/kg DM) and low content of available minerals and vitamins (Sundstol and Owen 1984; Owen, 1993). Crop residues, such as rice straw in general are deficient in essential nutrients such as sulphur, phosphorus, cobalt and vitamins A and E (Greenhalgh, 1984; Kabaija and Little, 1988). These residues have high cell wall content of low digestibility (<50%) and their voluntary intake is low (10-20 g/kg liveweight) (Nicholson, 1984; Doyle *et al*., 1986), due to poor susceptibility to microbial attack in the rumen. According to Little (1985) crop residue based diets are most likely to be deficient in sodium, copper and phosphorus. These are the same minerals found to be marginal or deficient in tropical grasses. Straws are also deficient in sodium, copper and phosphorus in addition to sulphur, cobalt and calcium. The high concentrations of oxalates and silicates in some of the straws, such as rice straw, may further reduce the availability of calcium and magnesium, which are lost as silicates and oxalates in the urine and faeces. These deficiencies according to Owen (1993) combine to make crop residues unpalatable, thus their consumption is also low (usually less than 15 g DM/kg liveweight daily).

Residues can usually be grouped by crop type-cereals, grain legumes, roots and tubers, and so on (World Bank, 1989; Nordblom and Shomo, 1995). Ruminants fed on crop residues, by-products and arable weeds add value to resources which are largely wasted in the absence of a ruminant component in the system (Jutzi, 1993). The over-riding constraint on feed supply in important tropical ruminant livestock areas is the seasonality in the availability and quality of animal feed supplies coinciding with dry and wet seasons (Onwuka and Davies, 1996). According FAO (1999) more than 1000 million tonnes of cereal residues are being produced annually in the developing world. If used strategically, a country like Ghana could save up to 186 million kg of livestock weight that is lost during the 120-day dry season from its 2.3 million tonnes of cereal crop residues produced (Amaning-Kwarteng, 1991).

2.7.1. Some crop residues used in Africa

Maize residues are of much greater importance in Eastern and Southern Africa than in West Africa. It is only since the late 1970s that maize has begun to replace sorghum, mainly in the sub humid zone of West Africa. Since varieties of short life span are usually preferred in the sub humid zone of West Africa and these are usually intercropped with late-maturing crops, residues may be inaccessible to livestock (Powell, 1986; Jabbar, 1993; Jabbar *et al.*, 1995). Forty percent (40%) of the upper parts (including threshing residues, upper stems and grainless tillers) of millet stover containing 7.8% CP with digestibility coefficient of 50.4% have been used as livestock feed (Powell and Fussell, 1993). Sorghum stover containing 38% leaves and 32% sheaths and have been fed to steers and sheep in Ethiopia and a clear indication of their preference by sheep has been documented (Reed *et al*., 1988; Aboud *et al*., 1993).

Groundnut haulm contains protein (8-15%), lipids (1-3%), minerals (9-17%), and carbohydrate (38-45%) at levels higher than cereal fodder as well as nutrient and CP digestibilities of 53% and 88% respectively (Singh and Diwakar, 1993). In northern Nigeria, where crop residues supply up to 80% of livestock feed (Mortimore, 1991), haulms from cowpea and groundnut produced accounted for 30% of the total roughage supply and 75% of the total CP output of livestock (Hendy, 1977). The leaves, stems and roots of these cowpea haulms have been reported to contain CP values of 7.7-21.7% (Kaasschieter *et al*., 1998; Savadogo *et al*., 2000) and will thus serve as a good supplement for the low quality feed of animals especially in Sub Saharan Africa. The potential of cassava and sweet potato residues based diets for ruminants have been reviewed by several authors (Semenye and Hutchcroft, 1992; Smith, 1992). Cassava flower and peels have been tried as energy sources in goats' diets (Ifut, 1992). Although little information is available on post-harvest cotton residues, feeding trials showed that most leaf litter and husks left after picking of cotton bolls is acceptable to sheep. Rice, wheat and other straws have been treated and used as livestock feed, especially for ruminants, by several researchers (McManus *et al.,* 1972; Alhassan and Akorfur, 1982; Walker, 1984; Sudana and Leng, 1986).

2.7.2. Chemical composition and nutritive value of crop residues

Crop residues are invariably bulky, high in fibre, poorly degraded in the rumen, low in nitrogen and minerals resulting in very low intakes (Osuji *et al*., 1995). The proximate nutrient composition of various crop residues used as feed for goats and sheep is presented in Table 2.2, as nutrient concentrations vary from as low as 2 percent crude protein for maize stover to as high as 27 percent for cassava tops (Smith, 1988). The values presented (Table 2.2) are representative of a wide array of residues of tropical origin, particularly from Sub Saharan Africa. Similar values for DM, CP and Ash for crop residues have been reported (Camara, 1996; Kaasschieter *et al*., 1998; Savadogo *et al*., 2000; Addass *et al*., 2011; Pipat *et al*., 2011; Asaolu *et al*., 2012). Ben Salem *et al.* (2004) also reported that most common crop residues (i.e. straws and stubble) have low CP content, in the range of 2-5% on a DM basis and this suggests a basic limitation in the value of some of the residues (e.g. wheat and barley straw). The wide ranges observed within a particular crop residue for specific nutrients are attributable to factors such as variety of the crop, age of the residue or stage of harvest, physical composition, i.e. the proportion of stems and leaves, length of storage, cultural practices, harvesting practices, Soil fertility and maturity

(Smith, 1988; Adebowale, 1988).

Table 2.2. Proximate composition of some crop residues

Crop residue	% DM						
	Moisture (%)	CP	OM	Crude fibre	Ether extract	Ash	NFE
Maize stover	10	2–8	85–91	28–46	1–2	9–15	35–53
Sorghum stover	10	3–6	96	31–35	1–2	4	50–56
Rice straw	10	2–9	75–90	20–45	1–4	10–25	29–48
Groundnut haulms	10–12	11–17	87–90	21–29	1.5–2.5	10–13	51–57
Cowpea vines	10–12	6–18	82–90	25–30	1–1.5	8–10	48–50
Cassava tops	70–80	17–27	89–94	8–26	3–8	6–11	35–60

Sweet potato tops	90	20–22	82–83	15	3–3.5	17–18	42–46
Sugarcane tops	70–80	5–8	81–95	28–34	1.5–2.5	5–9	44–54
Banana leaves	80	10–15	91	24	12	9	45
Banana Pseudostems	90	2–9	86–91	21–32	2–3	9–14	61
Cocoa-pods	75	2–9	75–90	20–45	1–4	10–25	33–56
Empty oil palm fruit bunch	56	3–4	95	-	6–8	5	-

Source: Smith, 1988

Although their nutritive value and digestibility is very low, crop residues are especially suitable for ruminant livestock feeding and provide small ruminants with most of their annual nutritive intake (Gatenby, 1985). The low digestibility results in limited intakes of these untreated residues usually characterized by low nitrogen content, high cell wall components and little cell contents. The cell walls, which constitute the major fraction of crop residues may be highly indigestible, depending on the relative proportions of its component parts; lignin, cellulose, hemicellulose, silica, and how they are complexed with each other (Smith, 1988). When such residues are fed, structural polysaccharides (which comprise the carbohydrate fraction) are only partially degraded by the rumen microorganisms. This results in low digestibility and low rates of disappearance or passage from the gastrointestinal tract during digestion and limited intake, thus limiting the value of crop residues as a feed component (Adebowale, 1988). According to Smith, (1988) the very high half-life values of most residues confirm their poor degradability in the rumen. Such slow rates of degradability mean slow movement of the material out of the rumen, and therefore low intake, and low total digestibilities.

A review of some published studies in which crop residues were fed as the sole or major material confirmed the low degradability of crop residues in the rumen (Smith, 1988). Cheva-Isarakul and Cheva-Isarakul (1985) fed adult wethers, weighing about 30 kg, five different varieties of rice straw *ad libitum* to estimate voluntary intake and digestibility. On the average the sheep consumed about 2.2 percent of their body weight or 52 g/kg metabolic weight of the straw. The DM digestibility was 49.8 percent. Suriyajantratong and Senakas (1985) reported higher DM intakes for sheep fed groundnut haulms (2.9 percent Body weight), with a DM digestibility of 52 percent. Mean DM intakes of 1.1 (sorghum stover), 0.7 (maize stover), 2.0 (sorghum leaves) and 0.8 (cowpea vines) percent body weight with their respective DM digestibilities of 52, 53, 57 and 47 have been reported by Alhassan *et al.* (1984).

According to Pearce (1984) such low DM digestibilities coupled with low intakes may not satisfy maintenance needs. If diets based on crop residues are to be productive, the residues must be upgraded to improve the nutritive value through supplementation or treatment of some sort or a combination of both.

2.7.3. Improving the feeding value of crop residues

Crop residues as feed resources need to be improved during the dry season, especially in Sub Saharan Africa. It has been established that intake and utilization of crop residues, especially the high lingo-cellulose cell-wall materials may be increased by various pre-treatment methods which improve the rumen environment for growth of cellulolytic microbes, thus, facilitating a greater rate of fibre digestion. (Jackson 1977; Sundstol *et al*., 1979; Gatenby, 1985; Adebowale, 1988; Ørskov, 1990). Mehrez and Ørskov (1977) reported that species, variety, environment, methods of harvesting and handling, feeding methods which include diet composition, levels of feeding and efficiency of treatment affect digestibility of crop residues.

From a nutritional standpoint, plant material is made up of two components - cell contents which are usually highly digestible, and cell wall made up of lignocellulosics and non-cellulosic polysaccharides (Meng, 1990). Complex lignocellulosic bonding prevents easy access of digestive enzymes to cell contents, to the equally digestible, non-cellulosic polysaccharides such as hemicelluloses and pectins, and to cellulose, the major component of all plant cell walls. Apparently these and other components of the cell wall are bound together into one great macromolecular matrix (Morrison *et al*., 1989). Any treatment that can alter and open up the matrix in such a way as to make the digestible components available to enzymatic hydrolysis by celulases complex produced by rumen microbes will efficiently improve digestibility and intake of crop residues.

The various treatment methods that have been used are;

1. Chemical
2. Physical
3. Physico-chemical
4. Biological
5. Generous offer (*ad libitum* feeding)
6. Supplementation

2.7.3.1. Chemical treatment

Since the mid 1970's there has been much research and development into finding ways of alleviating the deficiencies of crop residues (e.g. Sundstol and Owen 1984; Doyle *et al* 1986). Much emphasis has been put on straw upgrading techniques using treatment with chemicals (Owen and Jayarisuya 1989). The three chemicals that play an important role in improving the feeding value of crop residues are sodium hydroxide (NaOH), ammonia (NH_3) and urea.

Sodium hydroxide is generally regarded as the most effective alkali for improving the digestibility of crop residues. Considerable increases in *in-vitro* as well as *in-vivo* digestibilities and intake of treated crop residues with NaOH have been reported (Ibrahim and Pearce, 1983b; Doyle *et al.*, 1986). In spite of the effectiveness of NaOH, problems of availability, health risks, costs, handling and additional labour limits it‘s by smallholder farmers in humid West Africa. A cheaper and relatively available alternative is the use of alkalis available to the farmer such as ashes of left after burning of wood, oil palm bunches and cocoa (Smith, 1993). Available evidence (Adebowale 1985) suggests that these ashes are as effective as equimolar concentrations of sodium hydroxide solutions, with the added advantage of availability. In addition, farmers are used to handling such ashes for soap making and soil amendments.

Adebowale (1985) reported higher digestible energy intake of goats fed maize straw treated with varying levels of cocoa-pod ash solutions than those of control goats fed untreated maize straw diets. Growth rates were 42 and 20 g/day respectively.

The use of urea and ammonia in treating crop residues is relatively safe and easy. It helps improve the nitrogen status and break down the ligno-cellulose bonds of the residue, increasing the rate and extent of rumen microbial digestion (Amata, 2014; Ramirez *et al*., 2007; Oji *et al*, 2007). The use of urea as a precursor of ammonia has been recommended for developing countries for its simplicity and safety in application, availability in local markets at cheap prices and preservative properties (El-Shobokshy *et al*., 1989). Jaiswal *et al* (1988) reported increased crude protein (CP) from 4.6 percent in untreated rice straw to 11.9 percent in urea treated straw. Similarly, Ngele *et al.* (2009) reported an increase in CP from 4.4% in untreated rice straw to12.4% in 4% urea treated rice straw.

Although chemical methods are being applied, several reasons limit their application in developing, tropical countries reasons being that technologies are too "high tech." for application by smallholder farmers, the perceived unjustification of cost and effort of treating crop residues (Owen and Jayarisuya 1989) and the argument that farmers would benefit more if the urea was used as a fertiliser to increase crop yield, instead of using it to upgrade the crop residue (Owen, 1993) because only about 30% of nitrogen of urea applied is recovered in treated forage with 70% polluting the air as ammonia.

2.7.3.2. Physical treatment

Physical treatment methods of improvement include grinding, chopping, pelleting, soaking, gamma-irradiation etc. These methods of treatments may decrease particle size and/or increase palatability through reduced dustiness and breakdown cell wall structure but may not significantly affect digestibility (Smith, 1988). Wetting and soaking reduce the feed value because it causes substantial losses of soluble cell contents with a resultant decrease in digestibility. A reduction in the soluble cell material and *in vitro* digestibility of cowpea vines was reported after soaking in boiling water for 30–90 minutes, dry matter losses of 8–14 percent resulted from soaking rice straw for 3 days and 5 percent reduction in nylon bag degradability of soaked rice straw have been reported (Ibrahim and Pearce, 1983a; Dumlao and Perez, 1976; McManus and Choung 1976). Increased intakes of crop residues following soaking or wetting have also been reported (Chaturvedi *et al*., 1973) occasionally.

Chopping reduces wastage and facilitates feeding. Since chopping does not alter cell wall structure, it generally does not improve digestibility (Smith, 1988). Chopping of groundnut haulms, maize and sorghum stovers and rice straw have been reported to improve intake and hence the performance of sheep better than those fed long haulms in terms of intake, digestibility and growth (Adu and Lakpini, 1983; Osafo *et al*., 1994; Devendra, 1983).

Grinding and pelleting reduce particle size and increases the rate of passage and hence increasing intake, as well as increasing the cellulosic surface area exposed to microbial attack in the rumen, with the resultant increase in digestibility (Smith, 1988). Tomlin *et al*., 1965 reported that pelleting of roughage or simply reducing its size by cutting has been found to increase dry matter intake by 15%.

A 10 to 31% increases in digestibility have been reported with energy consuming methods such as steaming under pressure, gamma irradiation and explosion (Hennig *et al*., 1982; Ryu, 1989). These methods disrupt cell walls by separating and cleaving bonds between cell wall constituents, in addition to a hydrolytic action of acids resulting from the processes (Doyle *et al*., 1986). Although the process has no practical application for farmers in humid West Africa because of the cost involved, energy intensity and marginal ineffectiveness, shorter mean retention time of rice straw in sheep and solubilisation of cellulose, hemicellulose and lignin in the cell wall of most fibrous residues have been reported (Walker, 1984; Doyle *et al*., 1986; McManus *et al.*, 1972).

2.7.3.3. Physico-chemical treatments:

There is evidence that combining physical treatments such as milling, grinding and steaming, which decrease particle size, with chemical treatments, increase the effectiveness of the chemicals (Thiruchittampalam and Jayarisuya, 1978), although the effects may not always be additive (Coombe *et al*., 1979).

2.7.3.4. Generous offer

This involves giving the animal, crop residues *ad libitum* and allowing them to select botanical fractions that are more digestible (Osafo *et al.*, 1994). Wahed *et al*. (1990) found that intake of straw digestible organic matter by sheep increased from 6.6 to 10.5 and 12.7 g/kg live weight/day, respectively, when generous amounts (18 to 54 and 90 gDM/kgLW/day) of barley straw was offered. Work in Ethiopia by Aboud *et al*. (1993) showed that sheep and goats increased their intake of chopped stover when the amount offered was increased from 25 to 50 g/kgLW/day, but there was little further intake when the amount offered was increased to 75 g/kgLW/per day. In the same study, sheep gained weight (28.0, 54.0 and 62.0g/day at levels of 25, 50 and 75 g/kg live weight per day, respectively) faster than goats (9.0, 23.0 and 31.6 g/day at levels of 25, 50 and 75 g/kg live weight per day respectively). Those on a higher level of offer showed a faster rate of gain than those on a lower level of offer.

2.7.3.5. Biological treatment

Biological treatment involves the development and use of naturally occurring organisms to degrade lignin in crop residues. Enzyme addition, fungal growth, fermentation, composting and ensiling are some of the biological methods that have been used to increase the digestibility of crop residues (Gatenby, 1985; Ryu, 1989). An increase in the in vitro dry matter digestibility of wheat straw from 14.3 to 29.5% after a 30 day incubation period with *Pleurotus ostreatus* mushrooms have been reported by Calzada *et al*. (1987). Ramirez-Bribiesca *et al*. (2010) also reported that *P. ostreatus* treatment for 15 days on corn straw increased crude protein (39.5%) and soluble protein (165%), soluble carbohydrates (621%), ash (188.32%) and decreased neutral detergent fibre (14.5%).

Although these methods improve digestibility, they are also associated with some loss of dry organic matter, because many organisms, particularly, edible fungi, in addition to attacking lignin, consume majority of soluble sugars and hemicelluloses which are easily digestible by ruminants (Kewalramani *et al*., 1988; Morrison *et al*., 1989). Dry matter (DM) losses varied widely from 6 to 40%, depending on the organism used, duration of fermentation, type of substrate and environmental conditions (Agosin and Odier, 1985).

2.7.3.6. Supplementation

A supplement is a feed that will increase total intake whilst maintaining or increasing intake of the basal diet (Kempton 1977). According to Devendra (1985) an adult ruminant can maintain its body if its feed contains a crude protein level of 6–7 percent, a dry matter digestibility of 50–55 percent and a dry matter intake of about 1.7 percent of body weight. Most crop residues rarely meet these requirements. Preston and Leng (1981) have suggested that to ensure an adequate rumen ecosystem and complement the needs of the animal as well as optimize the utilization of crop residues, nutritional supplements should provide fermentable energy and nitrogen, micronutrients e.g. B vitamins, roughage, by-pass protein and by-pass energy. Chemical or other treatments may improve intake and digestibility, but if the feed is deficient in nutrients, much of the additional energy released will be inefficiently used (Smith, 1988). Feeding studies with sheep and goats have shown that sorghum stover and wheat straw supplemented with ureamolasses and rice straw supplemented with oil palm slurry can promote satisfactory performance

(Olayiwole and Olorunju, 1987; Sudana and Leng, 1986; Alhassan and Akorfur, 1982).
A study conducted by Okello *et al*. (1996) on the effects of various supplements (cotton seed cake, maize bran, banana peels and leucaena leaves) on weight gain and carcass characteristics of male Mubende goats fed elephant grass *ad libitum* in Uganda showed that the goats supplemented with cotton seed cake had the highest growth rate, which was attributed to a higher protein and energy supply from the cottonseed cake. Also, supplementation with cottonseed cake and maize bran improved body condition scores and carcass weight compared with the other diets. Tolera and Sundstøl (2000) also observed increases in DMI (43.2, 53.8, 63.1 and 66.1g/kg $W^{0.75}$/day) and Crude protein intakes (12.1, 29.8, 47.2 and 62.4 g/head/day) as well as body weight gains (-32, 9,

34 and 44g/day) of sheep fed a basal diet of maize stover supplemented with graded levels (0, 150, 300, 450 g/head/day) of *Desmodium intortum* hay. Adequate supplementation is therefore required for efficient utilization of crop residues by animals.

2.7. Storage of fodder and its effects on nutrient content

In livestock enterprises, one of the most important factors determining profitability is to achieve optimal levels of feeding (Davies and Onukwa, 1996). However, a shortage of affordable feeds of adequate quality and quantity, particularly during the dry season is a major obstacle to improving production (Chedly and Lee, 1999). A "staircase" growth pattern is observed when animals are not adequately fed during the dry season. Therefore, livestock farmers in most developing countries face the biggest challenge of feeding during the dry season (Ikhatua and Adu 1984). There is good potential to improve food security and family incomes by improving livestock production (Chedly and Lee, 1999) by conserving forages, crop residues and Agro byproducts during periods of abundance for use in feeding livestock during future periods of feed shortages. Conservation can be achieved by sun drying (hay), artificial drying (meal) and addition of acids or fermentation as silage (Mannetje, 1999). As both grasses and legumes decline in quality as the dry season progresses, ways of preserving nutritive quality through hay making or ensiling during the rainy season may be worthwhile (Duru and Columbani 1992). According to Mannetje (1999), three important considerations to take into account before embarking on silage making are;

1. Is there a need to store?
2. Are there enough good quality forages or other products available to store?
3. Can the conditions for good storage be met?

Storage of feed usually has the advantage of being a feed reserve to increase productivity in seasons of drought and scarcity. It also ensures the judicious use of excess vegetative growth and enables the storage of potentially unstable material (Cowan, 1999). Even though storage aims to preserve the quality and quantity of feed for later use, losses of nutrients, particularly crude protein, during the storage process have been reported. Losses in crude protein contents of *Pennisetum purpureum* forage and *Gliricidia sepium* leaves, stored as hay for a period of four weeks, have been reported by Davies and Onukwa (1996). Fasae *et al*. (2009) also reported that storing cassava leaves beyond 3 months increased the dry matter content, while crude protein content declined with the length of storage. Declines in crude protein, fat and ash content of conventional feedstuffs like fishmeal have been reported by Omer (2012). Changes in nutrient composition of forages and various feeds in storage may be due in part to volatilization (Merchen and Satter, 1983), exposure to high degrees of temperature, shifts in temperature, initial autolysis (Enzymatic) and bacterial activity due to conditions of transporting and handling (Omer, 2012)

A trial by Antwi *et al.* (2011) that tested the effect of different farmer storage techniques (roof, shed and field storage) on nutrient retention in dual-purpose cowpea haulm after different periods in storage showed that crude protein remaining declined in the cowpea haulms in the field storage. In the same trial Acid Detergent Insoluble Nitrogen (ADIN), Acid Detergent Fiber (ADF) and Neutral Detergent Fiber (NDF) remaining increased in concentration in the cowpea haulms left in the field and the roof storage systems. Thus, the plant materials in the cowpea haulm left as standing hay in the field lignifies, making the plants' nitrogen to complex with the carbohydrate making it unavailable to the animal. In addition, the heat generated in the haulm stored under roof system may have promoted Maillard reaction, hence the high ADIN recorded under that system.

The study concluded that the shed system of storage retains the quality and availability of haulm in respect of dry matter and crude protein contents.

2.8. Importance and quality of manure

Declining soil fertility resulting from continuous cultivation threatens productivity of the tropical soils (Dechsel *et al*. 2004). In high potential agricultural areas, smallholder farmers often mine their soil nutrients through crop extraction, removal of weeds, grazing livestock, cutting forage to feed livestock, or selling fodder (Powell et al., 2004). After limited soil moisture, low soil fertility is the most important constraint limiting crop productivity in Sub-Saharan Africa (Gicheru, 2012; Fischer and Qaim, 2012). Livestock plays a significant role in stabilizing farming systems by providing manure, which is a valuable resource in the replenishment of soil fertility (Wanjiku and Manyengo, 2005; Mohamed Saleem, 1998). Application of organic amendments, including animal wastes increases soil organic matter, supplies nutrients to the crop, impacts communities of soil organisms and may stimulate organisms that are antagonistic to plant parasitic nematodes (Orisajo *et al*., 2007; Orisajo *et al*., 2008). Sheep and goat manure have been used as soil amendment and are actually far better than the inorganic fertilizers because they contain large amounts of organic matter, so they feed and build the soil while nourishing the plants (Mitchell, 1992; Giyinyu *et al.*, 2005). Additional benefits of applying manure include increased soil electric conductivity (EC), Cation Exchange Capacity (CEC), organic carbon, soil moisture content and crop yield (Aggarwal *et al.*, 1997; Kimani, *et al*., 1999).

Consistency, composition and nutrient content of manure strongly vary between seasons due to variation in feed quality and intake, addition of organic material, nutrient losses and contamination

with soil (Probert *et al*., 1992; Warren *et al*., 1996; Snijders et al., 2009). Characterisation studies by Williams *et al*. (1995) indicated that manure quality is very variable, e.g. 0.23–1.76 % N; 0.08–1.0 % P; 0.2–1.46 % K; 0.2–1.3 % Ca and 0.1–0.5 %Mg. Another study conducted by Mikile (2001), showed that, of the nutrient composition of different manures, cattle manure had the lowest N, P and K contents followed by sheep, and goat manure had the highest content of N, P and K. High-quality manure has been defined as that with N content greater than1.6% N or C: N ratios less than 10; while low-quality manure has N content less than
0.6% and C:N ratio greater than 17 (Bationo *et al*., 2004). An adult sheep of average weight of 18.25 kg is capable of voiding as much as 146.91 kg of manure on DM basis per year, supplying 2.89 kg N, 0.98 kg P, and 1.31kg K per annum (Fasae *et al*., 2009).

Manure quantity and composition can vary substantially between seasons due to differences in feed availability and quality. Powell (2004) observed that manure quantity and quality in West Africa are generally (much) lower in the dry season than in the rainy season except in situations where cropping strongly limits feed availability during the rainy season (Powell and Williams, 1995). Variation in feed digestibility and protein content can result in large variations in nutrient contents of manure as feeds with higher digestibility and crude protein contents lead to higher N contents in faeces and urine (Delve *et al*., 2001; Snijders and Wouters, 2003). Ash, and to some extent, carbon contents of manures can also vary strongly, due to variation in organic matter content, feed digestibility, and contamination of feeds and excreta with soil during collection and processing (Snijders *et al*., 2009) thereby also changing N content.

2.8.1. Nutrient losses and quality improvement of manure

The most important processes that lead to nutrient losses in manure are leaching of soluble nutrients from urine (particularly Nitrogen, potassium and sulphur) and gaseous losses during collection, storage and application, particularly ammonia (Snijders *et al*., 2009). A larger surface area for collection and storage facility of manure increases the risks for ammonia volatilisation (Smits *et al*., 1995; Chadwick, 2005) and leaching.

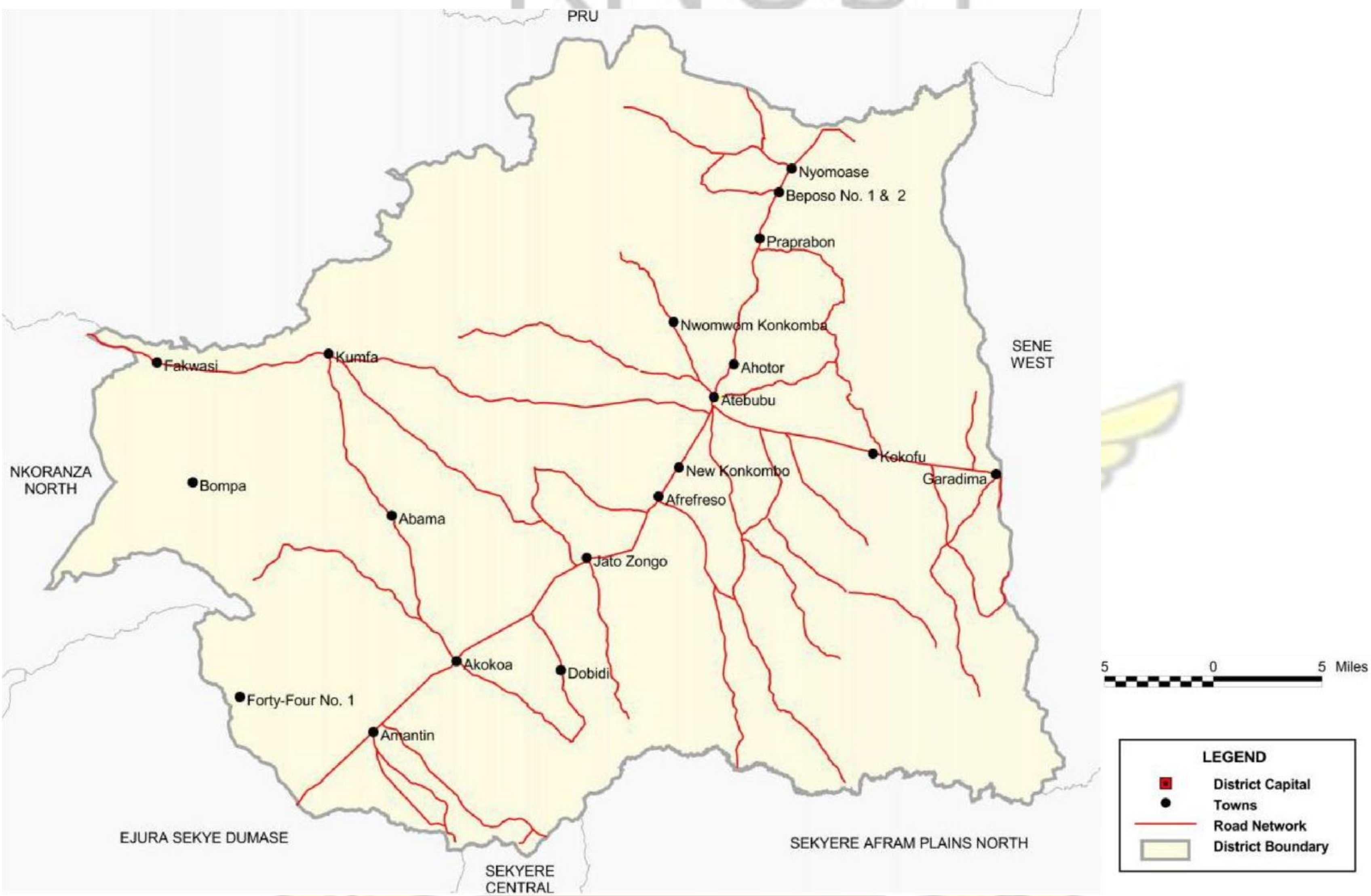
Approximately 80-95% of the N and P consumed by livestock are excreted. Whereas most P is voided in faeces (Ternouth, 1989), N is voided in both urine and faeces (Powell *et al.*, 1998). Up to two-thirds of the urine-N is in the form of urea (Bristow *et al*, 1992) which is easily lost if poorly managed. Feed with higher digestibility and crude protein content (exceeding 11-12%) leads to higher N contents in faeces and urine with higher risks for N losses (Snijders and Wouters, 2003). In order to optimize manure quality, proper knowledge is required for manure collection, storage and utilization that would minimize nutrient loss and allow the nutrients to be available for crop use (Fenning *et al*., 2010). Studies suggest that feeding of concentrates, zerograzing rather than traditional kraaling, manure stored under cover instead of in the open, and on concrete rather than soil floors results in higher quality manure (Lekasi *et al*., 1998). Consumption (browsing) of forages containing tannins may limit N excretion and losses from urine (Delve *et al*., 2001). Crop residue incorporation has been found to minimise nutrient losses through aerobic volatilisation or anaerobic denitrification (Bationo *et al*., 2004).

2.9. Atebubu-Amantin District

The Atebubu-Amantin District (7°38′N 1°4′W7.633°N 1.067°W) is one of the 22 districts in the Brong Ahafo Region of Ghana created out of the former Atebubu District in 2003 and has

Atebubu as its administrative capital. It is bordered to the north by East Gonja District in the Northern Region and Pru district in the Brong Ahafo region and to the south by EjuraSekyeredumasi, Sekyere East and Sekyere Afram plains Districts in the Ashanti Region. To the east, it shares boundaries with the Sene District and to the west with Kintampo and Nkoranza Districts, all in the Brong-Ahafo Region (GSS, 2013). The District covers a land area of 2,624 km^2 with an estimated population of 105,938 with 50.7 percent males and 9.3 percent females (GSS, 2010a). The District falls in the Guinea Savannah agro-ecological zone of Ghana (within the transitional zone between the wet, semi-equatorial and tropical savannah climate regions and the vegetation comes under the interior wooded savannah type of Ghana). Mean monthly temperatures fluctuate between a minimum of 24°C and a maximum of 30°C with a mean annual temperature ranging between 26.5^{o}C and 27.2^{o}C (GSS, 2013). The SSW wind blows with a speed of 6kmh. The area receives bimodal rainfall distribution with a mean annual rainfall of 1400-1800mm (GSS, 2010b). The major rainy season extends from May to August whereas the minor season lasts from September to November followed by the dry season from December to April. The difference between the minor and the major seasons is hardly noticed because of the transitional nature of the area. Atebubu-Amantin is associated with agro-pastoral production systems and is noted for the production of cowpea, groundnuts, maize, rice, sorghum and cassava in association with sheep, goats and cattle. As high as 14,283 of the 20,349 households, are engaged in agriculture with about 95.5 percent of the agricultural households into crop farming (GSS, 2013). A higher proportion of males (71.3%) are engaged in skilled agricultural, forestry and fishery than females. Livestock rearing comes second to crop farming as the most important agricultural activity in the district. Out of the 9,708 animal keepers in the district, 40.7 %, 29.8% and 13.2 % keep chicken, goat and sheep respectively (GSS, 2010b).

Figure 1: MAP OF ATEBUBU-AMANTIN DISTRICT



Source: Ghana statistical service (2013)

2.10. Inferences from literature:

Sheep and goats are a very prominent feature of the subsistence rural economy in most West African homes, even in places where cattle are not commonly kept (Tweneboah, 2000). They are reared mainly for their meat and sold for income even in times of crop failure. The manure generated by sheep can also be used as fertilizer in crop production. Worldwide sheep and goat numbers have been increasing over the past twenty years, unlike other livestock species. Since small ruminant production in Africa is not well developed and considered as being casual rather than an organised activity because animals are poorly housed and managed, their productivity is low and that there is ample opportunity for improvement (Otchere *et al*., 1985). An efficient, well-planned animal health service, going hand in hand with an adequate improvement in the provision of feed, is a pre-requisite for increasing small ruminant production, which would directly improve the diet and standard of living of the large number of rural smallholders in tropical Africa (Otchere *et al*., 1985).

Crop residues are an excellent source of feed that can be obtained from the farm and even though they have the potential of being a feed resource, only a small fraction is currently being used for livestock feeding because of problems of collection, transportation, storage and processing, alternative uses, seasonal availability, and perhaps most importantly, an apparently poor nutritional value and digestibility (Sansoucy and Emery, 1982; Owen, 1985). Such low digestibilities of crop residues, coupled with low intakes, may not satisfy maintenance needs and must be upgraded to improve their nutritive value through supplementation or treatment of some sort or a combination of both. Such treatments include grinding, chopping, pelleting, soaking, gamma-irradiation, enzyme addition, fungal growth, fermentation, composting, ensiling and the use of chemicals such as Sodium hydroxide (NaOH), ammonia (NH_3) and urea.

In spite of the possibilities of using crop residues being ignored, groundnut and cowpea haulms, bean vines, maize, sorghum and millet stover, constitute the bulk of ruminant feed during the dry season in Ghana (MOFA, 1998). The bulk of residues in the major cropping season in the Atebubu-Amantin district are destroyed during the dry season by bush fires. There is thus the need to store adequate amounts of residues in the rainy season so as to use them in feeding animals during the dry season. Storage methods used should however be focused on preservation and maintenance of the nutritive quality of these residues throughout the storage period for adequate dry season feeding. Although feeding of residues and other agro by-products is very common amongst most of our farmers, evidence on the feeding value with respect to liveweight changes and other parameters, of most of these crop residues and by-products is scanty.

CHAPTER THREE

3.0. MATERIALS AND METHODS

3.1 Description of study

Two studies were undertaken as follows;

- ✓ Assessment of the effect of two storage methods (Open and Closed/Shed storage) on the crude protein content of groundnut and cowpea residues and

- ✓ Assessment of the nutrient composition of crop residues and other Agro based byproducts available in the study area as well as effects of feeding them on growth performance and the manure of sheep and Goats.

3.2. Description of study area

The study was conducted in Atebubu and Amantin in the Atebubu-Amantin district of the BrongAhafo Region of Ghana.

3.3. Selection of farmers

Purposive sampling was used in selecting sheep and goat farming project sites based on the population of sheep and goats. Stratified sampling technique was employed to obtain a sample crop (cereals and legumes) -sheep or goats farm households, and other actors along the value chain. Each of the actors (farmers, butchers, traders, etc.) along the crops (cereals and legumes)sheep and goats value chain formed a stratum from which samples were taken. Six farmers (three males and three females) from each of the two towns (Atebubu and Amantin) in the District were selected for the study on storage, animal feeding and manure management assessment. These selected farmers were part of a larger group of farmers participating in a 3-year Australian-Aid (AusAid) funded project purposed to develop and strengthen the crop–sheep and goats value chain in the sub-humid (Ghana, Benin), and Semi-arid (Gambia and Mali) tropics of West Africa. A total of 600 value chain actors in the four countries (150 per country for the 4 countries over the 3 year period) were selected. These farmers were those engaged in planting cereal and legume mixtures (intercrop) or in rotation and were also having some goats and/or sheep.

3.4. Feeding of experimental animals

Feed resources comprised farmers own feed which ranged from basal diets of maize stover, cassava peels and yam peels supplemented with cowpea and groundnut residues. The animals were stall fed ad-libitum with basal diets comprising mostly of cereal residues and kitchen waste comprising cassava and yam peels (about 5% of the body weight of the animal with 3, 1 and 1% maize stover, cassava peels and yam peels respectively). These basal feeds were supplemented with cowpea and groundnut residues at 300g/animal/day. The additional supplements given to the experimental animals were monitored and recorded – type of supplement and quantity offered. The experimental diets used as feed was compounded using the feed resources stated above and designated as Treatment 1 (T1), Treatment 2 (T2) and Treatment 3 (T3). TI comprised a basal feed of maize stover, cassava peels and yam peels, T2 comprised a supplementation of the maize stover, cassava peels and yam peels (T1) with cowpea residues and T3 comprised a supplementation of the maize stover, cassava peels and yam peels (T1) with groundnut residues. The feed was offered *ad libitum* twice daily (09:00 hours and 16:00 hours). Each farmer provided water and **salt lick[1]** *ad-libitum*. The study spanned for ninety (90) days, including two weeks of adaptation to the feed.

Salt Lick[1]: Composition - Sodium Chloride; Sodium content: 38.05%. Obtained from MULTIVET LTD, KWADASO-KUMASI.

3.5. Experimental animals and design of experiment

A total of seventy two (72) animals, comprising eighteen (18) male West African Dwarf goats and eighteen (18) male West African Dwarf sheep aged 12-14 months from each of the two towns were used in the experiment. Each farmer used six animals comprising three sheep and three goats. They were then randomly allotted to three (3) dietary treatments, namely, T1, T2 and T3 in with T1 as the Control diet. Each treatment was replicated six (6) times. The mean initial weights for sheep were 15.00, 15.05 and 15.02 Kg for treatments T1, T2 and T3 respectively in

Amantin and 15.09, 15.17 and 14.85 Kg for treatments T1, T2 and T3 respectively in Atebubu. The mean initial weights for the goats were 10.05, 10.32 and 10.10 Kg for treatments T1, T2 and T3 respectively in Amantin and 10.03, 10.00 and 10.15 Kg for treatments T1, T2 and T3 respectively in Atebubu. The feed and water were offered *ad libitum* in a randomized complete block design. Each block contained three dietary treatments and six (6) replicates per treatment each for sheep and goats in each community. The locations were the blocks and the animal species owned by farmers were the replicates.

3.6. Housing

A portion of the farmers' already existing pen was partitioned and used for housing the animals. Where space was available, small pens were constructed and the experimental animals separated according to the species by fencing. The animals were housed near the homes of each farmer.

3.7. Parameters measured

3.7.1. *Feed intake*

The feed was weighed daily with a weighing scale before offering to the animals. Feed intake was measured and recorded daily as the difference between feed offered and feed refused. Average feed intake per day was determined by dividing the total feed intake by the number of days of the experiment.

3.7.2. L*iveweight changes*

Animals were weighed at the beginning of the experiment and every two weeks during the experimental period with a spring balance. Weight gain was determined by subtracting the weight of the animals from the beginning of the experiment from the weight of each animal after the experiment.

The average daily gain (ADG) was determined by dividing the weight gained by each animal by the duration of the experiment as shown in the formula below;

$$\text{ADG (g)} = \frac{\text{Final weight (g) - Initial weight (g)}}{\text{Number of days (days)}}$$

3.7.3 *Feed conversion ratio (feed/gain)*

Feed to Gain ratio was estimated as the daily feed intake divided by the daily weight gain of each animal.

$$\text{Gain/Feed ratio} = \frac{\text{Daily feed intake gain (g/day)}}{\text{Daily weight gain (g/day)}}$$

3.8. Storage of cowpea and groundnut residues

The effect of two (2) storage methods being the shed/closed and the open methods, on the crude protein (CP) content of groundnut and cowpea residues was assessed in Atebubu and Amantin communities. The closed system of storage was done in rooms specially set aside by farmers to store the feed of their animals. With the open system of storage, residues were stored in the open i.e. without any shed. The residues under storage comprised leaves, vines and stems of groundnut and cowpea. Three of the six farmers selected in each community stored their leguminous residues in sheds and the other three farmers stored theirs in the open. Storage of the residues was monitored for twenty eight (28) weeks in a split-strip plot design with the storage system being the main plot, the sub plot being the communities with the farmers in each community as replicates, and the sampling period i.e. 1, 4, 8, 12, 14, 20, 24 and 28 weeks as a repeated measure on the experimental unit and time being the strip plot. Samples were then taken at 1, 4, 8, 12, 14, 20, 24 and 28 weeks to analyse for changes in crude protein concentration using the methods of AOAC (2002).

3.9. Chemical analysis

Samples of feed traditionally used by the farmers in both communities were collected and sent to ascertain their proximate compositions as described by AOAC (2002) at the Animal and Soil Science Laboratories, K.N.U.S.T., Kumasi-Ghana.

Feed offered and the refusals were measured to determine voluntary intake of feed offered. Samples of feed offered were collected each day per feed type during the fourth and fifth week of the study for 7 to 9 days. Samples collected were pooled by feed type for each farmer and two samples taken per feed type for laboratory analysis. The proximate compositions of the sampled feed were determined as described by AOAC (2002) at the Animal and Soil Science Laboratories, K.N.U.S.T., Kumasi-Ghana.

Daily manure produced by sheep and goat in each community were pooled together, bagged and analysed for Organic Carbon, Nitrogen, pH, Potassium and concentration ash at the Crop and Soil Science Laboratories, K.N.U.S.T., Kumasi-Ghana.

Samples of Leguminous residues under shed/closed and open storage, sampled at 1, 4, 8, 12, 14, 20, 24 and 28 weeks were analysed for changes in crude protein concentration using the methods of AOAC (2002).

3.10. Statistical analysis

The design used in the feeding trial in each community was the Randomized Complete Block Design. Each block contained three dietary treatments and six (6) replicates per treatment each for sheep and goats in each community. The locations were the blocks and the animal species owned by farmers were the replicates.

A split plot design was also applied to the storage of leguminous residues. The storage system was the main plot, the sub plot being the communities with the farmers in each community as replicates, the sampling period i.e. 1, 4, 8, 12, 14, 20, 24 and 28 weeks as a repeated measure on the experimental unit and time being the strip plot.

The randomized complete Block design was also applied to the daily manure produced by sheep and goat in each community with the feed type being the treatments and the animals (Sheep and goats) being the replicates.

All the data collected were statistically analysed using the Generalized Linear Model (GLM) procedures of SAS (SAS, 2006). All the statistical tests were done at a significance level of 5%. The Waller K-ratio test was used to compare significant differences between the treatment means.

CHAPTER FOUR

4.0. RESULTS AND DISCUSSION

4.1. Nutrient composition of feed resources

Table 4.1 shows the chemical composition of various feed resources available as feed for sheep and goats at the two locations. Feed was designated as either base or supplement depending on their type (of cereal or leguminous source) and crude protein content. The nutrient composition for basal feed materials used in Atebubu ranged from 72-92% DM, 82-97.2% OM, 2.8-18% Ash and 3.2-12.6% CP. Basal feed materials for Amantin had 66.5-93% DM, 84-97.2% OM, 7.5-15.5 Ash and 3.7-9.0% CP. The nutrient composition of feed resources analysed in the two communities were comparable in nutrient composition and averaged 85.4% DM, 91.0% OM, 9.0% Ash and 8.6% CP for Atebubu and 86.7% DM, 88.1% OM, 11.3% Ash and 8.3% CP for Amantin. With the exception of Abass Tanko (labeled as FARE) in Amantin who recorded the least feed DM of 66.5%, in Atebubu, FARB and FARA had the least CP (3.2%), OM (82%) and Ash (2.8%). The low DM values obtained for cassava and yam peels for FARE in Amantin and Amantin may be due to the amount of flesh retained during the peeling process. Same reason could be attributed to the low DM content of 72% for yam peels used by FARE in Atebubu. The browse plant *"Kankani"* used in the study by FARE in Amantin had low DM (72%) because it is a browse plant and was harvested at a relatively younger age and at a high moisture content.

Differences in specific nutrients (DM, OM, Ash and CP) of the feed resources used in the study area are attributable to factors such as variety of the crop, age of residue or stage of harvest, physical composition, i.e. the proportion of stems and leaves, length of storage, cultural practices, harvesting practices, processing technique/method, soil fertility and maturity.

Table 4.1. Nutrient composition of feed resources in Atebubu and Amantin.

ATEBUBU Farmers	Ingredients	Content (%) DM	OM	CP	Ash
Adwoa Danso(FARA)	Cassava peels (B)	92	88	4.3	12
	Maize residues (B)	91	88.8	3.2	11.2
	Groundnut husk (S)	82	90.7	8.1	9.3
Ajara Seidu (FARB)	Mango Leaves (B)	89	82	9.6	18
	Cassava peels (B)	86	84	3.5	16
	Maize (B)	72	96	7.9	4.0 14
	Cajanus cajan (S)	81	86	16.5	
Salamatu Amidu (FARC)	Maize residues (B)	87	92.5	3.8	7.5
	Maize (B)	88	97.2	8.75	2.8
	Banana leaves (B)	79	86	12.6	14
	Groundnut haulm (S)	89	91	12	9
	Cowpea husk (S)	89	88	7.13	12
Charles Waja (FARD)	Cassava peels (B)	82	96	4.38	4.0 5.3
	Pito mash (B)	90	94.7	3.97	4.0
	Cajanus cajan (S)	76	96	13.5	10
	Groundnut haulm (S)	89	90	8.3	4
	Cowpea husk (S)	91.2	96	6.81	
Mustapha Ali (FARE)	Maize residues (B)	86	91.1	3.8	8.9
	Yam peels (B)	72	88	9.0	12
	Cooked yam (B)	84	93	6.3	7
	Cooked rice (B)	82	88	6.7	12
	Cajanus cajan (S)	81	91	15.9	9
	Groundnut haulm (S)	90	93	11.1	7.0
Amadu Jato (FARF)	Maize (B)	92	97.2 88	8.9	2.8
	Cajanus cajan (S)	87	93	17.3	12.0
	Cowpea haulm (S)	92		10.4	7.0

AMANTIN Farmers	Ingredients	Content (%) DM	OM	CP	Ash
Rita Narh (FARA)	Maize residues (B)	92.0	92.5	4.8	7.5
	Dry cassava peels (B)	88.2 92	88.0	5.8	12
	Groundnut haulms (S)	91	92	12.5 11	8.0
	Cowpea haulms (S)		90.1		9.9
Margaret Agyei (FARB)	Groundnut haulms (S)	89	82	11	18
	Cowpea haulms (S)	86	88	10.3	12
Abass Tanko (FARC)	Cassava peels (B)	66.5 87	84.5 92	4.8	15.5
	Groundnut haulms (S)	88	89	9.0	8
	Cowpea haulms (S)			10.4	11
Seidu Baba(FARD)	Maize residues (B)	93	89	3.8	11
	Maize (B)	82	97.2 87	9.0	2.8
	Cowpea haulms (S)	90		10.9	13
Fuseini Abubakari (FARE)	Cowpea haulms (S)	86	85	7.8	15
	—*Kankani*‖ (S)	72	91	9.0	9
Georgina Konabe (FARF)	Maize residues (B)	92	88	3.7	12
	Cowpea haulms (S)	92	74	8.13	16.0
	Groundnut haulms (S)	87	88	8.56	12.0

Where S is supplement, B is Base, DM=Dry matter, OM= Organic matter, CP= Crude protein.

Organic matter which varied from 84-97.2% could be attributed to anatomical differences between plant species which according to Phuc (2006) depends on effect of plant development and leaf: stem ratio. The CP levels recorded in the study (3.2-17.3) were higher than the 2-5% reported by Ben Salem *et al.* (2004). The CP contents of almost all the supplements used (about 91%) were higher than the 8% level reported by Norton (1994) for optimum rumen microbial activity and similar to the range of 8.9-16% reported by NRC (1981) for maintenance and moderate growth in goats. They were also similar to the recommended CP level of 15% reported by NRC (1975) for optimum maintenance of production. Legume based residues and by-products were used as supplement by the farmers and had higher crude protein contents than residues used as base.

4.1.1. Maize residues

Maize and its residues available in the study areas had 3.2-9.0% CP, 72-93% DM, 88-97.2% OM and 2.8-12.0% Ash. Malau-Aduli *et al.* (2003) reported higher CP (9.56%) and Ash (9.67%) contents for maize as a feed for goats in Nigeria. Though the OM (90.4%) content obtained by the authors was lower, the DM (90.73%) was similar to the results obtained in our study. Otchere *et al.* (1978) reported similar (*P>0.05)* values for CP and DM but lower values for Ash. Maize residues used in the study comprised of stovers, husk and offals. Olorunnisomo *et al*. (2003) obtained higher CP (12.7%) and Ash (8.5%) contents for maize offal as a feed for goats in Nigeria. The OM content (91.5%) was however lower but the DM (91.8%) was within the values recorded in the study. Ondiek *et al.* (2013) reported low DM (60.2%) similar CP (4.6%) and ash (9.8) contents for maize residues. The CP content for maize residues were also similar to that reported by Woyengo *et al*. (2004).

4.1.2. Groundnut residues

Groundnut residues comprised of haulms and husk. Groundnut husk was used by only FARA in Atebubu and contained 8.1% CP, 82% DM, 90.7% OM and 9.3% Ash. Groundnut haulms available in the study area also contained 8.3-12.5% CP, 87-92% DM, 7-12.0% Ash and 88-93% OM. Smith (1988) reported similar results of 88-90 DM, 87-90% OM, 11-17CP and10-13% Ash for groundnut haulms. Addass *et al*. (2011) reported 10.90% CP, 91%DM, 8.3% Ash and 91.7% OM for Groundnut haulms which was similar to the range obtained for Groundnut haulms in our study.

4.1.3. Kitchen waste

Cassava peels analysed contained 3.5-5.8% CP, 66.5-92% DM and 4-16% Ash. Asaolu *et al*. (2012) reported lower CP value of 3.28% for cassava peels. They also reported 9.19% Ash and 85.70% DM which are similar to the values obtained in study for cassava peels. Pipat *et al*. (2011) however reported low DM (26%), low protein (1.0%) and high ash (17.7%) contents for fresh cassava peels. Yam peels were used as feed by FARE in Atebubu (Table 4.2). It had 72% DM, 88% organic matter, 9.0% CP and 12% ash. Onwuka *et al*. (1997) reported lower CP (8.64%) and ash (6.3%) contents for yam peels when assessing the value of various residues as feedstuffs in Nigeria. The peels used in this study were sun-dried and this accounts for the differences in values.

FARE in Atebubu used cooked yam as a feed for sheep and goats (Table 4.1) and it contained 84% DM, 93% organic matter, 6.3% CP and 7% Ash. The crude protein contents of cooked yam were similar to the value (6.3±0.11 %) obtained by Olajumoke *et al*. (2012) but higher than the range of 1.73-2.33% CP reported by Sanni *et al*. (1999) in Abeokuta. This reduction may be as a result of the loss of free amino acids which took place as a result of the longer cooking time of yam. Ezeocha *et al*. (2012) however reported higher CP and lower ash contents for cooked water yam (8.11-9.12%CP and 2.05-2.70% Ash) and trifoliate yam (8.01-10.3% CP and 1.511.91%Ash). Cooked rice was also used by FARE in Atebubu and had 82% DM, 88% organic matter, 6.7% CP and 12% ash. These were higher than the range of values (2.22-2.35% CP and 0.37-0.43% ash) obtained by Sanni *et al*. (1999) in Abeokuta, Nigeria. Differences in the nutrient composition of cooked yam and rice depend on the cooking time which leads to loses of free amino acids and minerals. Also, water absorption during boiling can lead to dilution and hence, low amount of ash (Onyeike and Oguike, 2008).

4.1.4. Cowpea residues

Cowpea husk was used as supplements by FARC and FARD in Atebubu. Nutrient content for cowpea husk ranged from 6.81-7.13%CP, 89% DM, 88-96% OM and 4-12% Ash. Ososanyo *et al*. (2013) reported high CP (14.24%) and low DM (87.3%) for cowpea husk in his study. Mako *et al*. (2013) however reported DM (89.17%) and Ash (4.10) contents which were within the range of our study but higher CP content (15.67%) for cowpea husk. The CP contents of cowpea husk obtained in our study were also lower than the 12.97% reported by Addass *et al*. (2011) but similar to 7.10% by Malau-Aduli *et al*. (2003). Cowpea haulms available in the study areas had 86-92% DM, 74-93% OM, 7-16% Ash and 7.8-11% CP. The CP of cowpea haulms used in our study was within the range of 7.7-21.7% as reported by Camara, (1996) and Kaasschieter *et al*. (1998) and Savadogo *et al*. (2000) .On DM basis, Savadogo *et al*. (2000) reported DM, OM, Ash and CP of 92.7%, 91.1%, 8.9% and 10.0% respectively, which was similar to the results obtained in this study. Tarawali *et al*. (1997) also reported higher results of 13-17% CP for cowpea haulms which were higher than that obtained in our study. However, Mokoboki *et al*. (2000) reported similar ranges of CP (5.06-7.42%) but higher DM (95.36- 96.44%) for eight varieties of cowpea haulms as forages. The differences in nutrient composition of cowpea residues could be attributed to the variety, species, proportion of leaves to stem, time and age harvesting and soil nutrient status as suggested by Sundstol and Owen (1984)

The nutrient contents of the crop residues used in the study indicate that leguminous residues like cowpea and groundnut residues, have the potential to be used in ruminant diets as protein supplements for low quality maize, yam, cassava residues as well as other by-products. Efforts should thus be made to store them in adequate amounts for dry season feeding. Also, similarities in the nutrient (especially CP) contents of these residues may be used as a basis for selecting various residues and Agro-industrial by-products for comparative studies aimed at assessing their relative potentials as fodder resources in ruminant nutrition.

4.1.5. Other feed resources

Other feed residues available in the study area were *Cajanus cajan* (locally reffered to as *krayie*), banana leaves, *"Kankani",* pito mash and mango leaves. ―*Cajanus cajan"* and *"Kankani"* are local browse legumes used as feed supplements in Atebubu and Amantin respectively. Pito mash, mango leaves, banana leaves were also used as basal feed in Atebubu community.

Pito mash, as used by FARD in Atebubu, contained 90% DM, 94.7% OM, 5.3% Ash and 3.97% CP. These results are lower than those reported (28.76% CP, 12.47% ash and 96.83% DM) for sun dried pito mash by Kagya-Agyemang *et al*. (2013).

Banana leaves, used as basal feed ingredients by FARC in Atebubu contained 79% DM, 86% organic matter, 12.63% CP and 14% Ash. The CP, OM and ash contents of banana leaves obtained in our study were lower than the 15% CP, 9% ash and 91% OM obtained by Smith (1988). Mango leaves used as basal ingredient by FARB in Atebubu also contained 89% DM, 82% organic matter, 9.6% CP and 18% Ash. The CP value of 9.6% obtained for mango leaves is similar to the 10.1% obtained by Meecha and Adegbola (1980) but lower than the 20.38% and 12.77% reported by Ajayi *et al*. (2005) and Omoniyi *et al*. (2013) respectively. The values for Ash (10% and 13.66%) reported by Ajayi *et al*. (2005) and Omoniyi *et al*. (2013) were also lower than the value obtained in our study. Mango leaves and banana leaves assessed in the study also had high CP contents and could be considered in ruminant diet formulation in the tropics especially in the dry season where feed is scarce. The low nutrient compositions of mango and banana leaves in our study compared to other works is due to the quick wilting and drying of these leaves since they were collected in the dry season. Also the low CP contents of these leaves could be as a result of increased maturity of the plants.

Cajanus cajan, locally reffered to as *„Krayie"* is a leguminous browse plant used as feed for sheep and goat in Atebubu. It was used as a supplement feed by FARB, FARD, FARE and FARF in Atebubu. The nutrient content of Cajanus cajan was 81-87% DM, 86-96% OM, 8-14% Ash and 13.5-17.3% CP. The result agrees with the report of Getachew *et al. (*2000) that browse forages are higher in CP than tropical grasses and stovers. The values for CP, OM and ash obtained in our study was similar to the range of 95.2-97 % DM, 14.37-16.65% CP and 10-18% Ash values obtained by Njidda (2010). The CP contents of the *Cajanus cajan* fell within the range (i.e. above 13%) reported for West African browse species by Rittner and Reed (1992).

Another browse plant, locally reffered to as is *Kankani,* was also used as a supplement in Amantin by FARE. It contained 72% DM, 91% organic matter, 9% CP and 9% Ash. The CP content of *Kankani* was above 8% CP required to satisfy maintenance requirement of ruminant animals (Norton, 1994) and above the minimum level necessary to provide sufficient nitrogen required by rumen microorganisms to support optimum activity (McDonald *et al*., 2002). The high value of CP recorded is an indication that *Cajanus cajan* and *"Kankani"* could serve as a potential protein supplement to enhance the intake and utilization of low quality fibrous crop residues liked by ruminants.

4.2. Percentage nutrient composition of experimental diets

The percentage compositions of the feed ingredients used in feeding sheep and goats in both communities are shown in Table 4.2. Basal feed ingredients used in feeding sheep and goat in both communities comprised Maize stover, cassava peels and yam peels and had 83.55-84.22% DM, 88.96-89.43% OM, 9.57-11.04% Ash and 5.32-6.41% CP. The CP level of the basal feed ingredients recorded in this study was higher than the 2-5% reported by Ben Salem *et al.* (2004) and the 3.8% obtained by Osafo *et al*. (2013). They were however lower than the 8 % and 8.916% level reported by Norton (1994) and NRC (1981) for optimum rumen microbial activity and for maintenance and moderate growth in goats. They were also lower than the recommended CP level of 15% reported by NRC (1975) for optimum production needs.

Table 4.2. Percentage nutrient composition of the experimental diets

	ATEBUBU DIETARY TREATMENTS		
	T1 (BASE ONLY)	T2 (BASE + GROUNDNUT RESIDUES)	T3 (BASE + COWPEA RESIDUES)
% COMPOSITION	**BD***	**COWPEA RESIDUES**	**GROUNDNUT RESIDUES**
DM	84.22	88.04	84.50
OM	89.43	91.2	91.11
CP	6.41	11.51	11.58
ASH	9.57	8.80	8.88

	AMANTIN DIETARY TREATMENTS		
	T1 (BASE ONLY)	T2 (BASE + GROUNDNUT RESIDUES)	T3 (BASE + COWPEA RESIDUES)
% COMPOSITION	**BD***	**COWPEA RESIDUES**	**GROUNDNUT RESIDUES**
DM	83.55	89.40	88.75
OM	88.97	85.62	88.50
CP	5.32	10.15	10.27
ASH	11.04	12.38	11.50

Where DM = dry mater; OM = organic matter; CP = crude protein. BD= the average values of the basal diets of maize stover, cassava peels and yam peels.*

Cowpea residues used as supplements in feeding animals in both communities comprised husk and haulms left after harvest. Nutrient content of cowpea residues used as feed ingredients ranged 88.04-89.4% DM, 85.62-91.2% OM, 8.8-12.38% Ash and 10.15-11.51% CP. Ososanyo *et al*. (2013) reported high CP (14.24%) and low DM (87.3%) for cowpea husk in his study. The CP of cowpea residues used in our study is within the range of 7.7-21.7% as reported by Camara (1996), Kaasschieter *et al*. (1998) and Savadogo *et al*. (2000). Mako *et al*. (2013) also reported similar DM

(89.17%) and lower Ash (4.10) contents as compared to our study but higher CP content (15.67%) for cowpea husk.

Groundnut residues comprised haulms and husk of the groundnuts. Nutrient content of groundnut residues used as feed ingredients ranged 84.50-88.75% DM, 88.50-91.11% OM, 8.88-11.50% Ash and 10.27-11.58% CP. Smith (1988) reported similar results of 88-90 DM, 87-90% OM, 1117% CP and 10-13% Ash for groundnut haulms. Addass *et al*. (2011) reported 10.90%CP, 91%DM, 8.3% Ash and 91.7% OM for Groundnut haulms which was similar to the results obtained for Groundnut residues in our study.

The supplemental feed ingredients used in both communities had similar CP values (11.51% and 11.58% for cowpea and groundnut residues respectively in Atebubu; 10.15% and 10.27% for cowpea and groundnut residues respectively in Amantin) indicating that they are isonitrogenous. The CP levels obtained for the supplemental feed ingredients in the study (10.15-11.58%) were higher than the 2-5% reported by Ben Salem *et al.* (2004). The CP contents of all the supplements used were higher than the 8 % level reported by Norton (1994) for optimum rumen microbial activity and within to the range of 8.9-16% reported by NRC (1981) for maintenance and moderate growth.

4.3. Effects of storage type on crude protein levels of cowpea and groundnut residues

Table 4.3. shows the effect of storage type on the crude protein concentration of cowpea and groundnut residues.

Storage type significantly (P < 0.01) affected CP content of leguminous residues. Crude protein content was significantly lower (10.75) in the residues stored in the open than those stored under shed (12.49). Significant interactions (P<0.05) occurred between residue type and weeks in storage. The crude protein content of residues remained 11% at week 22 for both shed and open storage types (Figure 1). Interactions (P <0.01) also occurred between the weeks of storage and the storage type. In the two storage systems assessed, there was an insignificant decline in the crude protein concentration with time in the shed storage (Figure 1).

Table 4.3.: Effect of storage type on crude protein content of groundnut and cowpea residues

Residue	Storage	CP	SE
Cowpea chaff		9.31^{d}	0.074
Cowpea haulm		13.85^{a}	0.074
Groundnut haulm		11.53^{c}	0.074
Groundnut residue		11.79^{b}	0.074
	Open	10.75^{b}	0.055
	Shed	12.49^{a}	0.055
	Statistical Interactions		
Residue x week	*		
Storage x week	**		

Where. P < 0.05; ** P < 0.01; SE = standard error; CP = crude protein.*

The increase in crude protein content associated with the open system of storage could be due to residues‘ exposure to rain and sunlight. The heat generated in the residue as a result of wetting and drying might have resulted in Maillard reaction leading to protein-fibre complex. This explains the gradual increase in protein concentration with time in open storage and this bound protein will eventually not be available to the animal. The increase in crude protein concentration is also consistent with the studies of Rotz *et al*. (1991), who suggested that, in the event of rain, soluble nitrogen leaches at a slower rate than other constituents such as sugars, thereby causing nitrogen concentration to increase. With the residue and storage type with time, significant interactions (P<0.001) were also observed.

Figure 2 shows the effect of different storage practices on the crude protein concentration of groundnut and cowpea haulm.

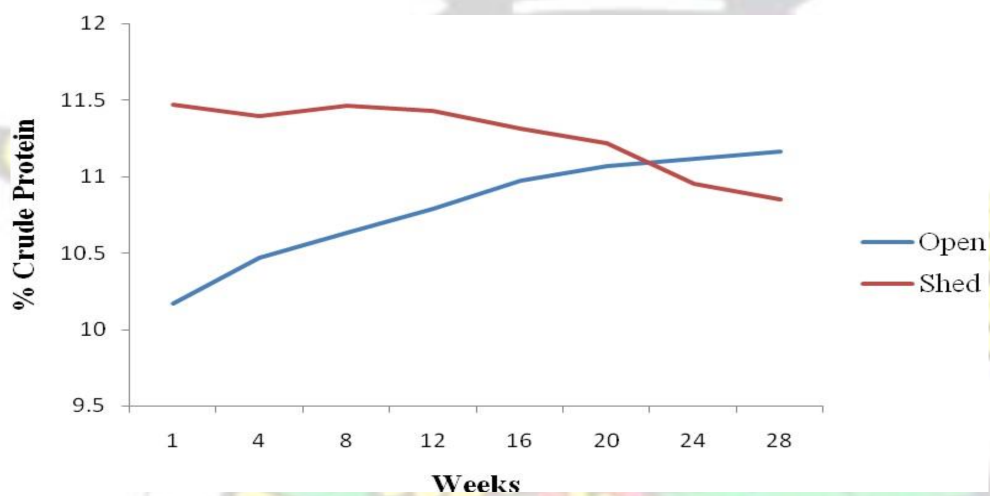


Figure 2: Effects of type of storage on crude protein concentration of groundnut and cowpea residues.

The protein level of the residues under the shed or closed system of storage declined gradually from 11.5% with time but stabilized at 10.8% after Twenty eight weeks. Similar observations in the decline of crude protein of ensiled grass and legume hays have been reported by Onwuka and Davies (1996). The decline in CP contents of the residues as storage length increases agrees with the findings of Oladotun *et al*. (2003) who observed reduction in the Crude protein with increased storage length. This fall in Crude protein content may be due to volatilisation (Merchen and Satter 1983). At the end of the storage, the CP content of fodder in storage was similar to the level (11 to 12%) required for moderate level of ruminant production (Gatenby, 2002), thereby suggesting its adequacy for ruminant production. This indicates that the cowpea and groundnut residues, when available in adequate in amounts the study areas (Atebubu and Amantin) during the cropping season, can be stored for dry season feeding of ruminants without dramatic losses in crude protein.

4.4. Growth performance

Tables 4.4 and 4.5 show the mean feed intakes, weight gain and feed conversion ratio of Sheep and goats in Atebubu and Amantin communities.

4.4.1. Feed intake of sheep

Feed intakes were generally higher for sheep than in goats. Thus the total, basal and supplement feed intakes were higher in sheep than in goats. This agrees with the observation by Baiden *et al*. (2007) that large animals will relatively eat more than small animals. Similar observations were made by Otchere *et al*. (1978) and Adebowale and Taiwo (1996). Feed intake as a percentage of body weight for sheep in both communities ranged from 4.04-4.18% for T1, 3.18-3.20 % for T2 and 3.12-3.22% for T3. The obtained results for sheep in both communities agree with 3 – 5% body weight as dry matter intake for ruminants (ARC, 1980 and Devendra, 1988). They were however lower than the 5.5% reported by Krebs *et al*, (2007) when he fed sheep with *A. saligna* but higher than the 2.29-2.5 reported by Maigandi and Tukor (2002) when they fed Fore-stomach digesta to growing sheep. They are also lower than the 4.45-4.97% and 4.6 % reported by Muhammad *et al*, (2008) and Otchere *et al*, (1978) who fed growing sheep with varying levels of Rice milling waste and cassava starch refuse, as a replacement for maize respectively. The intake of about 3-4% body weight obtained in this study implies that feed ingredients used in this study had no adverse effect on feed intake.

Table 4.4. Feed intake and growth performance of sheep in Atebubu and Amantin.

	TREATMENTS										
	T1		T2		T3						
	AM	**AT**	**AM**	**AT**	**AM**	**AT**	**SIGNIFICANCE**				
No. of Animals	**6**	**6**	**6**	**6**	**6**	**6**	**SEM**	**REP**	**LOC**	**FEED**	**LOC*FEED**
LIVEWEIGHT CHANGES											
Initial weight, Kg	15.09	15.00	15.05	15.17	15.02	14.85					
Final weight, Kg	16.20^{a}	16.35^{a}	17.08^{b}	17.48^{b}	17.15^{b}	16.66^{ac}	0.224	0.1082	0.9043	0.0008	0.1515
Weight Gain, Kg	1.11$_{ae}$	1.35$_{ad}$	2.03$_{bc}$	2.32$_{be}$	2.13$_{bc}$	1.82$_{cd}$	0.242	0.2400	0.7390	0.0021	0.4040
ADG, g/day	12.37^{a}	14.96^{ac}	22.59^{bc}	25.74^{b}	23.70^{bc}	20.18^{c}	2.686	0.2400	0.7390	0.0021	0.4040
DMI, g/day											
BFI, g/day	677.00^{a}	659.72^{a}	323.33^{b}	377.83^{c}	340.33^{bd}	358.33^{cd}	11.276	0.2170	0.0593	<0.0001	0.0166
SFI, g/day	-	-	220.50^{a}	180.84^{b}	213.50^{a}	161.22^{c}	8.575	0.2028	0.0003	<0.0001	0.0166
TOTINT, g/day	677.00^{a}	659.72^{a}	543.83^{bc}	558.67^{b}	553.83^{b}	519.55^{c}	13.130	0.2001	0.2670	<0.0001	0.1904
% BWC, %	4.18	4.04	3.18	3.20	3.23	3.12					
DMI, Kg/LW											
BFI, Kg/LW	41.80^{a}	40.37^{b}	18.96^{c}	21.62^{d}	19.83^{c}	21.50^{d}	0.694	0.5724	0.1030	<0.0001	0.0209
SFI, Kg/LW	-	-	12.88^{a}	10.33^{b}	12.46^{a}	9.71^{b}	0.462	0.0830	0.0001	<0.0001	0.0125
TOTINT,Kg/LW	41.80^{a}	40.37^{a}	31.84^{b}	31.95^{b}	32.28^{b}	31.21^{b}	0.753	0.4557	0.2109	<0.0001	0.5734
FCR (F:G)	64.24^{b}	54.31^{b}	42.27^{ab}	22.08^{a}	24.32^{a}	28.49^{a}	11.401	0.5859	0.3639	0.0207	0.5716

[abc]*Means in each row with different alphabets are significantly different* ***(P<0.05)****. Where* ***SEM: Standard error of mean****;* ***AM*** *= Amantin;* ***AT = Atebubu;*** *BFI = basal diet intake; SFI = supplement feed intake;* ***TOTINT*** *= Total feed intake;* ***ADG*** *(g/d) = average daily gain in grams per day,* ***FCR*** *=Feed Conversion ratio (Feed:Gain).* ***T1= Treatment 1 (base only); T2 = Treatment 2 (base supplemented with cowpea residues); T3 = Treatment 3 (base supplemented with groundnut residues); % BWC =*** *Percentage Body weight consumed. LOC=Location effect; FEED=Feed effect; LOC*FEED=Location by feed interaction.*

4.4.2. Dry matter intake of sheep

Feed type significantly affected the basal feed intake (BFI), Supplemental feed intake (SFI) and subsequently Total feed intake (TFI) of sheep ($P < 0.0001$; Table 4.4). BFI and TFI were high for sheep on T1 and lowest for T3. SFI was however high in T2 than T3. Locational effect was significant for SFI ($P = 0.0003$) and tends to approach significance for BFI ($P = 0.0593$) but was not significant for TFI ($P=0.2670$) in Amantin for sheep. With the exception of BFI, which was highest in Atebubu, SFI and TFI were highest in Amantin than in Atebubu. An interaction existed between the feed and location for the BFI and SFI ($P=0.0166$) of sheep. This interaction occurred across all treatments in the two locations. Similar observations were made for feed intake per kilogram liveweight of sheep.

There was no significant difference ($P > 0.05$) in the Total DM intake of sheep amongst treatments T1 and T2 in Atebubu and Amantin. Similar differences ($P>0.05$) in total DM intakes were observed by Baiden *et al*.(2007) when they replaced cassava peels with varying levels of cassava pulp in Sheep diets. Garba *et al*. (2012) also observed similar differences ($P>0.05$) in total DM intake for sheep fed graded levels of Rice milling waste and soyabean meal residue combinations. However, differences ($P<0.05$) existed in the total DM intakes of sheep between treatments within both communities. With the exception of sheep on T3 that had a significant difference ($P<0.05$) in TFI between Atebubu and Amantin no difference in TFI ($P>0.05$) was observed in T2 and T3 between Atebubu and Amantin. Significant differences ($P<0.05$) were also observed between T1 and all other treatments within both communities. Lemlem (2013) also observed differences ($P<0.05$) in the total DMI of Elle sheep fed on hay basal and legume supplementation.

The values for Total DMI for sheep in both communities (677.00, 543.83 and 553.83 g/day for

Amantin; 659.72, 558.67 and 519.55g/day for Atebubu) were lower than the range of 10281661g/day obtained by Bello and Tsado (2013) when they supplemented sorghum stover with graded levels of Poultry droppings for growing Yankassa Rams weighing between 11.5 to 15.5 Kg. This high intake in relation to our study might be due to breed differences and the nutrient content of the feed used. With the DMI of supplements, significant differences (P<0.05) existed between sheep on T2 and T3 in both communities. Similar differences (P<0.05) also existed in the DMI of basal feed between treatments within Amantin and Atebubu. The basal feed intake obtained in this study was higher than those reported by Bello and Tsado (2013) and Baiden *et al*. (2007) who supplemented sorghum stover with graded levels of Poultry droppings and replaced cassava peels with varying levels of cassava pulp in Sheep diets respectively. The higher basal feed intake could be due to the relatively lower nutrient composition of the basal diet, which might have influenced the higher intake by animals to meet their maintenance requirement.

Basal feed intakes per kilogram liveweight for sheep were slightly higher for T2 and T3 in Atebubu than in Amantin. There were significant differences (P<0.05) in the basal feed intake per kilogram liveweight of sheep amongst treatments in both communities. Basal feed intake was lowest for sheep on T2 in Amantin and highest for T1 in Amantin. This could be attributed to preference of sheep for the supplements which were higher in crude protein. Similar observations (P> 0.05) were made by Ososanya *et al*. (2013) when they supplemented *cyanodon dactylon* with groundnut haulms as feed for rams. Osafo *et al*. (2013) also made similar (P> 0.05) observations when they supplemented maize stover with cowpea haulms. The values for daily basal feed intakes for both communities (18.96-41.80 g/KgLW and 21.50- 40.37 g/KgLW for Amantin and Atebubu respectively) were comparable to the range of 13.5-25.3 g/KgLW obtained by Osafo *et al*. (2013)

when they supplemented maize stover with cowpea haulms. They were also similar to the range of 32.8-36.2 g/KgLW reported Ahaotu *et al*. (2013) who supplemented maize stover with *Moringa oleifera* as feed for West African Dwarf Sheep.

Supplemental feed intake per kilogram liveweight of sheep differed ($P<0.05$) between the animals on T2 and T3 in Atebubu and Amantin. There was however no difference ($P>0.05$) in the intake of supplements by sheep within Amantin on T2 and T3. Differences ($P<0.05$) were observed in the supplement feed intakes between sheep on T2 and T3 in Atebubu. Supplement feed intakes per kilogram liveweight for sheep between T2 and T3 was lower in Atebubu than in Amantin. This might be due to the differences in palatability of the supplements offered.

Total feed intake per kilogram liveweight was significant ($P<0.05$) among the sheep on T1 and T2 and T3 within Atebubu and Amantin. Similar observations ($P<0.05$) in total feed intake were made by Ososanya *et al*.(2013) when he supplemented *cyanodon dactylon* with 50% and 100% groundnut haulms as feed for rams. No significant differences ($P<0.05$) were observed in the TFI/KgLW between sheep on T1, T2 and T3 in the two communities. Total feed intake per kilogram liveweight was generally higher for sheep in Amantin than in Atebubu. The values for total feed intake for both communities (31.84-41.80 g/KgLW and 31.21-40.37 g/KgLW for Amantin and Atebubu respectively) were higher than the 13.5-25.3 g/KgLW reported by Osafo *et al*. (2013). They were also higher than the 26.73-29.80 and 22-32 g/KgLW/day reported by Baiden *et al*. (2007) and Aboud *et al*. (1993) respectively. The higher intakes in our study could be due to high crude protein content of supplements which provide rumen microbes with a source of nitrogen thereby boosting the rate of passage and digestibility with a corresponding increase in intake, even at relatively small levels of supplementation. The higher intakes could also be attributed to the improved palatability resulting from supplementation. Ahaotu *et al*. (2013) however reported a similar range of 32.8-42.8 g/KgLW/day for sheep.

4.5. Final weight and weight gain of sheep

Feed type significantly affected the final weight (P=0.0008) and average daily gain (P = 0.0021) of sheep. However locational effect was not significant for the ADG of sheep (P = 0.7390). No significant interaction existed between the feed and location for the ADG of sheep (P = 0.4040). Animals on all treatments gained weight indicating that the treatments had a positive effect on the liveweight performance of sheep in the study. Significant differences (P<0.05) in average daily gain of sheep between treatments T2 and T3 were also observed. This may be due to the level of feed intake and nutrient status of feed offered. The results obtained for the average daily gain of sheep on the treatments in both communities suggest that those on T2 in Atebubu and T3 in Amantin recorded the highest average daily gain of 25.74 and 23.70g/day respectively. Sheep on T1 recorded the least weight gain and may be due to the low crude protein levels in the basal feed thus leading to reduced rumen activities. The ADG values for sheep were below the reported range of 44-109g/day by Muhammad *et al*. (2004) for conventional feed ingredients. It was also lower than the range of 28.75-55.20g/day reported by Alli-Balogun *et al*. (2003) for sheep fed cassava foliage as protein supplement. Adu and Brinckman (1981) also reported higher ADG values of 78 – 183g when they fed fattened sheep with varying levels of guinea corn and groundnut cake with *Digitaria smutsii* hay as a source of roughage. The average daily gain values were also lower than the 29.24g/day, 48.98g/day and 49.19g/day reported by Ngwa and Tawa (1991), Obese (1998) and Issaka (2006) who supplemented Djallonke sheep with rice straw, groundnut haulms, cotton seed and cowpea vines respectively. The lower gains obtained in our studies could be due to the differences in crude protein contents of feed, level of feed intake and breed differences.

4.6. Feed conversion ratio of sheep

The results obtained for FCR for sheep in both communities suggests that those on T1 recorded the highest ratios of 64.24 and 54.31 for Atebubu and Amantin respectively. The high FCR is an indication that sheep on T1 in both communities were the poorest in converting the feed they consumed into liveweight gain. On the other hand, sheep on T2 in Atebubu and T3 in Amantin had the least ratios of 22.08 and 24.32 respectively indicating that sheep on these treatments were effective in converting the feed they consumed into liveweight gain, with sheep on T2 in Atebubu being most effective. The type of feeds‘ influence on FCR by sheep was significant ($P < 0.0001$) for sheep reared by farmers in the two locations. Locational effect ($P = 0.3639$) was not significant for the FCR of sheep. No significant interaction ($P = 0.5716$) as a result, existed between the feed and location for the FCR of sheep. Differences in feed conversion ratio due to feed type could be attributed to the crude protein contents of the feed used. Animals that were provided supplements with the cowpea and groundnut residues were efficient converters because supplements had crude protein contents which were adequate for optimum rumen microbial activity and hence improved digestibility and utilization.

Significant differences ($P<0.05$) were observed in the FCR of sheep on all treatments within Amantin and also between T1 and T2 within Atebubu. Differences ($P<0.05$) also existed in the FCR between sheep on T1 and T2 in both communities. The FCR values for sheep in Atebubu

(54.31,22.08 and 28.49 for T1, T2 and T3 respectively) and Amantin (64.24,42.27 and 24.32 for T1, T2 and T3 respectively) were similar to the range of 14.06-45.68 reported by Ososanya (2013) when he fed sheep with diets containing graded levels of corn cob and cowpea husk. Muhammad (2008) also reported a similar range (13.63 to 35.23) of FCR when he fed sheep with diets containing 0-45% rice milling waste. Garba *et al*. (2012) and Lemlem *et al*. (2013) however reported lower range of 8.83-8.25 and - 45 to 19.8 for Yankasa rams and Elle sheep when they supplemented hay with lablab and cowpea and graded levels of rice milling waste and soyabean respectively. This may be due to breed differences and the nutrient (especially crude protein) supply to rumen microbes for optimum digestion.

4.7. Feed intake of goats

Feed intake, as a percentage of body weight of goats in both communities ranged from 3.894.08% for T1, 3.03-3.09 for T2 and 2.73-2.80 for T3. The result agrees with the 3 – 5% body weight as dry matter intake for ruminants (ARC, 1980 and Devendra, 1988). With the exception of goats on T1 which had higher feed consumption in relation to their body weight, percentage body weight of feed consumed for goats on T2 and T3 were similar to the 2.5-3.0 reported by Devendra and Burns (1970) for tropical goats. They were also similar to the 47-3.65% reported by Hossain *et al*, (2003), Ranjhan (1980) and Ndemanisho *et al.*, (2007). Higher (6.41-7.13%) and similar (3.55-4.12%) range of percentages have also been reported for goats by Ajayi *et al*, (2005) and Asaolu *et al*, (2012).

Table 4.5. Feed intake and growth performance of goats in Atebubu and Amantin.

TREATMENTS	T1		T2		T3		SIGNIFICANCE				
	AT	AM	AT	AM	AT	AM					
No. of Animals	**6**	**6**	**6**	**6**	**6**	**6**	**SEM**	**REP**	**LOC**	**FEED**	**LOC*FEED**
LIVEWEIGHT CHANGES											
Initial weight, Kg	10.05	10.03	10.32	10.00	10.10	10.15					
Final weight, Kg	10.85^{a}	10.80^{a}	11.88^{b}	11.38^{cd}	11.62^{bd}	11.85^{b}	0.143	0.0419	0.3785	<0.0001	0.0569
Weight Gain, Kg	0.80^{a}	0.77^{a}	1.57^{bd}	1.38 ^{b}	1.52^{bd}	1.70^{cd}	0.108	0.0223	0.9008	<0.0001	0.2557
ADG, g/Day	8.89^{a}	8.52^{a}	17.41^{bc}	15.37^{b}	16.85^{bc}	18.89^{c}	1.199	0.0223	0.9001	<0.0001	0.2559
DMI, g/day											
BFI, g/day	443.00^{a}	420.17^{b}	207.67^{c}	190.67^{cd}	198.17^{cd}	188.67^{d}	8.931	0.1441	0.0355	<0.0001	0.7587
SFI, g/day	-	-	152.67^{ac}	161.17^{a}	119.50^{b}	143.17^{c}	5.001	0.5582	0.0162	<0.0001	0.0800
TOTINT, g/day	443.00^{a}	420.17^{b}	360.33^{c}	351.84^{c}	317.67^{d}	331.84^{d}	9.471	0.0695	0.4679	<0.0001	0.1698
% BWC, %	4.08	3.89	3.03	3.09	2.73	2.80					
DMI, Kg/LW											
BFI, Kg/LW	40.83^{a}	38.95^{b}	17.47^{c}	16.80^{c}	17.09^{c}	15.92^{c}	0.915	0.3179	0.1110	<0.0001	0.8052
SFI, Kg/LW	-	-	12.86^{a}	14.17^{b}	10.29^{c}	12.07^{ad}	0.412	0.5892	0.0061	<0.0001	0.1074
TOTINT,Kg/LW	40.83^{a}	38.95^{a}	30.33^{c}	30.97^{c}	27.38^{d}	27.99^{d}	0.997	0.2440	0.7960	<0.0001	0.3673
FCR (F:G)	50.45^{a}	53.45^{a}	20.85^{b}	23.17^{b}	20.21^{b}	18.38^{b}	3.737	0.2019	0.7075	<0.0001	0.7851

[abc]*Means in each row with different alphabets are significantly different* ***(P<0.05)***.
Where ***SEM: Standard error of mean****; **AM** = Amantin;* ***AT = Atebubu;*** *BFI = basal diet intake; SFI = supplement feed intake;* ***TOTINT*** *= Total feed intake;* ***ADG*** *(g/d) = average daily gain in grams per day,* ***FCR*** *=Feed Conversion ratio (Feed:Gain).* ***T1= Treatment 1 (base only); T2 = Treatment 2 (base supplemented with cowpea residues); T3 = Treatment 3 (base supplemented with groundnut residues); % BWC =*** *Percentage Body weight consumed. LOC=Location effect; FEED=Feed effect; LOC*FEED=Location by feed interaction.*

4.7.1. Dry matter intake of goats

Feed type significantly affected the basal feed intake (BFI; P <0.0001), Supplemental feed intake (SFI; P <0.0001) and Total feed intake (TFI; P <0.0001) of goats. BFI and TFI were high for sheep on T1 and lowest for T3. SFI was however high in T2 than T3. Locational effect was not significant for TFI in g/day (P = 0.4697) and TFI per kilogram liveweight (P = 0.7960) but was significant for BFI (P = 0.0355), SFI (P = 0.0162) and the supplemental feed intake per kilogram liveweight (P = 0.0061) for goats. There was no interaction between location and feed for BFI (P = 0.7587), SFI (P = 0.0800) and TFI (P = 0.1698) of goats. Similar interactions were observed with the feed intakes per kilogram liveweight of goats. The differences in the feed intake of goats might be attributed to the nutrient composition and palatability of the feed offered.

Total DM intake was highest in T1 and lowest in T3. The values for Total DMI for goats in both communities (317.67- 443.00 g/day and 331.84 – 420.17g/day for Amantin and Atebubu respectively) were similar to the 360.83-402.84g/day and 442-449g/day obtained by Fasae *et al*. (2011) and Ondiek *et al*. (2013) respectively. They were however higher than the 288.48311.25g/day reported by Asaolu *et al*. (2012) and this might be due to breed differences, palatability and nutrient composition of the various feed combinations.

With the DMI of supplements among goats, significant differences (P<0.05) existed between T2 and T3 in both communities. Significant differences (p<0.05) were also observed in the DMI of basal feed between treatments in Amantin and Atebubu. There was however no differences

(P>0.05) in the basal feed intake of goats on T2 in Atebubu and T3 in Amantin and between T2 and T3 within Atebubu. Similar differences (P<0.05) were observed in the DMI of supplements and base when Asaolu *et al*. (2012) supplemented a basal diet of cassava peels with dried *Moringa oleifera*, *Leucaena leucocephala* and *Gliricidia sepium* forages for West African Dwarf Goats. Ondiek *et al*. (2013) also observed significant differences (P<0.05) in supplemental and basal feed intakes when they fed East African goats with a basal diet of maize stover supplemented with *Balanites aegyptiaca* and *Acacia tortilis* leaf forages.

Feed type significantly affected the basal feed intake per kilogram liveweight (P <0.0001) of goats. Locational effect on basal feed intake per kilogram liveweight was not significant (P =

0. 1110). No interaction (P = 0.8052) also existed between the feed and location of study. No Significant differences were observed in the basal feed intake between T1 and T2 and T3. No differences were observed between T2 and T3. Yousuf *et al*. (2007) also observed no differences (P> 0.05) in the basal feed intake of goats by when they supplemented *Panicum maximum* with graded levels of cassava, *leucaena* and *glyricidia* leaf meals for goats. No differences (P > 0.05) were also observed by Baiden *et al*. (2007) in the basal feed intakes of goats with cassava pulp as supplements.

Basal feed intakes per kilogram liveweight were lowest for goats on T3 in Atebubu and highest for goats on T1 in Amantin. Basal feed intakes for goats were higher in Amantin than in Atebubu. The basal feed intakes recorded for goats in this study was higher than the 11.8 12.35g/KgLW/day recorded by Baiden *et al*. (2007) and that for T2 and T3 similar to the 15.3-

16.59 g/KgLW/day by Yousuf *et al*. (2007).

Feed type significantly affected the supplemental feed intake per kilogram liveweight (P <0.0001) of goats. Locational effect was significant for supplemental feed intake per kilogram liveweight (P = 0.0061) for goats. No interaction (P = 0.8052) however existed between the feed and location of study. Supplemental feed intake per kilogram liveweight of goats was highest in Atebubu than in Amantin. The higher supplemental feed intakes in Atebubu could be attributed to the high crude protein contents and palatability of the supplements used. Significant differences (P<0.05) in the intake of supplemental feed per kilogram liveweight were observed amongst all goats on T2 and T3 in both communities. Supplemental feed intake per kilogram liveweight of goats was lowest for T3 in Amantin and highest for T2 in Atebubu. The values for supplemental feed intakes per kilogram liveweight of goats for both communities (10.29- 12.86 and 12.07-14.17 g/KgLW/day for Amantin and Atebubu respectively) were lower than the 19.5820.82 g/Kg/LW/day reported by Baiden *et al*. (2007) for concentrates as supplements to cassava pulp mainly because of the high crude protein and energy levels of the concentrates used as supplements. They were however higher than the 8.55- 10.03 g/KgLW/day reported by Yousuf *et al*. (2007) who supplemented *Panicum maximum* with graded levels of cassava, *leucaena* and *glirincidia* leaf meals.

Feed type significantly affected the total feed intake per kilogram liveweight (P <0.0001) of goats. Locational effect was not significant for total feed intake per kilogram liveweight (P = 0.7960) for goats. No interaction (P = 0.7851) existed between the feed and location of study.

Total feed intakes were high for goats on T1 in than T2 and T3. No differences (P>0.05) in TFI/KgLW were observed between T2 and T3 in both communities. Mean total feed intake per kilogram liveweight of the goats ranged from 27.38 to 40.83 g/day/kg LW in both communities. The total feed intake for goats obtained in this study was higher than the reported range of 19-29 g/KgLW/day and 24.08-26.57 g/KgLW/day reported by Yousuf *et al*. (2007) and Aboud *et al*. (1993) but similar to the 31.94-32.66 g/KgLW/day reported by Baiden *et al*. (2007) for goats fed various crop residues based diets to goats. The Total feed intakes recorded for goats in this study was three times as high as the 11.8 -12.35g/KgLW/day recorded by Baiden *et al*. (2007) and twice as high as the 15.3-16.59 g/KgLW/day by Yousuf *et al*. (2007). The high total feed intakes in the study compared to other works could be attributed to the improvement in the nutrient composition of feed as a result of supplementation. Mtega & Shoo (1990) reported a positive correlation between crude protein content of feeds and dry matter intake.

4.8. Final weight and weight gain of goats

Feed type significantly affected the weight gain of goats ($P < 0.0001$). Locational effect was however not significant ($P = 0.9008$) in terms of weight gain by goat. Final weight and weight gains were higher for goats on T3 and lowest for T1. No significant interaction existed between the feed and location for the weight gain of goats ($P = 0.2557$). Fasae *et al*. (2011) reported no significant differences (P>0.05) in final weights of goats when he supplemented maize residues with leucaena. Isah *et al*. (2013) also reported significant differences (P<0.05) in final weights of goats in a study using *Pennisetum purpureum* and other browse forages.

Feed type significantly affected the average daily gain (ADG) of goats ($P < 0.0001$). Average daily gains were higher for goats on T3 and lowest for T1. The gain in weights could be due to increased availability of energy and protein from the supplements offered which allows for more microbial population growth and therefore more basal ration (roughage) digestion and ultimately more provision of protein and energy to the animals (Safari *et al*., 2011). Locational effect was however not significant for the ADG of goat ($P = 0.9001$). No significant interaction as a result, existed between the feed and location for the ADG of goats ($P = 0.2559$).

Animals on all treatments gained more liveweight. Significant differences ($P<0.05$) in average daily gain amongst goats on T2 and T3 were observed. ADG was almost twice as high in T2 and T3 than in T1. This indicates that the supplements had a positive influence on the weight of goats. The ADG values for goats agreed with the range of 14.64-29.19g/day reported by Isah *et al*. (2013) when they supplemented cassava peels and *Pennisetum purpureum* with different forages for goat. Asaolu *et al*. 2012 also recorded a similar range of ADGs (14.88 to 21.43 g/day) for West African Dwarf goats offered supplements of dried *Moringa oleifera*, *Leucaena leucocephala* and *Gliricidia sepium* forages to a basal diet of cassava peels.

Higher range (23.81-44.64g/day) was however reported by Ajayi *et al*. (2005) for West African Dwarf goats fed Mango (*Mangifera indica),* Ficus *(Ficus thionningii),* Gliricidia *(Gliricidia sepium),* foliages and Concentrates as Supplements to Basal Diet of Guinea Grass (*Panicum maximum*). Fasae *et al*. (2011) also reported higher (24.30-44.03g/day) average daily gains when they supplemented maize residues and with leucaena leaf for goats. The observed differences in growth rates with earlier studies could have been due to differences in the basal components of the diets, voluntary dry matter intake, efficiency of feed utilization and the physiological state of the animals. The higher growth rates of the animals on the T2 and T3 supplements in this study could be ascribed to their more efficient utilization by the animals as indicated by their lower feed conversion ratios

4.9. Feed conversion ratio (FCR) of goats

The type of feed‘s influence on FCR was significant ($P < 0.0001$) for goats reared by farmers in the two locations. Locational effect was not significant ($P = 0.7075$) for the FCR of goats. No significant interaction ($P = 0.7851$) as a result, existed between the feed and location for the FCR of goats. From the results, goats on T1 recorded the highest ratios of 50.45 and 53.45 indicating they were highly inefficient in converting feed consumed into liveweight gain. On the other hand, goats on T3 had the least ratios of 20.21 and 18.38 indicating that goats on T3 were effective in converting the feed they consumed into liveweight gain.

Significant differences in the FCR of goats between T1, T2 and T3 were observed. Similar differences ($P<0.05$) in FCR of goats were observed by Asaolu *et al*. (2012) for West African Dwarf goats offered supplements of dried *Moringa oleifera*, *Leucaena leucocephala* and *Gliricidia sepium* forages to a basal diet of cassava peels. With the exception of The FCR values for goat on T1 which was higher, those for the goats on T2 and T3 were lower than the range of 31.7-37.36 reported by Isah *et al*.(2013) when they supplemented cassava peels and *Pennisetum purpureum* with different forages for goat. Asaolu *et al*. (2012) also reported lower range of FCR

(14.88 to 16.54) for West African Dwarf goats offered supplements of dried *Moringa oleifera*, *Leucaena leucocephala* and *Gliricidia sepium* forages to a basal diet of cassava peels. Under grazing conditions, Hossain *et al*. (2003) also reported a lower range (6.84-10.84) of FCR for goats. The low FCR due obtained compared to other studies could be attributed to the high digestibility and crude protein content of the supplements thus providing sufficient fermentable nitrogen to ensure optimal microbial growth in the rumen. This, together with possible by-pass protein from the supplement will enhance the production of body tissues as reported by Leng (1990). The opposite thus occur for high FCR.

4.10. Quality of sheep manure

The weight and quality of Manure from sheep in both communities is presented in Tables 4.6. Feed type significantly affected the % Carbon (P=0.0003), % Nitrogen (P=0.0180), Carbon to Nitrogen (C/N) ratio (P<0.0001), % Potassium (P=0.0050) and weight of manure produced by sheep (P =0.0128). Feed type however did not significantly affect pH (P=0.7178) and Ash content of the manure produced by sheep (P=0.2355). Nitrogen and Potassium contents of sheep manure were higher in T2 and T3 than in T1. The high N contents of T2 and T3 could be attributed to the high crude protein contents in the supplements used in those treatments. Carbon contents and C:N ratio of sheep manure was higher for sheep on T1 than T2 and T3. The higher C: N ratio of T1 could be attributed to the generally low crude protein contents of basal diet hence reduced nitrogen. The Locational effect tended to approach significance for weight of Manure produced by sheep (P = 0.0636) but was significant for % Carbon (P=0.0288), Carbon to Nitrogen ratio (P=0.0188), pH (P=0.0009), Potassium (P<0.0001) and ash (P=0.0135) content of manure produced by sheep. Location however had no effect on the nitrogen content of sheep manure. An interaction existed between the feed and location for Nitrogen (P=0.0021), ash (P=0.0009) and Potassium content (P=0.0106) as well as pH (P=0.0001) of manure produced by sheep. No Location by feed interaction existed for weight (P=0.0602), carbon (P=0.1737) and

C:N ratio (P=0.0630) of manure produced by sheep in the two locations.

TABLE 4.6. Weight and quality of Sheep manure in Atebubu and Amantin

TREATMENTS	T1		T2		T3		SIGNIFICANCE				
	AM	**AT**	**AM**	**AT**	**AM**	**AT**					
No. of Animals	**6**	**6**	**6**	**6**	**6**	**6**	**SEM**	**REP**	**LOC**	**FEED**	**LOC*FEED**
MWT, g	392.17^{ac}	377.67^{a}	319.17^{b}	391.00^{ac}	399.00^{ac}	423.33^{c}	16.974	0.2201	0.0636	0.0128	0.0602
Carbon,%	28.29^{ad}	29.01^{a}	20.74^{b}	25.44^{c}	25.89^{c}	26.97^{cd}	1.125	0.9529	0.0288	0.0003	0.1737
Nitrogen,%	1.87^{a}	1.91^{a}	1.89^{a}	2.32^{b}	2.15^{b}	1.98^{a}	0.074	0.5888	0.1113	0.0180	0.0021
C:N ratio	15.13^{a}	15.53^{a}	10.95^{b}	10.98^{b}	12.05^{c}	13.61^{d}	0.317	0.0025	0.0188	<0.0001	0.0630
pH,	0.45^{a}	0.68^{b}	0.44^{a}	0.77^{b}	0.64^{b}	0.51^{a}	0.046	0.1483	0.0009	0.7178	0.0001
K,%	0.77^{a}	2.30^{b}	1.35^{c}	3.00^{d}	1.66^{c}	2.23^{b}	0.174	0.0202	<0.0001	0.0050	0.0106
Ash, %	14.50^{a}	20.97^{b}	26.50^{c}	9.52^{d}	25.25^{c}	18.45^{ab}	2.607	0.9969	0.0135	0.2355	0.0009

^{abc}*Means in each row with different alphabets are significantly different* ***(P<0.05)***.
Where Where ***SEM: Standard error of mean****; AM = Amantin;* ***AT = Atebubu; MWT****=Manure weight;* ***C: N*** *ratio=Carbon to Nitrogen ratio; pH= Acidity of manure;* ***T1= Treatment 1 (base only); T2 = Treatment 2 (base supplemented with cowpea residues); T3 = Treatment 3 (base supplemented with groundnut residues); % BWC =*** *Percentage Body weight consumed. LOC=Location effect; FEED=Feed effect; LOC*FEED=Location by feed interaction.*

No significant differences (P>0.05) were observed in the weights of manure produced by sheep for T1 and T2 in Atebubu and T1 and T3 in Amantin. Irungu *et al*. (2005) also observed no significant differences (P>0.05) when they measured the amount of manure produced by sheep fed three cultivars of Sweet potato vines. The values obtained in our study, was generally, similar to those (430.9-457.8g/day) obtained by Irungu *et al*. (2005). Significant differences (P<0.05) were however observed in the % Carbon of sheep manure between T1, T2 and T3 in Atebubu and Amantin. The differences in Carbon content of manure could be attributed to the nature of the feed and level of degradability. Similar differences (P<0.05) were also observed in the Total Nitrogen Content of sheep manure between T3 and the rest of the treatments in Amantin. For Ttotal Nitrogen of manure in Atebubu, significant differences were observed between all treatments. The differences in N content of manure between treatments could be due to the differences in digestibility and crude protein contents of feed, amount of urine and feed refusals combined with faeces, the level of leaching and volatilization of ammonia (lower in soils with low pH). Although there were significant differences (P<0.05) in pH of sheep manure in Atebubu, it was observed that manure produced from all the farms were highly acidic which is in agreement with the assertion made by KATC (2004) that fresh manure is acidic. Significant differences (P<0.05) were observed in the Ash contents of manure produced by sheep in Atebubu.

Significant differences (P<0.05) were also observed in the % K and ash of sheep manure amongst all treatments in both communities and this could be attributed to the rate of leaching and losses through urine (Kimani and Lekasi, 2004). The sheep on all treatments in both Atebubu and Amantin also had a C: N ratio of 10.95-15.53 which was lower than the critical C: N ratio of 20 reported by PPI (1983) below which net mineralization would readily occur when applied on soils.

4.11. Quality of goat manure

The weight and quality of Manure of goats in both communities is presented in Tables 4.7. Feed type significantly affected the % Carbon (P<0.0001), %Nitrogen (P=0.0002), Carbon to Nitrogen (C/N) ratio (P<0.0001) and % ash (P=0.0167) contents of manure produced by goats. Feed type however did not significantly affect pH (P=0.3562), % Potassium (P=0.1202) and weight (P=5195) of the manure produced by goats in the two locations. Weight of goat manure was higher in T1 than T2 and T3. Nitrogen content of goat manure was higher in T2 and T3 than in T1. The high N contents of T2 and T3 could be attributed to the high crude protein contents in the supplements used in those treatments. Carbon contents and C:N ratio of goat manure was higher for sheep on T1 than T2 and T3. The higher C: N ratio of T1 could be attributed to the generally low crude protein contents of basal diet hence reduced nitrogen content. Ash, K and pH were all higher in T2 than T1 and T3. Location had an effect on the C:N ratio (P=0.0188), Potassium (P=0.0417) and ash (P=0.0082) content of manure produced by goats but had little effect on % Nitrogen (P=0.1829), % Carbon (P=0.4516), pH (P=0.1390) and weight (P = 0.9581) of Manure produced by goats. With the exception of the C:N ratio of goat manure which was generally higher in Amantin, the weight as well as the Carbon, Nitrogen, Potassium, Ash, C:N ratio and pH of manure produced by goat was generally higher in Atebubu than in Amantin. An interaction existed between the feed and location for weight (P=0.0052) of manure produced by goats. No Location by feed interaction existed for Nitrogen (P=0.0826), ash (P=0.4984), Carbon (P=0.2018) and Potassium content (P=0.1687) as well as of pH (P=0.5753) and C:N ratio

(P=0.3506) of manure produced by goats in the two locations. Significant differences (P< 0.05) were observed in the weights of manure produced by goats on T1, T2 and T3 in Atebubu and Amantin. Similar differences (P<0.05) were observed by Saha *et al*. (2008) when they evaluated manure from goats fed *Panicum* basal diet, supplemented with madras thorn, Leucaena and Glirincidia. The weights obtained in our study were also higher than the 91.67-150.00 obtained by Saha *et al*. (2008).

TABLE 4.7: Weight and quality of Goat manure in Atebubu and Amantin

	TREATMENTS										
	T1		T2		T3						
	AM	AT	AM	AT	AM	AT					
No. of Animals	6	6	6	6	6	6	SEM	REP	LOC	FEED	LOC*FEED
MWT, g	209.67[a]	207.50[a]	178.67[b]	218.33[a]	216.17[a]	180.00[b]	10.220	0.4318	0.9581	0.5195	0.0052
Carbon,%	30.16[a]	30.61[a]	25.10[b]	25.77[b]	23.04[c]	19.58[d]	1.247	0.4424	0.4516	<0.0001	0.2018
Nitrogen,%	1.56[a]	1.83[b]	1.96[bc]	2.14[cd]	2.21[d]	2.07[cd]	0.091	0.9987	0.1829	0.0002	0.0826
C:N ratio	19.92[a]	16.64[b]	12.90[c]	12.04[c]	10.44[d]	9.49[d]	0.924	0.4347	0.0360	<0.0001	0.3506
pH,	0.37[a]	0.61[a]	0.50[a]	1.47[b]	0.37[a]	0.62[a]	0.390	0.6249	0.1390	0.3562	0.5753
K,%	0.82[a]	2.29[a]	1.47[a]	8.33[b]	1.52[a]	2.23[a]	1.700	0.5278	0.0417	0.1202	0.1687
Ash, %	10.75[a]	16.50[b]	18.00[b]	19.80[b]	12.25[a]	17.25[b]	1.747	0.9402	0.0082	0.0167	0.4984

[abc]Means in each row with different alphabets are significantly different ***(P<0.05)***.

Where Where ***SEM: Standard error of mean****; **AM** = Amantin;* ***AT = Atebubu; MWT****=Manure weight;* ***C: N*** *ratio=Carbon to Nitrogen ratio; pH= Acidity of manure;* ***T1= Treatment 1 (base only); T2 = Treatment 2 (base supplemented with cowpea residues); T3 = Treatment 3 (base supplemented with groundnut residues); % BWC =*** *Percentage Body weight consumed. LOC=Location effect; FEED=Feed effect; LOC*FEED=Location by feed interaction.*

Significant differences (P<0.05) were also observed in the % C, N, pH, K and ash of goat manure amongst all treatments in both communities. The nitrogen content of the manure varied (P<0.05) amongst treatments and was highest for T3 in both Amantin. Manure from goats on T1 in both communities had the highest C: N ratio of 16.64 and 19.92 for Atebubu and Amantin respectively. This indicates that all manure of goats from will readily cause net Nitrogen mineralization if applied directly on soils.

The range of values of Carbon (23.04-30.16 % and 23.04-30.61% for Amantin and Atebubu respectively) and Total Nitrogen (1.83-2.14% and 156-2.21% for Atebubu and Amantin respectively) were similar to the 26.4- 38.1% organic carbon and 1.4 - 2.3% Total Nitrogen reported by Moral *et al*. (2005) for goat manure. Also a general assessment of the potassium (K) values obtained in our study indicates that the values obtained for goats in Amantin is lower than the 2.4% reported by Kausar (1983) for goat manures in the tropics. The range of values for K in Atebubu was however higher.

The chemical composition of the manure generated by both sheep and goats showed that they can be used as a substitute or alternative for relatively expensive inorganic fertilizers for amending poor soils in rural communities.

CHAPTER FIVE

5.0. CONCLUSIONS AND RECOMMENDATIONS

5.1. CONCLUSIONS

The results of the study showed that locally available feed resources compares in nutrient compositions to other conventional feeds like maize. However, it was evident that the animals consumed more of the feed to put on weights lesser than those found in literature. Feed type significantly affected intakes of both sheep and goats in both communities. Supplementation with groundnut and cowpea residues resulted in improved weight gains of animals.

The results obtained indicate that low quality sheep and goat feed can be supplemented with cowpea and groundnut residues for dry season feeding without any detrimental effects on the liveweight of sheep and goats.

Crude protein content of cowpea and groundnut residues after storage was similar to the level required for moderate ruminant production thereby suggesting that when available in adequate amounts in the study areas (Atebubu and Amantin) during the cropping season, they can be stored for dry season feeding of ruminants without dramatic losses in crude protein.

The fertilizer value of sheep and goat manure is comparable to nitrogen, potassium and carbon values in inorganic fertilizers commonly used in Ghana indicating their potential role in amending soils of declining fertility.

5.2. RECOMMENDATIONS

Carcass, serum biochemical and haematological analysis of sheep and goat fed crop residue based diets should be carried out to determine whether there is an unusual deposition of fat or disease condition in the body that may threaten meat quality.

Since the residues stored using the open and closed/shed systems retained most of the crude protein over a long period, they can be adopted during the major season of crop harvest, where fodder is available in larger quantities, to store fodder for dry season feeding where fodder is limiting both in quantity and quality.

Since farmers left most of the leguminous fodder on the field because of difficulties in transportation, strategies like box baling would be recommended to ease transporting as well as storage of these residues.

The chemical composition of the manure generated by both sheep and goats showed that they can be used as a substitute or alternative for relatively expensive inorganic fertilizers for amending soils of in rural communities.

REFERENCES

Aboud, A. A. O., Owen, E., Said, A. N., Gill, M. and McAllan, A. B. (1993). Feeding sorghum stover to Ethiopian goats and sheep: effect of amount offered on intake, selection and performance. In *Animal production in developing countries* (ed. M. Gill, E. Owen, G. E. Pollott and T. L. J. Lawrence), British Society of Animal Production occasional publication no. 16, pp. 202-203.

Addass, P.A., Nyako, H.D., Agga, D.P., Mohammed, I.D., Midau A., Fintan, J.S. and. Ja'afar-Furo, M.R. (2011). Nutrients evaluation of some common feed resources for cost effective feeding of ruminants in Mubi, Nigeria. Agric. Biol. J. N. Am., 2(1): 15-18.

Adebowale, E. A. and Taiwo, A.A. (1996). Utilization of crop resources and agro-industrial byproducts as complete diets for West African Dwarf sheep and goats. Nig. J. Anim. Prod., **23**(1): 153-160.

Adebowale, E.A. (1985). Organic waste ash as possible source of alkali for animal feed treatment. Anim. Feed Sci. Technol., 13: 237-248.

Adebowale, E.A. (1988). An overview of recent trends and developments in the use of unconventional feed ingredients for ruminant animals: applicability to the Nigerian conditions. Proceedings of National Workshop on Alternative Formulations of Livestock Feeds in Nigeria, organized by the Economic Affairs Office, The Presidency, held at ARMTI, Ilorin, 21-25 November 1988, pp. 544-578.

Ademosun, A.A. (1993). The Scope for Improved Small Ruminant Production in the Humid Zone of West and Central Africa: The Approach of the West African Dwarf Goat Project. In: Ayeni, A.O. and Bosman, H.G., Eds.,Goat Produc- tion Systems in the Humid Tropics, Pudoc Scientific Publishers, Wageningen, pp. 2-13.

Adeyanju, S.A., Oguntuga, D.B.A., Illori, J.O. and Adegbola, A.A. (1975). Cocoa pod in maintenance rations for sheep and goats in the tropics. Nutr. Rep. Intl., 11:351–357.

Adu, I.F. and Brinckman, W.L. (1981). Feedlot performance and carcass characteristics of sheep fed varying concentrate levels. J. Anim. Prod. Res. 1(1): 1-12.

Adu, I.F. and Lakpini, G.A.M., (1983). Effect of feeding chopped and unchopped groundnut haulm on nutrient utilization and the production of some rumen metabolites in yankasa lambs. Nig. J. Anim. Prod. 10, 110-113.

Adu, **I.F. and Ngere, L.O. (1979).** The indigenous sheep of Nigeria. World. Rev. Anim. Prod. 15(3):51–62.

Aggarwal, R.K., Praveen, K. and Power, J.F. (1997). Use of crop residue and manure to conserve water and enhance nutrient availability and pearl millet yield in an arid tropical region. Soil and Tillage **4,** 43-51.

Aguilera, J.F. (1989). Use of Agro-industiral by-products in the feeding of ruminants. Revista Argentina de production animal, 9: 253–67.

Ahaotu, E.O., Uwalaka, R.E. and Ihezuo, J.P. (2013). Enhancing maize stover utilization by West African Dwarf Sheep using *Moringa oleifera*. Inter J Agri Biosci, 2(4): 153-155.

Ajayi, D.A., Adeneye J.A. and Ajayi F.T. (2005). Intake and nutrient utilization of West African Dwarf Goats fed mango (*Mangifera indica),* ficus *(Ficus thionningii),* gliricidia *(Gliricidia sepium)* foliages and concentrates as supplements to basal diet of guinea grass (*Panicum maximum*). World Journal of Agricultural Sciences 1 (2): 184-189.

Aletor, V.A. (1986). Some agro-industrial by-products and ―wastes‖ in livestock feeding: A review of prospects and problems. Wld. Rev. Anim. Prod., 22:35-41.

Alhassan, W.S. and Akorfur, V.A. (1982). Influence of oil palm slurry on the digestibility of rice straw by sheep. J. Anim. Prod. Res. 2: 81–89.

Alhassan, W.S., Ehoche, O.W., Adu I.F. and Obilana, A.T. (1984). Crop residue potential of Agricultural Development Projects: Nutritive value and residue management. 1984 Nigeria Animal Production Research Institute Animal Report, Shika, Zara Nigeria, pp 35-45.

Alli-Balogun, **J.K., Lakpini, G.A.M., Alawa, J.P., Muhammed A. and Nwanta, J.A. (2003).** Evaluation of cassava foliage as a protein supplement for sheep. Nig. J. Anim. Prod., 30: 37-46.

Amaning-Kwarteng, K. (1991). Sustainable dry season feeding of ruminants in Ghana. The use of crop residues and leguminous shrubs as feed stuffs. In: The complementarity of feed resources for animal production in Africa. Proceedings of the Joint Feed Resources Networks workshop held in Gaborone, Botswana 4-8 March 1991.

Amata, I.A. (2014). The use of non-conventional feed resources (NCFR) for livestock feeding in the tropics: a review**.** Journal of Global Biosciences, 3(2): 604-613.

Anandan, **S., Khan, A. A., Ravi, D., Jeethander Reddy. and Blummel, M. (2010).** A comparison of sorghum stover based complete feed blocks with a conventional feeding practice in a peri-urban dairy. Animal Nutrition and Feed Technology, 10: 23-28.

Annor, S. Y., Djang-Fordjour K.T. and Gyanfi, K.A. (2007). Is growth rate more important than survival and reproduction in sheep farming in Ghana? Journal of Science and Technology, 27 (3): 23-31.

Antwi, C., Osafo, E.L.K., Fisher, D.S., Yacout, H.M., Hassan, A.A., and Adu-Dapaah, H. (2011). Storage practices and their effect on nutrient and haulm availability of four dual-purpose cultivars of cowpea (*Vigna unguiculata* L.walp) haulm. Ghanaian Journal of Animal Science, 5(2): 1-9.

AOAC (Association of Official Analytical Chemists), (2002). Official Methods of Analysis, 17th Edition. AOAC: Washington, D.C.

ARC (Agricultural Research Council). (1980). The Nutrient Requirements of Ruminant Livestock. Commonwealth Agricultural Bureaux, Slough, England.

Aregheore, E. M (1998). Application of biotechnology to improve feed resources for ruminant livestock nutrition in the South Pacific. Journal of South Pacific Agriculture 15(2): 31 -38.

Aregheore, E.M. (2000) Crop Residues and Agro-industrial By-products in Four Pacific Island Countries: Availability, Utilisation and Potential Value in Ruminant Nutrition. Asian-Aus. J. Anim. Sci. 13: 266-269.

Asaolu, V., Binuomote, R., Akinlade J., Aderinola O. and Oyeniyi Oyolami, O. (2012). Intake and Growth Performance of West African Dwarf Goats Fed *Moringa oleifera*, *Gliricidia sepium* and *Leucaena leucocephala* Dried Leaves as Supplements to Cassava Peels. Journal of Biology, Agriculture and Healthcare. 2,(10): 76-88.

Avornyo, F., Karbo, N. and Addo–Kwarfo, A. (2001). The performance of sheep fed fonio or rice straw in combination with two levels of whole cotton seed. Bulletin of Animal Health and Production of Africa, 49: 300-307.

Baah, J., Tuah, A.K., Addah, W., and Tait R.M. (2012). Small ruminant production characteristics in urban households in Ghana. Livestock Research for Rural Development. Volume 24, Article #86.http:// www.lrrd.org/lrrd24/5/ baah24086.htm. Retrieved 21 July, 2012.

Baiden, R. Y., Rhule S. W. A.,Otsyina, H. R., Sottie, E. T. and Ameleke, G. (2007). Performance of West African Dwarf sheep and goats fed varying levels of cassava pulp as a replacement for cassava peels. Livestock Research for Rural Development, 19 (35).

Baiden, R.Y. and Obese, F.Y., (2010). Performance of West African Dwarf Sheep (The Djallonké) fed fattening diets containing Agro-industrial By-products in Ghana. Ghanaian Journal of Animal science, 5(1): 60-65.

Bationo, A., Nandwa, S.M., Kimetu, J.M., Kinyangi, J.M., Bado, B.V., Lompo, F., Kimani, S., Kihanda, F. and Koala, S. (2004). Sustainable intensification of crop-livestock systems through manure management in eastern and western Africa: lessons learned and emerging research opportunities. In:Williams, T.O., Tarawali, S., Hiernaux, P., Fernandez- Rivera, S. (Eds.), Proceedings of the International Conference on Sustainable Crop-livestock Production for Improved Livelihoods and Natural Resource Management in West Africa. International Livestock Research Institute, Addis Abeba, Ethiopia, pp. 173–198.

Bello, A.A., and Tsado, D.N. (2013). Feed intake and nutrient digestibility of growing yankasa rams fed sorghum stover supplemented with graded levels of dried poultry droppings based diet. Asian Journal of Animal Sciences, 7: 56-63.

Ben Salem, H., Nefzaoui, A. and Makkar, H.P.S. (2004). Towards better utilization of nonconventional feed resources by sheep and goats in some African and Asian countries. In: Nutrition and feeding strategies of sheep and goats under harsh climates. Proceedings of the Ninth Seminar of the Sub-Network on Nutrition of the FAO-CIHEAM Inter-Regional Cooperative Research and Development Network on Sheep and Goats, Hammamet (Tunisia), 810 Nov 2001. pp. 177–187.

Benerjee, G.C. (1993). Animal Husbandry. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi.

Bhatti, M.B. and Khan, S. (1996). Fodder Production in Pakistan. FAO PARC, Islamabad.

Blench, R. (1999). Traditional Livestock Breeds: Geographical Distribution and Dynamics in Relation to the Ecology of West Africa. Working Paper 122, Overseas Development Institute (ODI), London.

Bosso, N.A., Cissé, M.F., van der Waaij, E.H., Falla, A. and van Arendonk, J.A.M. (2007). Genetic and Phenotypic Parameters of Body Weight in West African Dwarf Goat and Djallonké Sheep. Small Ruminant Research, 67, 271-278.

Botha, C.J. and Penrith, M.L. (2008). Poisonous plants of veterinary and human importance in southern Africa. Journal of Ethnopharmacology 119:549–558.

Bristow, A.W., Whitehead, D.C. and Cockburn, J.E. (1992). Nitrogenous constituents in the urine of cattle, sheep and goats. *Journal of the Science of Food and Agriculture* 59: 387-394.

Calzada, J.F., Franco, L.F., De Arriola, M.C. (1987). Acceptability, body weight changes and digestibility of spent wheat straw after harvesting of *Pleurotus sajorcaju*. Biol. Wastes. 22:303309.

Camara, O.S. (1996). Utilisation des residus de reacolte et du fumier dans le Cercle de Koutiala: Bilan des elements nutritifs et analyse eÂconomique. Rapport PSS 18. AB-DLO, Wageningen, the Netherlands. pp. 140

Chadhokar, P.A. (1984). Non-conventional feed resources for livestock in soil and water conservation program. Community Forestry and Soil Conservation Development Department, Ministry of Agric. FAO. Adis-Ababa, Ethiopia.

Chadwick, D.R. (2005) Emissions of ammonia, nitrous oxide and methane from cattle manure heaps: effect of compaction and covering. Atmospheric Environment 39, 787-799.

Chandiramani, M., Jones, J. and Kosina, P. (2007). Crop residue management**.** Cereal Knowledge Bank**,** CIMMYT and IRRI. http:/Knowledgebank.irri.org/ckb/agronomy-wheat/cropresidue-management.html.

Charray, J., Humbert, J. M. and Levifi, J. (1992). Manual of sheep production in the humid tropics of Africa. CAB International, Wallingford, U.K., pp. 92-114.

Chaturvedi, M.L., Singh, U.B. and Ranjhan, S.K. (1973). Effect of feeding water-soaked and dry wheat straw on feed intake, digestibility of nutrients and VFA production in growing zebu buffalo calves. J. Agric. Sci. Cambridge. 80: 393–397.

Chedly, K. and Lee, S. (1999) Silage from by-products for smallholders**.**In Mannetje, L.'t (Ed.), Silage Making in the Tropics with Particular Emphasis on Smallholders. Proceedings of the FAO Electronic Conference on Tropical Silage, FAO Plant Prod. And Protect. Paper 161. 1 Sept. – 15 Dec. 1999. Rome, Italy. Paper 3.0 :71-78.

Cheeke, P.R. (1991). Cereal milling by-products. In: Applied Animal Nutrition: Feeds and Feeding. Macmillan, New York, pp. 53-57.

Cheva-Isarakul, B. and Cheva-Isarakul, B. (1985). Variation in the nutritive value of rice straw in Northern Thailand: II. Voluntary feed intake and digestibility by sheep. In proceedings of International Workshop on Relevance of crop residues as animal feeds in developing countries (Eds. Wanapat and Devendra), Thailand,1985.

Coombe, **J.B., Dinius, D.A., Goering, H.K. and Oltjen, R.R. (1979).** Wheat straw-urea diets for beef steers: alkali treatment and supplementation with protein, momensin and a feed intake stimulant. J. Anim. Sci. 48: 1223–1233.

Cowan, T. (1999) Use of ensiled forages in large scale animal production systems. In Mannetje, L.'t (Ed.), Silage Making in the Tropics with Particular Emphasis on Smallholders. Proceedings of the FAO Electronic Conference on Tropical Silage, FAO Plant Prod. And Protect. Paper 161. 1 Sept. – 15 Dec. 1999. Rome, Italy. Paper 3.0 :31-39.

DAGRIS (2007). Domestic Animal Genetic Resources Information System (DAGRIS). General Breed Information for Djallonke Goats. http://dagris.ilri.org/display.asp? ID=803. Accessed 29 March, 2007.

Dechsel, P., Kunze, D. and Penning de Vries, F. (2004). Soil Nutrient Depletion and Population Growth in Sub-Saharan Africa: A Malthusian Nexus? Springer, Netherlands (Vol 22), [http://www.springerlink.com/content/u1l8x71325166654/]. Date retrieved 6TH March,2008.

Delve, R.J., Cadisch, G., Tanner, C., Thorpe, W., Thorne, P.J. and Giller, K.E. (2001). Implications of livestock feeding management on soil fertility in the smallholder farming systems of sub-Saharan Africa. Agriculture Ecosystems and Environment 84, 227-243.

Dettmers, A. and Hill, D.H. (1974). Animal breeding in Nigeria. In: First world congress on genetics applied to livestock production, Madrid. Volume 3. pp. 811-820.

Devendra, C. (1977). Cassava as a feed resource for Ruminants. In: Cassava as Animal feed. Nestle, B. and M. Grahan (Eds.). IDRC, Canada, pp: 107-119.

Devendra, C. (1983). Physical treatment of rice straw for goats and sheep and the response to substitution with variable levels of cassava (Manihot esculenta crantz), Leucaena (Leucaena leucocephala) and gliricidia (Gliricidia maculata) forages. MARDI Research Bulletin, 11: 272–290.

Devendra, C. (1985). Forage supplements: potential value of in-feeding systems based on crop residues and agro-industrial byproducts in South East Asia. Proc. Relevance of Crop Residues and Animal Feeds in Developing Countries. (Eds. Wanapat, M.and Devendra C.) Bangkok, Thailand, p. 221-248.

Devendra, C. (1988). Non-conventional feed resources and fibrous agricultural residues; Strategies for expanded utilization. Proceedings of a Consultation held in Hisar, India, 21-29 March 1988, IDRC, ICAR.

Devendra, C. and Burns, M. (1970). Goat Production in the Tropics. CAB, UK.

Devendra, C. and Mcleroy, G.B. (1982). Goat and Sheep Production in the Tropics. Intermediate Tropical Agricultural Series, Longman group Ltd. Harlow,Essex, UK. pp. 271.

Doyle, P.T., Pearce, G.R. and Egan, A.R. (1986). Potential of cereal straws in tropical and temperate regions. pp. 63-79. In: M.N.M. Ibrahim and J.B. Schiere, eds. Rice straw and related feeds in ruminant rations. Proceedings of an international workshop held in Kandy, Sri Lanka, 24-28 March 1986. Straw Utilization Project, Kandy, Sri Lanka.

Dumlao, C.T. and Perez Jr., C.B. (1976). Improving the feeding value of rice straw by calcium oxide treatment. Philippines. J. Vet. Anim. Sci. 2: 95–110.

Duru, M. and Colombani, H. (1992). Hay making: Risks and uncertainties in Central Pyreneen Grassland. Agricultural System 38 (2):185–207.

Economides, S. (1981). Paper presented at the FAO/UNDP Workshop on the Improved Utilization of Feed Resources for Sheep Fattening in the Near East. April, 1981, Amman. Jordan.

Economides, S. (1984). FAO European Cooperative Research Subnetwork meeting on Goat Production. 16–18, October, 1984. Grangeneuve, Switzerland.

El-Nouby, H.M. (1991). The role of by-products and Crop residues in SR production In: K.O. Adeniji (Ed). Proceedings of the Workshop on the improvement of Small Ruminants in North Africa, Cairo, Egypt 3-7, June, 1991. pp.189.

El-Shobkshy , A.S., James D.L.L., Marai , I. F. M., Owen , J.B. And Philips, C.J.C. (1989). New techniques in feed processing for cattle. In: C.J. Philips (Ed.), New techniques in cattle production. Buterworth And co. (Publishers)Ltd., pp 67 – 86.

Epstein, H. (1971). The Origin of the Domestic Animals of Africa. Africana Publication Corporation, New York, 214- 220.

Ezeocha V.C., Ojimelukwe, P.C. and Onwuka G.I. (2012). Effect of cooking on the nutritional and phytochemical components of trifoliate yam (*Dioscorea dumetorum*)**.** Global Advanced Research Journal of Biochemistry and Bioinformatics. 1(2): 26-30.

Fall, A., Diop, M., Sandford, J., Wissocq, Y.J., Durkin, J. and Trail, J.C.M. (1982). Evaluation of the productivities of Djallonke sheep and N'Dama cattle at the Centre de Recherches Zootechnique, Kolda, Senegal. Research Report No. 3. ILCA, Addis Ababa, Ethiopia.

FAO (Food and Agriculture Organization) (1999). ‗Yearbook of Fertilizers‘. Food and Agriculture Organization of the United Nations, Rome, Italy.

FAO (Food and Agriculture Organization) (2004). Scaling soil nutrient balances. FAO Fertilizer & Plant Nutrition Bulletin No. 15. Rome.

FAO (Food and Agriculture Organization) (2005). Fertilizer use by crop in Ghana. FAO Corporate Document Repository, Rome.

FAOSTAT (2008) FAOSTAT database. Accessible via FAO home page at http://faostat.fao.org/default.aspx. Food and Agriculture Organization.

Fasae, O. S., Adesope, A. I. and Ojo, V. O. A. (2011). The effect of leucaena leaf meal supplementation to maize residues on village goat performance. Journal of Animal and Plant Sciences, 2: 1276 – 1282.

Fasae, O.A., Adu, I.F., Aina, A.B.J. and Elemo, K.A. (2009). Production, defoliation and storage of cassava leaves as dry season forage for small ruminants in smallholder crop – livestock production system. Agricultura Tropica et Subtropica. 42 (1): 15-19.

Fasae, O. A., Emiola, O. S. and Adu, I. F. (2009). Production of manure from West African Dwarf Sheep. Archivos de Zootecnia, 58(1): 601-604

Fenning, J.O., Adjei-Gyapong, T., Ewusi-Mensah, N. and Safo, E.Y. (2010). Manure management, quality and mineraliztion for sustaining smallholder livelihoods in the Upper East region of Ghana. Journal of Science and Technology, 30 (2):1-10

Fischer, E. and Qaim, M. (2012). Linking smallholders to markets: determinants and impactsof farmer collective action in Kenya, World Development 40:1255-1268.

Fourie, N., Van der Lugt, J.J., Newsholme, S.J., Nel, P.W., (1987). Acute *Lantana camara* toxicity in cattle. Journal of the South AfricanVeterinary Association 58, 173–178.

Frohne, D. and H.J. Pfander. (1983). A Colour Atlas of Poisonous Plants: A Handbook for Pharmacists, Doctors, Toxicologist and Biologist. Wolfe Publishing Ltd., London, England. pp. 291.

Gall, C. (1996). Goat Breeds of the World. CTA—Margraf Verlag, Germany, 186 p.

Garba, M.G., Maigandib, S.A. and Muhammad I.R. (2012). Performance of Yankasa ram lambs fed graded levels of rice milling waste and soyabean meal residue combination in the semi-arid zone, Nigeria. Scientific Journal of Animal Science (2012) 1(4) 146-153

Gatenby, R. M. (2002). Sheep**: In:** A. J. Smith (ed).The tropical agriculturalist. 2nd Edn., Macmillan Publishers Ltd., CTA, London. Wageningen, The Netherlands. pp 32 – 33.

Gatenby, R.M. (1985). Sheep Production in the Tropics and Subtropics. Longman Group Ltd. Longman House, Harlow Essex, England. pp 56–57.

Gerner, H., Asante, G.H., Owusu-Bennoa, E.O. and Marfo, K. **(1995)**. Ghana privatization scheme, IFDC-Africa, Lomé.

Getachew, G., Makkar, H. P. S. and Becker,K. (2000). Effect of polyethylene glycol on in vitro degradability of Nitrogen and microbial protein synthesis from tannin rich browse and herbaceous legumes. Bri. J. Nutri. 84: 73-83.

Ghana Statistical Service (2010a). 2010 Population and Housing Census Enumerators' Manual. GSS, Accra, Ghana.

Ghana Statistical Service (2010b). 2010 National Analytical Report. GSS Accra, Ghana.

Ghana Statistical Service (2013). Regional Analytical Report, Brong Ahafo Region. GSS, Accra, Ghana.

Gicheru, P. (2012). An overview of soil fertility management, maintenance,and productivity in Kenya, Archiv. Agron. Soil Sci. 58(1):S22-S32.

Gihad, E.A., El-Badawy, T.M. and Mehrez, A.Z. (1980). Fiber digestion by goats and sheep. J. Dairy Sci., 63: 1701–1706.

Ginisty, L. (1976). Amelioration de la productivite des petits ruminants. In: Centre de Recherches Zootechniques de Minankro-Bouake. Rapport annuel succinct 1976. Ministere de la Recherche Scientifique, Bouake, Ivory Coast.

Giyinyu, B.M., Ahonsi, S.O. and Barau, M. (2005). Effects of different types of organic manure on growth and yield of tomato var. VFN. Proceeding of the 1st National Conference on organic Agriculture in Nigeria held. University of Agriculture. Abeokuta. Nigeria. 25th to 28th October, 2005. pp. 28.

Goosen, B. (1998). Sustainability of Small Ruminant Production in the Gambia with Special Reference to the Improved Husbandry of Trypanotolerant Sheep. Veterinary Parasitology, 79, 283-297.

Grandin, T. (ed.). (2007). Livestock handling and transport. 3rd Ed. CABI, Wallingford, UK. pp. 386.

Greenhalgh, J.F.D. (1984). Upgrading crop and agricultural by- products for animal production. In: Herbivore Nutrition in the Subtropics and Tropics. Eds. F. M. C. Gilchrist and R I Mackie. Science Press. Craighall. S. Africa.

Gregory, N. G. (1998). Animal welfare and meat science. CABI, Wallingford, UK. 298 pp.

Hendy, C.R.C. (1977). Animal Production in Kano State, Nigeria. Land Resource Report No. 21. Land Resource Division, Tolworth, UK.

Hennig, A., Leonhardt, J., Wolf, I., Flachowsky, G. and Bar, M. (1982). Nachweis des Strohaufschlusses mit gamma-Strahlen in vivo. Arch. Tierernahr 32: 789-795.

Hossain, M.E., Shahjalal, M., Khan, M.J. and Hasanat, M.S. (2003). Effect of dietary energy supplementation on feed intake, growth and reproductive performance of goats under grazing condition**.** Pakistan Journal of Nutrition 2 (3): 159-163.

Houpt, K. A. (2004). Behavioural physiology. In: Reece, W. O . (ed.). Dukes‘ Physiology of domestic animals. 12th Ed. Cornell Univ. Press, Ithaca, New York. pp. 952-961.

Huston, J. E. (1978). Forage utilization and nutrient requirements of the goat. Journal of Dairy Science. 61:988-993.

Ibrahim, M.N.M. and Pearce, G.R. (1983a). The effects of boiling and of steaming under pressure on the chemical composition and in-vitro digestibility of crop by-products. Agric. Wastes, 4: 443–452.

Ibrahim, M.N.M. and Pearce, G.R. (1983b). A soak-and-press method for the alkali treatment of fibrous crop residues. Laboratory studies on aspects of the procedure. Agric. Wastes, 8: 195–213.

Ifut, O.J. (1992). The potential of cassava peels for feeding goats in Nigeria. In: Hahn, S.K., Reynolds; L. and Egbunike, G.N. (eds), Cassava as Livestock Feed in Africa. Proceedings of a Workshop, 14-18 November 1988, International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria, pp. 53-72.

Ikhatua, U.J. and Adu, L.F. (1984). A comparative evaluation of the utilization of groundnut haulms and *Digitaria smutsii* hay by Red Sokoto goats. J. Anim. Prod. Res. 4:145–151.

ILCA, (International Livestock Centre for Africa), (1979). Small ruminant production in the humid tropics. ILCA, Addis Ababa, Ethiopia. pp. 122.

ILCA, (International Livestock Centre for Africa), (1982). Evaluation of the productivities of Djallonke sheep and N'Dama cattle at the Centre de Recherches Zootechniques, Kolda, Senegal. ILCA Research Report No. 3. International Livestock Centre for Africa, Addis Ababa, Ethiopia.

Irungu, K.R.G., Ashiono, G.B., Ondabu, N. and Indetie, D. (2005). Manure output and its nutrient composition when sheep were fed on three cultivars of sweet potato vines. Conference Proceedings of African Crop Science. 7: 551-554

Isah, O.A., Oguntuyo, S.A., Dawodu, R.O. Diya, O.O. Afolabi, M.O. and Omoniyi. L.A. (2013). Feed utilization, rumen parameters, and microbial profile of goats fed different tropical browse plants with *Pennisetum purpureum* as basal diet. Pacific Journal of Science and Technology. 14(1):397-405.

Issaka, J. (2006). Studies on nutritive value of sheanut cake, further studies on the growth response of sheep fed sheanut cake-based diets. BSc. (Agric. Tech) Dissertation, University for Development Studies, Tamale, pp 20-26.

Jabbar, **M.A. (1993).** Evolving crop/livestock farming systems in the humid zone of West Africa: Potential and research needs. Outlook on Agriculture, 22: 13-21.

Jabbar, M.A., Reynolds, L. and Francis, P.A. (1995). Sedentarization of cattle farmers in the derived savanna region of southwest Nigeria: Results of a survey. Tropical Animal Health and Production, 27: 55-64.

Jackson, M.E. (1977). Review article: The alkali treatment of straws. Anim. Feed Sci. and Technol. 2:105-130.

Jaiswal, R. S., Verma, M. L., Agrawal, I. S., (1988). Effect of various protein supplements added to ammonia (urea) treated rice straw diet on nutrient intake, digestibility and growth in crossbred heifers. Indian J. Anim. Nutr., 5 (3): 188-194.

Jutzi, S.C. (1993). Animal feed research in Eastern and Southern Africa: priorities and trends. Anim. Res. Dev., 37: 38-78.

Kaasschieter, G.A., Coulibaly, Y., Heitkonig, I.M.A. and Ketelaars, J.J.M.H. (1998). La supplementation du betail: une necessite! In: Breman, H., Sissoko, K. (Eds.), L'intensication Agricole au Sahel. Karthala, Paris, pp. 79-105.

Kabaija, **E. and Little, D.A. (1988).** Nutrient quality of forages in Ethiopia with particular reference to mineral elements. In: African forage plant genetic resources, evaluation of forage germplasm and extensive livestock production systems. Proceedings of the Third Workshop held at the International Conference Centre, Arusha, Tanzania, 27-30April 1987. ILCA, Addis Ababa.

Kagya-Agyemang, J.K., Nelson, A. and Kagya-Agyemang, C. (2013). Growth performance of weaner rabbits fed on dried pito mash as a replacement for maize. Journal of Agricultural and Biological Science. Asian Research Publishing Network (ARPN). 8(4):267-272.

Karbo, N. and Bruce, J. (2000). The contribution of livestock to the food security in Northern Ghana. CIDA (Canadian International Development Agency) Food Security Programme Report, Tamale, Ghana, pp 3-11.

Karbo, N., Avornyo, F., Addo-Kwarfo, A. and Bruce, J. (2002). Preference study of untreated and urea-treated fonio and rice straw with sheep in the moist Guinea savanna zone. Ghana J. Sci., 42: 41-48.

KATC (Kasisi Agricultural Training Centre), (2004). Manure handling and storage. Study Circle manual, KATC,Lusaka, Zambia**.** In assoc. Swedish Cooperative Centre.

Kausar, **R. (1983)**. Review on recycling of animal wastes as a source of nutrients for freshwater fish culture within an integrated livestock system. Pakistan Agricultural Research Council, Islamabad, Pakistan. pp.49.

Kellerman, T.S., Coetzer, J.A.W., Naudé, T.W. and Botha, C.J. (2005). Plant Poisonings and Mycotoxicoses of Livestock in Southern Africa, 2nd ed. Oxford University Press,Cape Town.

Kempton, T. J., Nolan, J. U. & Leng, R. A. (1977). Principles for the use of non-protein nitrogen and bypass proteins in diets of ruminants. *Wid Anim. Rev. 22,2-10.*

Kimani, S.K. and Lekasi, J.K. (2004) Managing manures throughout their production cycle enhances their usefulness as fertilisers: A review. In: Bationo A. (Ed.) Managing Nutrient Cycles to sustain Soil Fertility in Sub-Saharan Africa. CIAT-TSBF, Nairobi, Kenya.

Kimani, S.K., Mangele, N., Gathua, K.W., Delve, R. and Cadish, G. (1999). Effect of beanmaize intercropping, phosphorus and manure addition on nitrogen fixation and grain yield of Phaseulus Vulgaris in Central Kenya. Proceedings of the 6th KARI Scientific Conference, Nairobi, Kenya. pp. 205 -211.

Kinghorn, A.D. (ed.) (1979). Toxic plants. Symposium on Toxic Plants. Columbia University Press. 195 pp.

Kolff, **H.E. and Wilson, R.T. (1985).** Livestock production in central Mali: The mouton de case system of smallholder sheep fattening. Agricultural Systems, 16: 217-230.

Kossila, V. L. (1985). Global view of the potential use of crop residues as animal feed. In Better Utilisation of Crop Residues and By-products in Animal Feeding: Research Guidelines. 1. State of Knowledge. Proceedings of the FAO/ILCA Experr Consultation 5-9 March. 1984. PAD Animal Production and Health Paper No 50. Eds. Preston. T R. Kossila. V L. Vappu. L. Goodwin. J and Reed. Sheila B. Food and Agriculture Organisation. Rome.

Krebs, G.L., Howard, D.M. and K. Dods, K. (2007). Feeding *Acacia saligna* to Sheep and Goats with or without the Addition of Urea or Polyethylene Glycol**.** Asian-Aust. J. Anim. Sci. Vol. 20, No. 10:1551 – 1556

Leak, S., Faye, D. and Geerts, S. (2002). Genetic Resistance to Vectors and Vector-Borne Diseases in Indigenous West African Livestock. CPTV Newsletter, (6): 36-38.

Lebbie, S.H.B. (2004). Goats under Household Conditions. Small Ruminant Research, 51: 131 - 136.

Lekasi J.K., Tanner J.C., Kimani S.K. and Harris P.J.C. (1998). Manure management in the Kenya Highlands. Practices and potential. 2nd edn. HRDA (Henry Doubleday Research Association) Publication, Coventry, UK. pp. 35.

Lemlem, A. (2013. Effect of intercropping maize with cowpea and lablab on sheep growing performance in Ethiopia, Tigray region, District, RayaHerald Journal of Agriculture and Food Science Research, 2 (3): 98 – 108.

Little, D. A. (1985). The dietary mineral requirements of ruminants: Implications for the utilization of tropical fibrous agricultural residues. In: Doyle P T (ed), *The utilization of fibrous agricultural residues as animal feeds.* Proceedings of the Fourth Annual Workshop of the Australian-Asian Fibrous Agricultural Residues Research Network held in Khon Kaen, Thailand, 10-14 April 1984. International Development Program of Australian Universities and Colleges Limited, Canberra, Australia. pp. 37-43.

Louca, A., Antoniou, T. and Hadjipanayiotou, M. (1982). Comparative digestibility of feedstuffs by various ruminants, specifically goats. In: 3rd Int. Conf. Goat Production and Disease, Tuscon Arizona, U.S.A., 1982. pp 122–132.

MacDonald, D.W. and Sillero-Zubiri, C. (eds) (2004). The Biology and conservation of wild canids. Oxford University Press, Oxford. ISBN 0-19-851555-3.

Mack, **S.D. (1982).** Disease as a constraint to productivity. In: Gatenby, R.M. and Trail, J.C.M. (eds) Small Ruminant Breed Productivity in Africa. ILCA: Addis Ababa. pp. 81-83.

Maglad, M.A., Lutfi, A.A.A. and Gabir, S. (1986). The effect of grinding groundnut hulls either with or without alkali treatment on dig of diet and on ruminal and blood components. Anim. Feed Sci. Technol., 15: 69–77.

Maigandi, S. A. and Tukur, H. M. (2002). Potential of Fore-stomach Digesta as an unconventional feed ingredient. Journal of Agriculture and Environment, **3(1):** 55-64.

Mako, A.A., Akinwande V.O. and Oyegunwa A.S. (2013). Nutritive value assessment of the alternative feed resources using gas fermentation techniques and acceptability by WAD goats International Journal of AgriScience, 3(4): 365-371.

Malau-Aduli, B.S, Eduvie, L., Lakpini, C. and Malau-Aduli, A.E.O. (2003). Variations in liveweight gains, milk yield and composition of Red Sokoto goats fed crop-residue-based supplements in the subhumid zone of Nigeria. Livest Prod Sci 2003, 83: 63–71.

Malechek, J.C. and Provenza, F.D. (1983). Feeding behavior and nutrition of goats on rangelands. World. Anim. Review, 47: 38–48.

Mannetje, L. (1999). Introduction to the conference on silage making in the tropics. In Mannetje, L.'t (Ed.), Silage Making in the Tropics with Particular Emphasis on Smallholders. Proceedings of the FAO Electronic Conference on Tropical Silage, FAO Plant Prod. And Protect. Paper 161. 1 Sept. – 15 Dec. 1999. Rome, Italy.

McDonald, P.R.A., Edwards, J.F., Greenhalgh, D. and Morgan, C.A. (2002). Animal Nutrition. 6th ed. Prentice Hall, London, pp. 583-585.

McIntire, J., Bourzat, D. and Pingali, P. (1992) Crop/Livestock Interactions in sub-Saharan Africa. World Bank, Washington DC, USA.

McManus, W.R. and Choung, C.C. (1976). Studies of forage cell walls. 2. Conditions for alkali treatment of rice straw and rice hulls. J. Agric. Sci. (Cambridge) 86: 453–470.

McManus, W.R., Manta, L., McFarlane, J.D. and Gray, A.C. (1972). The effect of diet supplements and gamma irradiation on dissimilation of low quality roughages by ruminants. III. Effects of feeding gamma-irradiated based diets of wheaten straw and rice straws to sheep. J. Agric. Sci. (Cambridge) 79: 55–56.

Meecha, I. And Adegbola, T.A. (1980). A note on the chemical composition, intake, and digestibility of some dry season forages fed to goats. Nig. J. Anim Prod. 15:71-75.

Mehrez, A.Z. and Orskov, E.R. (1977). A study of the artificial fibre bag technique for determining the digestibility of feeds in the rumen. J. Agric. Sci. (Camb.), 8: 645-650.

Meng, Q.X. (1990). Upgrading utilization of roughage including crop residues in ruminant production. Hebei J. Anim. Sci. Vet. Med. , 1 :52-55.

Merchem, N.R. and Satter, L.D. (1983). Digestion of nitrogen by lambs fed alfalfa conserved as baled hay or as a low moisture silage. Journal of Animal Science 56:943–951.

Mikile, Z. (2001). The use and agronomic effectiveness of kraal manures in the Transkei region of the Eastern Cape, South Africa. Unpublished M Sc. Agric. Dissertation, University of Fort Hare, Alice, South Africa.

Mitchell, C. (1992). Using livestock manure as fertilizer. Extension Agronomist, Agronomy. Auburn University.

Moberg, G. P. and Mench, J.A. (2000). The biology of animal stress: basic principles and implications for welfare. CABI, Wallingford, UK. pp. 1-21.

MOFA, **(Ministry of Food and Agriculture) (1998).** Statistics Research and Information Directorate of MOFA report, Accra-Ghana.

MOFA, (Ministry of Food and Agriculture) (2000). 1997/1998 Annual report, Livestock Planning and Information Unit, Accra, Ghana.

MOFA, (Ministry of Food and Agriculture) (2011). Agriculture in Ghana. Facts and figures., Statistical Research and Information Directorate, Accra, Ghana.

Mohamed Saleem, M.A. (1998). Nutrient balance patterns in African livestock systems. Agric Ecosyst.Environ., 71:241-254

Mokoboki, H.K., Ayisi, K.K. and Ndlovu, L.R. (2000). Chemical composition and physical characteristics of cowpea haulms as forage for ruminants. South African Journal of Animal Science 1: 87-88.

Moody, K., Monroe, C.E., Lubigan, R.T. and Paller, E.C. (1984). Major Weeds of the Philippines, University of the Philippines Los Baños, College, Laguna,Philippines. pp. 328.

Moral. R., Moreno-Caselles, J., Perez-Murcia, M.D., Perez-Espinosa, A., Rufete, B and Paredes, C. (2005). Characterisation of the OM pool in manures. Bioresource Technology, 96(2).

Morrison, I. M., Brice, R. E. and Mousdale, S. A. (1989). Biodegradation of lignocellulosic materials: Present status and future prospects. Proceedings of a combined advisory group meeting and a research coordinating meeting on feeding strategies for improving productivity of ruminant livestock in developing countries. IAEA, Vienna, 13-17 March, 1989. pp. 191-204.

Morrison, I.M. and Brice, R.E. (1984). The digestion of untreated and ammonia-treated barley straw in an artificial rumen. Anim. Feed Sci. Technol., 10: 229–38.

Mortimore, M. (1991). A review of mixed farming systems in the semiarid zone of sub-Saharan Africa. Livestock Economics Division, Working Document 17. International Livestock Centre for Africa (ILCA), Addis Ababa, Ethiopia. pp. 27-28

Mtega, L. and Shoo, R. (1990). Growth rate, feed intake and feed utilization of Small East African goats supplemented with *Leucaena leucocephala*. *Small Ruminant Research,* 3: 9 – 18.

Muhammad, N., S.A. Maigandi, S.A., W.A. Hassan, W.A., and A.I. Daneji, A.I. (2008). Growth performance and economics of sheep production with varying levels of rice milling waste. Sokoto Journal of Veterinary Sciences (2008). **7**(1): 59-64.

NASS, (NATIONAL AGRICULTURAL STATISTICS SERVICES) (2010). Sheep and goats death loss. Agricultural Statistics board, U.S. department of Agriculture. Retrieved 2007-12-27.

Naudé, T.W., Kellerman, T.S. and Coetzer, J.A.W. (1996). Plant poisonings and mycotoxicoses as constraints in livestock production in East Africa: the southern African experience. Journal of the South African Veterinary Association, 67:8–11.

Ndemanisho, E. E., Kimoro, B. N., Mtengeti, E. J. and Muhikambele, V. R. M. (2007). In vivo digestibility and performance of growing goats fed maize stover supplement with browse leaf meal and cotton seed cake - based concentrate. Livestock Research for Rural Development, 19 (8).

Ngele, M. B., Kalla, D. J. U., Abubakar, M., Dass, U. D. and Amba, A.A. (2009). Enhancing crop residues for livestock feeding in the tropics. Journal of league of researchers in Nigeria,10(2):1-20.

Ngere, L.O., Adu, I.F. and Okubanjo, I.O. (1984). The Indigenous Goats of Nigeria. Animal Genetic Resources Infor- mation, 3:1-9.

Ngwa, A.T. and Tawah, C.L. (1991). Effects of Legume crop residues and concentrate supplementation on voluntary intake and performance of Kirdi sheep fed basal diet of rice straw. In: Supplementary feed resources network workshop held in Gaborne, Botswana, pp. 240-247.

Nicholson, J W G (1984). Digestibility. nutritive value and feed intake. Chapter 12. In: Straw and Other Fibrous By-products as Feed, Eds. F Sundstol and E Owen. Elsevier. Amsterdam.

Njidda, A.A. (2010). Determining dry matter degradability of some semi-arid browse species of North-Eastern Nigeria using the *In Vitro* Technique. Nigerian Journal of Basic and Applied Science, 18(2): 160-167.

Nordblom, J.L. and Shomo, F. (1995). Food and Feed Prospects to 2020 in the West AsiaNorth Africa Region. ICARDA Social Science Paper No. 2, International Centre for Agricultural Research in the Dry Areas, Aleppo, Syria. pp.55.

Norton, B. W. (1994). The Nutritive Value of Tree Legumes. In: Forage Tree Legumes in Tropical Agriculture, Eds. Gutteridge, R. C. and H. M. Shelton. CABI, UK, pp: 177 – 191.

NRC, (National Research Council), (1975). Nutrient requirements of domestic animals 5th Edition), Nutrient requirements of sheep, NRC, Washington DC, USA.

NRC, (National Research Council), (1981). Nutrient Requirements of Goats: Angora, Dairy and Meat Goats in Temperate and Tropical Countries. National Academy Press, Washington DC, USA. pp. 91.

Nuru, S. (1985). Strategies for improved production of fresh foods in Nigeria. Nigerian Institute of Food Science and Technology, Federal Industrial Research Organisation (FIRO), Oshodi, Lagos, Nigeria, pp. 12.

Obese, A. M. (1998). The effects of agricultural by-products supplementation on the growth performance of the Djallonke sheep. BSc. (Agric. Tech) Dissertation, University for Development Studies, Tamale, pp. 24-35.

Ockling, S. (1986). Position Paper on Sheep and Goat Production in Ghana. In. Timon, V.M. and R.P. Baber (eds). Sheep and goat meat production in the humid tropics of West Africa. FAO Animal Production and Health Paper 70.

Oji, U.I., Etim H.E. and Okoye, F.C. (2007). Effects of urea and aqueous ammonia treatment on the composition and nutritive value of maize residues. Small Rumin. Res., 69: 232-236.

Okai, D.B., Abora, P.K.B., Davis, T. and Martin, A. (2005). Nutrient composition, availability, current and potential uses of ―*Dusa*‖: A cereal by-product obtained from ―*koko*‖ (porridge) production. Journal of Science and Technology, 25:33-38.

Okello, K.L. and Obwolo, M.J. (1985). Review of the potentialities of goat production.World. Anim. Rev. 53: 27–32.

Okello, K.L., Ebong, C., Opuda-Asibo, J. (1996). Effect of feed supplements on weight gain and carcass characteristics of intact male Mubende goats fed elephant grass (*Pennisetum purpureum*) *ad libitum* in Uganda. In: Lebbie, S.H.B., Kagwini, E. (Eds.), *Small Research and Development in Africa*. Proceedings of the Third Biennial Conference of the African Small Ruminant Research Network, UICC, Kampala, Uganda, 5-9 December 1994. ILRI (International Livestock Research Institute), Nairobi, Kenya.

Oladotun, O.A., A.B.J. Aina and E.B. Oguntona, (2003). Evaluation of formulated agroindustrial wastes as dry season feed for sheep. Nig. J. Anim. Prod., 30: 71-80.

Olajumoke, O.L., Margaret, A., Agiang, A.M. and Mbeh, U. E. (2012). Proximate and antinutrient composition of white Guinea yam (*Dioscorea rotundata*) diets consumed in Ibarapa, South West region of Nigeria Scholars Research Library J. Nat. Prod. Plant Resources, 2 (2):256260.

Olayiwole, M. B. and Olorunju, S. A. (1987). Feedlot performance of yearling steers previously maintained on different crop residue/supplementation regimes. In: Utilization of Agricultural By-Products as livestock feeds in Africa. ARNAB/ILCA. pp. 72-82.

Olorunnisomo, O. A., Adewumi, M.K. and Babayemi, O. J. (2006). Effects of nitrogen level on the utilization of maize offal and sorghum brewer's grain in sheep diets. Livestock Research for Rural Development. Volume 18(10).

Omer, M. M. (2012). Effect of storage time on fishmeal made from four commercial Nile fishes collected from the White Nile, Sudan. Bulletin of Environment, Pharmacology and Life Sciences. 1 (5): 21- 25.

Omoniyi, L.A., Isah, O.A., Taiwo, O.O., Afolabi, A.D. and Fernandez, A.J. (2013). assessment of nutritive value of some indigenous plants consumed by ruminants in the humid and sub-humid region of nigeria using *in vitro* technique. Pacific Journal of Science and Technology. 14(1):413-421.

Ondiek, O.J., Ogore, P.B., Shakala, E.K. and Kaburu, G.M. (2013). Feed intake, digestibility and performance of growing small East African goats offered maize (Zea mays) stover supplemented with *Balanites aegyptiaca* and *Acacia tortilis* leaf forages. Basic Research Journal of Agricultural Science and Review, 2(1): 21-26.

Onwuka C.F.I., Adetiloye P.O. and Afolami, C. A. (1997). Use of household waste and crop residues in small ruminant feeding in Nigeria. Small Ruminant Res.; 24: 233-237.

Onwuka, C.F.I. and Davies, A. T. and (1996). Conservation of forage for dry season feeding in the humid zone of Nigeria. African Feed Resources Network Proc. (Eds. J. Ndikumana and P. N. de Leeuw). 2nd African Feed Resources Network Workshop AFRNET, Nairobi, Kenya. pp. 93-96.

Onyeike, E.N. and Oguike, J.U. (2008). Influence of Heat Processing Methods on the Nutrient Composition and Lipid Characterization of Groundnut (Arachis hypogacaea) Seed Pastes. Biokemistri 15(1):34-43.

Onyeike, E.N. and Oguike, J.U. (2008). Influence of Heat Processing Methods on the Nutrient Composition and Lipid Characterization of Groundnut (Arachis hypogacaea) Seed Pastes. Biokemistri 15(1):34-43.

Oppong-Anane, K. (2001). Country Pasture/Forage Resource Profile, Ghana. In Country Pasture Profiles. http://www.fao.org/ag/AGP/agpc/doc/pasture/forage.htm. (28th August, 2010).

Oppong-Anane, K. (2011). Ghana livestock sector review report. A report submitted to the Food and Agriculture Organization of the United Nations, Rome, Italy. pp. 55.

Orisajo S. B, Okeniyi, M.O., Fademi, O.A. and Dongo, L.N. (2007). Nematicidal effects of water leaf extracts of *Acalypha ciliata, Jatropha gossypifolia, Azadirachta indica* and *Allium ascalonicum* on *Meloidogyne incognita* infection on cacao seedlings. J. Res. in Biosci,3 (3): 4953.

Orisajo, S. B., Afolami, S. O. Fademi, O. and Atungwu, J.J. (2008). Effects of poultry litter and carbofuran soil amendments on *Meloidogyne incognita* attacks on cacao. J. Appl. Biosci., 7: 214 – 221.

rskov, E. R. (1990). Possibility of manipulating resource quality by genetic selection. Animal Research and Development, 41: 23-37.

Osafo, E.L.K., Antwi, C., Donkoh, A. and Adu-Dapaah, H. (2013). Feeding graded levels of an improved cultivar of Cowpea haulm as supplement for Rams fed maize stover diet. International Journal of Agricultural Research, 8:87-93.

Osafo, E.L.K., Owen, E., Said, A.N., Gill, M. and Sherington, J. (1994). The effect of variety of chopped sorghum stover and amount offered on intake, weight-change and digestibility in sheep. In: Programme and Abstracts of the Third Small Ruminant Research Network (SRNET) Biennial Conference, Uganda International Conference Centre, Kampala, Uganda, 5-9 December 1994, 19.

Oseni, S.O. and Ajayi, B.A. (2014). Phenotypic Characterization and Strategies for Genetic Improvement of WAD Goats under Backyard Systems. Open Journal of Animal Sciences, 4(5):9-10.

Ososanya, T.O., Alabi, B.O. and A.O. Sorunke, A.O., (2013). Performance and digestibility of corncob and cowpea husk diets by West African Dwarf Sheep. Pakistan Journal of Nutrition, 12 (1): 85-88.

Osuji, P.O., Fernandez-Riviera, S. and Odeyo, A. (1995). Improving Fibre Utilisation and Protein Supply in Animals Fed Poor Quality Roughages. ILRI Nutrition Research and Plans. In: Wallace, R.J. and A. Lahlou-Kassi (Eds)., Rumen Ecology Research and Planning, 1. International Livestock Research Institute, Addis Ababa, pp:1-22.

Otchere, E. O., Adanse-Pipim, K. A. and Barnes, A. R. (1986). Digestibility and feedlot performance of sheep fed cocoa husk - based diets. J. Anim. Prod. Res, 6 (2): 97-106.

Otchere, E. O., Dadzie, C. B. M, Erbyn, K. G. and Ayebo, D. A. (1977). Response of sheep on rice straw or cassava peels fortified with urea and molasses as supplemental feeds to grazing sheep. Ghana J. of Agric. Sci., 10: 61-66.

Otchere, E. O., Musah, I. A. and Bafi-Yaboa, M. (1983). The digestibility of Cocoa husk based diets fed to sheep. Tropical Animal Production, 8: 33-38.

Otchere, E.O. (1985). Small ruminant production in tropical Africa. In: Small ruminant production in developing countries. FAO (Food and Agricultural Organization) Anim. Prod. Health, pp: 203-210.

Otchere, E.O., Ahmed, H.U., Adesipe, Y.M., Kallah, M.S. and Mzamane, N. (1985). Livestock production among pastoralists in Giwa District, Kaduna State, Nigeria. Livestock Systems Research Project, NAPRI, Shika, Zaria, Nigeria.

Otchere, E.O., Odo, F.N.A. and Ayebo, D.A. (1978). Cassava starch refuse as substitute for maize or sorghum in sheep and goat rations. Ghana J. of Agric. Sci., 11: 165-169.

Owen, **E. (1985).** Crop residues as animal feeds in developing countries, use and potential use. In: (Eds. Wanapat and Devendra), Proceedings of an International Workshop on relevance of crop residues as animal feeds in developing countries, Thailand, 1985.

Owen, E. (1993). Cereal crop residues as feed for goats and sheep. In Tingshuan, G., Yanglian, F., Jianxin, L., Jiaqui, W. and Zhishan, Z. (ed.) Increasing Livestock Production Through Utilization of Local Resources - Proceedings of the International Conference, Beijing. Beijing 100026, 11 Nongzhanguan Nanli: Bureau of Animal Production and Health, Ministry of Agriculture China, 1993, 360-372.

Owen, E. and Jayarisuya, M.C.N. (1989). Use of crop residues as animal feeds in developing countries – A review. Research and Development in Agriculture 6(3):124-138

Ozung, P.O., Nsa, E. E., Ebegbulem, V. N. and Ubua, J.A. (2011). The potentials of small ruminant production in cross river rain forest zone of Nigeria: A review. Continental J. Animal and Veterinary Research 3 (1): 33 – 37.

Pancho, J.V. and Plucknett. D.L. (1971). *Chromolaena odorata* (L.). In: R.M. King and H.Robinson (eds), A new record of a noxious weed in the philipines. Philipine Journal of Animal Sciences, 8:143-149.

Peacock, C.P. (1982). Seasonal breeding aspects on productivity. In: Small Ruminant Breed Productivity in Africa (eds). Gatenby, R.M. and Trail, J.C.M. ILCA: Addis Ababa. pp. 72-80.

Pearce, G. R. (1984). Factors contributing to variation in the nutritive value of fibrous agricultural residues. In: The Utilization of Fibrous Agricultural Residues as Animal Feeds. Proceedings of the

3rd Annual Meeting of the Australian-Asian Fibrous ARricultural Residues Research NetWork. Ed. P.T. Doyle. University ofPeradeniya, Sri Lanka. 17-22 April, 1983. School of Agriculture and Forestry, University of Melbourne.

Phuc, B. H. N. (2006). Review of the nutritive value and effects of inclusion of forages in diets for pigs. In: Forages for Pigs and Rabbits. Proceedings of a workshop-seminar held 21-24 August, 2006. MEKARN-CelAgrid.

Pipat, L., Khungaew, M. and Suksombat, W. (2011). Silage production from cassava peel and cassava pulp as energy source in cattle diets. J. Anim. Vet. Adv., 10: 1007-1011

Powell J.M., Williams, T.O. (1995). An overview of mixed farming systems in sub-Saharan Africa. In: Powell, J. M., Fernández-Rivera, S., Williams, T. O., Renard, C. (Eds) Livestock and Sustainable Nutrient Cycling in Mixed Farming Systems of sub-Saharan Africa. Volume II: Technical Papers. Proceedings of an International Conference held in Addis Ababa, Ethiopia, 22–26 November 1993. International Livestock Centre for Africa, Addis Ababa. pp. 568.

Powell, J.M. (1986). Crop/livestock interactions in the subhumid zone of Nigeria. In: von Kaufmann, R., Chater, S. and Blench, R. (eds), Livestock Systems Research in Nigeria's Subhumid Zone. Proceedings of a Symposium, 20 October-2 November 1984, Kaduna, Nigeria. International Livestock Centre for Africa (ILCA), Addis Ababa, Ethiopia, pp. 268-303.

Powell, J.M. (2004) Crop-Livestock interactions in the West African Drylands. Agronomy Journal 96, 469-483.

Powell, J.M. and Fussell, L.K. (1993). Nutrient and structural carbohydrate partitioning in pearl millet. Journal of Agronomy, 85: 862-866.

Powell, J.M., Ikpe, F.N., Somda, Z.C. and Fernández-Rivera, S. (1998). Urine effects on soil chemical properties and the impact of urine and dung on pearl millet yield. *Experimental Agriculture* 34 : 259-276.

Powell, J.M., Pearson, R.A., Hiernaux, P. (2004). Crop–Livestock Interactions in the West African Drylands. Agron. J. 96:469-483.

PPI (Potash and Phosphate Institute), (1983). Soil fertility manual. 2801 Buford Hwy., NE Atlanta, GA. pp. 93

Preston, T. R. and Leng, R. A. (1981). Utilisation of tropical feeds by ruminants. In Ruschebush, W; Thivend, P. ed: Digestive Physiology, London MPA press Ltd.

Probert, M.E., Okelebo, J.R., Simpson, J.R. and Jones, R.K. (1992). The role of boma manure for improving soil fertility In: Probert, M.E. (ed.). ACIAR Proceedings, 41, 63-70.

Ramirez, G. R., Aguilera-Gonzalez, J. C., Garcia- Diaz, G., Nunez-Gonzalez, A. M., (2007). Effect of urea treatment on chemical composition and digestion of *Cenchrus ciliaris* and Cynodon dactylon Hays and Zea mays residues. J. Anim. Vet. Adv., 6 (8): 1036-1041

Ramirez-Bribiesca, J.E, Soto-Sanchiez, A., Hernandez-calva, L.M., Salinas-Chavira, J., Galaviz-Rodriguez, J.R., Cruz-Monterrosa, R.G., Vargas-Lopez, S. (2010). Influence of *Pleurotus ostreatus* spent corn straw on performance and carcass characteristics of feedlot Pelibuey lambs. Indian J. Anim. Sci. 80:754-757.

Ranjhan, S. K., (1980). Animal Nutrition in the Tropics. Vikas Publishing House Pvt. Ltd. Vikas House, Ghajiabod V.P. (India). pp. 163-167.

Ranjhan, S.K. (1993). Animal nutrition and feeding practices. 4th Ed. Vikas publishing house PVT Ltd. New Delhi, India.

Reed, J.D., Kebede, Y. and Fussell, L.K. (1988). Factors affecting the nutritive value of sorghum and millet crop residues. In: Reed, J.D., Capper, B.S. and Neate, P.J.H. (eds), Plant Breeding and the Nutritive Value of Crop Residues. Proceedings of a Workshop, 7-10 December 1987, International Livestock Centre for Africa, (ILCA), Addis Ababa, Ethiopia, pp. 233-251.

Rege, J.E.O. (1994). Indigenous African Small Ruminant Resources: A Case for Characterization and Improvement. In: Lebbie, S.H.B., Rey, B. and Irungu, E.K., Eds., Small Research & Development in Africa. Proceedings of the 2nd Bi- ennial Congress of the African Small Ruminant Research Network, Arusha, 7-11 December 1992, 205-212.

Rittner, U. and Reed, J.D. (1992). Phenolics and in-vitro degradability of protein and fiber in West African Browse. Journal Science Food Agriculture 58:21-28.

Rotz, C. A., Davis, R. J. and Abrams, S. M. (1991). Influence of rain and crop characteristics on alfalfa damage. Trans. ASAE 34: 1583–1591.

Ryder, M. L. (1999). Domestication, history and breed evaluation in sheep. In: Maijala, K. (ed.) genetic resources of pigs, sheep and goats. World Animal Science Elsevier, U.K, pp. 157-177.

Ryu, D.D.Y. (1989). The enhancement of nutritional value of cellulosic feed resources by pretreatment and bioconversion. pp 223-243:In Biotechnology for livestock production FAO, Rome.

Sabri, M. M., Kasalu-Coffin, E. and Bucher, D. (2001). Appraisal report of Livestock development project. Republic of Ghana. African development Fund, pp. 01-15.

Safari, J.G., Mushi, D.E., Mtega, L.A., Kifaro, G.C. and Eik, L.O. (2011). Growth, carcass yield and meat quality attributes of Red Massai sheep fed wheat straw-based diets. Tropical Animal Health and Production, 43:89–97.

Saha, H.M., Kahindi, R.K., and Muinga, R.W., (2008). Evaluation of manure from goats fed panicum basal diet and supplemented with madras thorn, leucaena or gliricidia. Tropical and Subtropical Agroecosystems, 8 (2008): 251 – 257.

Sanni, S.A., Bernstein, O., Clara, R. and Sanni, L.O. (1999). Chemical and nutritional composition of some common foods in Abeokuta, Nigeria. Brazilian Archives of Biology and Technology 42(3): 331-337.

Sansoucy, R. and Emery, B., (1982). Utilisation actuelle des residue de recolte et sous-produits agro-industrielle en alimentation animale. In : Crop residues and agro-industrial by-products in animal feeding. FAO, Rome, p. 5-18.

SAS Institute, Inc. (2006). SAS user‘s guide: Statistics. 8th ed. SAS Institute, Inc., Cary, NC.

Savadogo, M., Zemmelink, G., Nianogo, A.J. and Van Keulen, H., (2000). Cowpea (*Vigna unguiculata L. Walp*) and groundnut (*Arachys hypogea L.*) haulms as supplements to sorghum (*Sorghum bicolor L. Moench*) stover: Intake, digestibility and optimum feeding levels. Animal Feed Science and Technology 87:57-69.

Sekondi, A. A. (1991). The effect of feeding graded levels of cassava peel meal on the performance of laying birds. Paper presented at NAPRI Seminar.

Semenye, P.P. and Hutchcroft, T. (1992). On- farm Research and Technology for Dualpurpose Goats. Small Ruminant Collaborative Research Support Program (SR- CRSP), Nairobi, Kenya. pp. 144.

Simmons, P. and Ekarius C., (2001). Storey's Guide to Raising Sheep. North Adams, MA: Storey Publishing LLC. ISBN 9781580172622.

Sindhu, A.A., Khan Mahr-Un-Nisa, M.A. and Sarwar, M. (2002). Agro-Industrial by-products as a potential source of livestock feed;Review. International Journal of Agriculture and Biology, 4(2):307-310

Singh, F. and Diwakar, B. (1993). Nutritive Value and Uses of Pigeon pea and Groundnut. Manual. Patancheru: International Crops Research Institute for the Semi-Arid Tropics.

Smith, M.C. (1994). Goat Medicine. Lippincott Williams and Wilkins. pp. 7

Smith, **O. B. (1992)**. Small ruminant feeding systems for small scale farmers in humid West Africa. Proceedings of the Joint feed resources networks workshop on the complementarity of feed resources for animal production in Africa. ILCA, Ethiopia: 363-376.

Smith, **O.B. (1988)**. Studies on the Feeding Value of Agro-Industrial By-products. Effect of forage supplementation on the utilization of cocoa-pod based diets by ruminants. J. Anim. Res., 8(1): 1-14.

Smith, O.B., (1993). Feed resources for intensive smallholder systems in the tropics: the role of crop residues. Proc. Of the XVII International Grassland congress. 18-21 February, 1993. Rockhampton, Australia.

Smits, M.C.J., Valk, H., Elzing, A., Keen, A. (1995). Effect of protein nutrition on ammonia emission from a cubicle house for dairy cattle. Livestock Production Science 44, 147-156.

Snijders, I. P. J. M., Davies, O., Wouters, A. P., Gachimbi, L., Zake, J., Ergano, K., Abduke,M. and van Keulen, H. (2009). Cattle manure management in east africa: Review of manure quality and nutrient losses and scenarios for cattle and manure management. *Lelystad: Wageningen,UR,LivestockResearch*. http:// library.wur.nl/WebQuery/wurpubs/383108. Accessed September 2011.

Snijders, P.J.M. and Wouters, B. (2003). Livestock and Soil Nutrient Management. Contribution to the Development of a Curriculum for Farmer Field Schools on Integrated Nutrient Management in East Africa. http://www.inmasp.nl/files/9937ac05134a9512244c8d8afca24b60.pdf. Accessed 19.12.03.

Squires, V.R. (1984). Behaviour and management of free ranging sheep and cattle in the arid zone of inland Australia. World. Anim. Review, 52: 29–33.

Sudana, I.B. and Leng, R.A. (1986). Effects of supplementing a wheat straw diet with urea or a urea-molasses block and/or cottonseed meal on intake and liveweight change of lambs. Anim. Feed Sci. Technol. 16:25-35.

Sundstol, F. and Owen, E. (1984). Straw and other fibrous by-products as feed. Elsevier, vol. 19(2), pages 153-156.

Sundstol, F., Said, A. N. and Arnason, J. (1979). Factors influencing the effect of chemical treatment on the nutritive value of straw. Acta Agricola Scandinavica, 29(2):179-190.

Suriyajantratong, W. and Senakas, U. (1985). Yield and nutritive value of groundnut vines at the pod-harvesting stage. In: (Eds. Wanapat and Devendra). Proceedings of an International Workshop on relevance of crop residues as animal feeds in developing countries. Thailand, 1985.

Suttie, J. M. (2000). Hay and straw conservation for small-scale farming and pastoral conditions. FAO Plant Production and Protection Series No. 29, FAO, Rome.

Tarawali, S., Singh, B.B., Peters, M. and Blade, S.F. (1997). Cowpea haulms as fodder. In: (Singh, B.B., Dashiel, K.E. and Jackai, L.E.N Eds.) Advances in Cowpea Research, IITA. pp.313-325.

Ternouth, J.H. (1989). Endogenous losses of phosphorus by sheep. *Journal of Agricultural Science* 113: 291-297.

Thiruchittampalam, S. and Jayarisuya, M.C.N. (1978). Influence of particle size on the nutritive value of alkali treated rice straw. J. Natl. Agric. Soc. Celon. 15: 97–100.

Thornton, P.K., Krushka, R.L., Henninger, N., Kristjanson, P., Reid, R.S., Atieno, A.N. and Ndegwa, T. (2002). *Mapping Poverty and Livestock in the Developing World*, ILRI, Nairobi, Kenya, pp.118

Tolera, A., Sundstøl, F., (2000). Supplementation of graded levels of *Desmodium intortum* hay to sheep feeding on basal diets of maize stover harvested at three stages of maturity 1. Feed intake, digestibility and body weight change. Anim. Feed Sci. Technol. 85, 239-257.

Tomlin, D. C., Johnson, R. R. and Dehority, B. A. (1965). Relationship of lignification to *in* vitro cellulose digestibility of grasses and legumes. J. Anim, Sci. 24 : 16

Tuah, A. K., Buadu, M. K., Obese F.Y. and Brew, K. (1992). The performance, potentials and limitations of the West African Dwarf goat for meat production in the forest belt of Ghana. In:Rey B, Lebbie S. H. B. and Reynolds L. (editors). Small ruminant research and development in Africa. Proceeding of the first Biennial conference of African small ruminant research network ILCA, Addis Ababa, Ethiopia.

Tweneboah, C.K. (2000). Modern Agriculture in the Tropics with special reference to Ghana. Co-Wood Publishers, Accra, Ghana. pp. 195.

Van Raay, H.G.T. and de Leeuw, P.N. (1974). Fodder Resources and Grazing Management in a Savanna Environment: An Ecosystems Approach. Occasional Paper No. 5, Institute of Social Studies, The Hague, The Netherlands.

Van Vlaenderen, G (1985).Northern Togo goat husbandary development. World Anim. Review, FAO. NO. 55. pp.19-26

Verma, D.N. (1997). A Text Book of Animal Nutrition, 1st Ed. R. 814, New Rajinder nagar, New Delhi.

VSD. (2010). Veterinary Services Directorate, MOFA, Accra. Assessment of animal numbers. Draft Report. pp. 5 – 10.

Wahed, R. A., Owen, E., Naate, M. and Hosking, B. J. (1990). Feeding straw to small ruminants: effect of amount offered on intake and selection of barley straw by goats and sheep. Animal Production 51: 283-289.

Walker, H.G. (1984). Physical treatment. In: (Sundstöl, F. and Owen, E. eds.). Straw and other fibrous by-products as feeds. Development in Animal and Veterinary Sciences, 14. Elsevier Amsterdam. pp 79–105.

Wanjiku J. and Manyango J.U. (2005). Effect of soil fertility technologies on the profitability of kale and tomatoes in Western Kenya. African crop science conference proceedings. Vol 7 pp 915-917.

Warren, G.P., Muthamia, J. and Irungu, J.W. (1996). Soil fertility improvement under manuring in Semi-Arid Lower Embu and Tharaka-Nithi, Proceedings of the 5th KARI Scientific Conference, Nairtobi, Kenya. pp. 151 -163.

Waterhouse, D.F. (1994). Biological control of weeds: Asian prospects. ACIAR Monograph. No. 26, 302 pp.

Wesseh, A. (1999). The effects of agricultural by-products supplementation on the dry season reproductive performance of Djallonke ewes. BSc. (Agric. Tech) Dissertation, University for Development Studies, Tamale, pp. 25-38.

Williams T.O., Powell J.M. and Fernandez-Rivera S. (1995). Manure utilisation, drought cycles and herd dynamics in the Sahel: Implications for crop productivity. In: Powell J.M., Fernández-Rivera S., Williams T.O. and Renard C. (eds), Livestock and sustainable nutrient cycling in mixed farming systems of sub-Saharan Africa. Volume II. Technical Papers. Proceedings of an international conference held in Addis Ababa, Ethiopia, 22–26 November 1993. ILCA (International Livestock Centre for Africa) Addis Ababa, Ethiopia. pp. 393–409.

Wooster, C. and Hansen, G., (2005). Living with Sheep: Everything you need to know to raise your own flock. Guilford, Connecticut: The Lyons Press. ISBN 1-59228-531-7.

World Bank (1989). Sub-Saharan Africa: From Crisis to Sustainable Growth. Washington DC, USA.

Woyengo, TA, Gachuiri, C.K., Wahome, R.G. and Mbugua, P.N. (2004). Effect of supplementation and urea treatment on utilization of maize stover by Red Maasai sheep. South African J. Anim.Sci. 34 (1) 23-30.

Yapi – Gnaore, C. V., Oya, A., Rege, J. E. O. and Dagnogo, B. (1997). Analysis of an open nuclear breeding programme for Djallonke sheep in Ivory Coast; an examination of non – genetic factors. British J. Animal Science, 64: 291 - 300.

Yousuf, M. B. Belewu, M A., Gbadamosi, H. A. and Ogudun, N. I. (2007). Replacing cotton seed cake with cassava leaf meal in corn bran based diet fed to the goat. Bulgarian Journal of Agricultural Science, 13, 231-236.

APPENDICES

APPENDIX A: DATA ON FEED INTAKE AND GROWTH PERFORMANCE.

			MEAN INTAKE AND GROWTH PERFORMANCE OF GOATS										
Loc	**REPS**	**TRT**	**BFI**	**SFI**	**TFI**	**INWT**	**FNWT**	**WG**	**ADG**	**FCR**	**BFILW**	**SFILW**	**TFILW**
AMAN	1	3	171.00	110.00	281.00	10.10	11.80	1.70	18.89	14.88	14.49	9.32	23.81
AMAN	1	2	203.00	157.00	360.00	10.40	12.10	1.70	18.89	19.06	16.78	12.98	29.75
AMAN	1	1	439.00	0.00	439.00	10.30	11.20	0.90	10.00	43.90	39.20	0.00	39.20
AMAN	2	3	200.00	118.00	318.00	10.30	11.90	1.60	17.78	17.89	16.81	9.92	26.72
AMAN	2	2	201.00	163.00	364.00	10.70	11.90	1.20	13.33	27.30	16.89	13.70	30.59
AMAN	2	1	511.00	0.00	511.00	10.10	11.00	0.90	10.00	51.10	46.45	0.00	46.45
AMAN	3	3	210.00	127.00	337.00	10.00	12.30	2.30	25.56	13.19	17.07	10.33	27.40
AMAN	3	2	220.00	152.00	372.00	10.20	11.80	1.60	17.78	20.93	18.64	12.88	31.53
AMAN	3	1	489.00	0.00	489.00	9.80	10.60	0.80	8.89	55.01	46.13	0.00	46.13
AMAN	4	3	205.00	117.00	322.00	10.00	11.30	1.30	14.44	22.29	18.14	10.35	28.50
AMAN	4	2	227.00	148.00	375.00	10.30	11.80	1.50	16.67	22.50	19.24	12.54	31.78
AMAN	4	1	416.00	0.00	416.00	10.00	10.80	0.80	8.89	46.80	38.52	0.00	38.52
AMAN	5	3	205.00	108.00	313.00	9.90	11.00	1.10	12.22	25.61	18.64	9.82	28.45
AMAN	5	2	190.00	159.00	349.00	10.00	11.60	1.60	17.78	19.63	16.38	13.71	30.09
AMAN	5	1	415.00	0.00	415.00	10.40	11.00	0.60	6.67	62.25	37.73	0.00	37.73
AMAN	6	3	198.00	137.00	335.00	10.30	11.40	1.10	12.22	27.41	17.37	12.02	29.39
AMAN	6	2	205.00	137.00	342.00	10.80	12.10	1.30	14.44	23.68	16.94	11.32	28.26
AMAN	6	1	388.00	0.00	388.00	9.70	10.50	0.80	8.89	43.65	36.95	0.00	36.95
ATEB	1	3	202.00	162.00	364.00	10.20	12.80	2.60	28.89	12.60	15.78	12.66	28.44
ATEB	1	2	207.00	159.00	366.00	10.10	11.80	1.70	18.89	19.38	17.54	13.47	31.02
ATEB	1	1	419.00	0.00	419.00	10.20	11.00	0.80	8.89	47.14	38.09	0.00	38.09
ATEB	2	3	178.00	168.00	346.00	10.10	11.60	1.50	16.67	20.76	15.34	14.48	29.83
ATEB	2	2	180.00	172.00	352.00	10.00	11.20	1.20	13.33	26.40	16.07	15.36	31.43
ATEB	2	1	412.00	0.00	412.00	10.30	11.20	0.90	10.00	41.20	36.79	0.00	36.79
ATEB	3	3	178.00	160.00	338.00	10.00	11.90	1.90	21.11	16.01	14.96	13.45	28.41
ATEB	3	2	192.00	147.00	339.00	9.90	11.20	1.30	14.44	23.47	17.14	13.13	30.27
ATEB	3	1	436.00	0.00	436.00	10.00	10.9	0.90	10.00	43.60	40.00	0.00	40.00
ATEB	4	3	211.00	127.00	338.00	10.10	11.70	1.60	17.78	19.01	18.03	10.85	28.89
ATEB	4	2	228.00	163.00	391.00	9.30	10.80	1.50	16.67	23.46	21.11	15.09	36.20
ATEB	4	1	428.00	0.00	428.00	10.10	10.8	0.70	7.78	55.03	39.63	0.00	39.63
ATEB	5	3	169.00	118.00	287.00	10.00	11.30	1.30	14.44	19.87	14.96	10.44	25.40
ATEB	5	2	153.00	169.00	322.00	10.20	11.60	1.40	15.56	20.70	13.19	14.57	27.76
ATEB	5	1	409.00	0.00	409.00	9.60	10.00	0.40	4.44	92.02	40.90	0.00	40.90
ATEB	6	3	194.00	124.00	318.00	10.50	11.80	1.30	14.44	22.02	16.44	10.51	26.95
ATEB	6	2	184.00	157.00	341.00	10.50	11.70	1.20	13.33	25.58	15.73	13.42	29.15
ATEB	6	1	417.00	0.00	417.00	10.00	10.90	0.90	10.00	41.70	38.26	0.00	38.26

Where; BFI*=basal diet intake;* ***SFI****=supplement feed intake;* ***TFI****=Total feed intake;* ***ADG****=Average daily gain;* ***FCR*** *=Feed Conversion ratio;* ***INWT****=Initial weight;* ***FNWT****=Final weight,* ***WG=*** *Weight gain;* ***TFILW=****Total feed intake per Kilogram liveweight****; BFILW=*** *basal diet intake per Kilogram liveweight****; SFILW=*** *supplement feed intake per Kilogram liveweight.*

			MEAN INTAKE AND GROWTH PERFORMANCE OF SHEEP										
Loc	**REPS**	**TRT**	**BFI**	**SFI**	**TFI**	**INWT**	**FNWT**	**WG**	**ADG**	**FCR**	**BFILW**	**SFILW**	**TFILW**
AMAN	1	3	362.00	180.00	542.00	15.00	17.20	2.20	24.44	22.17	21.05	10.47	31.51
AMAN	1	2	350.00	210.00	560.00	15.00	17.30	2.30	25.56	21.91	20.23	12.14	32.37
AMAN	1	1	672.00	0.00	672.00	15.02	16.50	1.48	16.44	40.86	40.73	0.00	40.73
AMAN	2	3	370.00	201.00	571.00	15.00	17.70	2.70	30.00	19.03	20.90	11.36	32.26
AMAN	2	2	320.00	204.00	524.00	15.00	16.70	1.70	18.89	27.74	19.16	12.22	31.38
AMAN	2	1	724.00	0.00	724.00	15.30	16.00	0.70	7.78	93.09	45.25	0.00	45.25
AMAN	3	3	320.00	210.00	530.00	15.00	16.50	1.50	16.67	31.80	19.39	12.73	32.12
AMAN	3	2	300.00	186.00	486.00	15.20	15.50	0.30	3.33	145.80	19.35	12.00	31.35
AMAN	3	1	686.00	0.00	686.00	15.10	16.40	1.30	14.44	47.49	41.83	0.00	41.83
AMAN	4	3	300.00	216.00	516.00	15.30	16.90	1.60	17.78	29.03	17.75	12.78	30.53
AMAN	4	2	320.00	249.00	569.00	15.30	18.00	2.70	30.00	18.97	17.78	13.83	31.61
AMAN	4	1	616.00	0.00	616.00	15.00	15.60	0.60	6.67	92.40	39.49	0.00	39.49
AMAN	5	3	360.00	234.00	594.00	15.00	17.60	2.60	28.89	20.56	20.45	13.30	33.75
AMAN	5	2	350.00	221.00	571.00	14.60	17.00	2.40	26.67	21.41	20.59	13.00	33.59
AMAN	5	1	694.00	0.00	694.00	15.20	16.00	0.80	8.89	78.07	43.38	0.00	43.38
AMAN	6	3	330.00	240.00	570.00	14.80	17.00	2.20	24.44	23.32	19.41	14.12	33.53
AMAN	6	2	300.00	253.00	553.00	15.20	18.00	2.80	31.11	17.78	16.67	14.06	30.72
AMAN	6	1	670.00	0.00	670.00	14.90	16.70	1.80	20.00	33.50	40.12	0.00	40.12
ATEB	1	3	384.00	135.33	519.33	15.00	17.00	2.00	22.22	23.37	22.59	7.96	30.55
ATEB	1	2	373.00	204.67	577.67	15.20	18.20	3.00	33.33	17.33	20.49	11.25	31.74
ATEB	1	1	631.33	0.00	631.33	14.72	16.70	1.98	22.00	28.70	37.80	0.00	37.80
ATEB	2	3	377.00	158.33	535.33	15.10	16.20	1.10	12.22	43.80	23.27	9.77	33.05
ATEB	2	2	341.00	132.67	473.67	14.80	16.60	1.80	20.00	23.68	20.54	7.99	28.53
ATEB	2	1	635.33	0.00	635.33	14.70	16.30	1.60	17.78	35.74	38.98	0.00	38.98
ATEB	3	3	334.00	201.33	535.33	14.60	15.80	1.20	13.33	40.15	21.14	12.74	33.88
ATEB	3	2	321.00	227.00	548.00	15.20	17.20	2.00	22.22	24.66	18.66	13.20	31.86
ATEB	3	1	635.33	0.00	635.33	14.50	16.50	2.00	22.22	28.59	38.51	0.00	38.59
ATEB	4	3	322.00	142.33	464.33	14.50	16.60	2.10	23.33	19.90	19.40	8.57	27.97
ATEB	4	2	440.00	134.67	574.67	15.20	17.50	2.30	25.56	22.49	25.14	7.70	32.84
ATEB	4	1	678.67	0.00	678.67	15.60	16.20	0.60	6.67	101.80	41.89	0.00	41.89
ATEB	5	3	380.00	142.00	522.00	14.90	17.50	2.60	28.89	18.07	21.71	8.11	29.83
ATEB	5	2	370.00	196.00	566.00	15.80	18.30	2.50	27.78	20.38	20.22	10.71	30.93
ATEB	5	1	674.67	0.00	674.67	15.20	16.20	1.00	11.11	60.72	41.65	0.00	41.65

ATEB	6	3	353.00	188.00	541.00	15.00	16.90	1.90	21.11	25.63	20.89	11.12	32.01
ATEB	6	2	422.00	190.00	612.00	14.80	17.10	2.30	25.56	23.95	24.68	11.11	35.79
ATEB	6	1	703.00	0.00	703.00	15.30	16.20	0.90	10.00	70.30	43.40	0.00	43.40

APPENDIX B:

TREATMENT AND LOCATION MEANS FOR SHEEP AND GOAT PARAMETERS

TREATMENT AND LOCATION MEANS OF GOAT GROWTH PARAMETERS IN ATEBUBU AND AMANTIN

		Feed intake (g/day)			Feed intake (Kg/LW)			Weight (kg)				
		BFI,	**SFI,**	**TFI**	**BFI,**	**SFI,**	**TFI**	**INWT**	**FNWT**	**WG**	**ADG (g)**	**FCR**
Treatments												
T1		431.58^{a}	0.00^{a}	431.58^{a}	39.89^{a}	0.00^{c}	39.89^{c}	10.04	10.83^{b}	0.78^{b}	8.70^{b}	51.95^{a}
T2		199.17^{b}	156.92^{b}	356.08^{b}	16.50^{b}	11.17^{b}	27.68^{a}	10.13	11.73^{a}	1.61^{a}	17.87^{a}	19.30^{b}
T3		193.42^{b}	131.33^{c}	324.75^{c}	17.14^{b}	13.51^{a}	30.65^{b}	10.16	11.63^{a}	1.48^{a}	16.39^{a}	22.01^{b}
SEM		6.315	3.537	6.697	0.647	0.291	0.705		0.101	0.076	0.848	2.64
	Location											
	Amantin	282.94^{a}	90.72^{a}	373.66^{a}	25.13^{a}	7.72^{a}	32.85^{a}	10.16	11.45^{a}	1.29^{a}	14.4^{a}	31.6^{a}
	Atebubu	266.50^{b}	101.44^{a}	367.94^{a}	23.89^{a}	8.75^{b}	32.63^{a}	10.06	11.34^{a}	1.28^{a}	14.3^{a}	30.5^{a}
	SEM	5.16	2.89	5.47	0.528	0.238	0.576		0.082	0.062	0.692	0.692
Statistical interaction												
Feed		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001		<0.0001	<0.0001	<0.0001	<0.0001
Location		0.0355	0.0162	0.4679	0.1110	0.0061	0.7960		0.3785	0.9008	0.9001	0.7075
Loc *Feed		0.7587	0.0800	0.1698	0.805	0.107	0.367		0.057	0.256	0.256	0.785

Where; BFI*=basal diet intake;* ***SFI****=supplement feed intake;* ***TFI****=Total feed intake;* ***ADG****=Average daily gain;* ***FCR*** *=Feed Conversion ratio;* ***INWT****=Initial weight;* ***FNWT****=Final weight,* ***WG=*** *Weight gain;* ***T1= Treatment 1 (base only); T2 = Treatment 2 (base supplemented with cowpea residues); T3 = Treatment 3 (base supplemented with groundnut residues)*** *Loc*Feed=Location by feed interaction.*

TREATMENT AND LOCATION MEANS OF SHEEP GROWTH PARAMETERS IN ATEBUBU AND AMANTIN

		Feed intake (g/day)			Feed intake (Kg/LW)			Weight (kg)				
		BFI	**SFI**	**TFI**	**BFI**	**SFI**	**TFI**	**INWT**	**FNWT**	**WG**	**ADG (g)**	**FCR**
TREATMENT												
T1		668.36 ^{a}	0.00 ^{a}	668.36 ^{a}	41.09^{b}	0.00^{c}	41.09^{b}	15.05	16.28^{b}	1.23^{a}	13.67 ^{a}	59.27 ^{a}
T2		350.58 ^{b}	200.67 ^{b}	551.25 ^{b}	20.29^{a}	11.60^{a}	31.89^{a}	14.93	17.28^{a}	2.18^{b}	24.17 ^{b}	32.18 ^{b}
T3		349.33 ^{b}	187.36 ^{b}	536.69 ^{b}	20.66^{a}	11.09^{a}	321.74^{a}	15.10	16.91^{a}	1.98^{b}	21.94 ^{b}	26.40 ^{b}
SEM		7.973	6.063	9.284	0.491	0.327	0.533	0.252	0.153	0.171	1.899	8.061
	LOCATION											
	AMANTIN	446.89 ^{a}	144.67 ^{a}	591.56 ^{a}	26.86 ^{a}	8.45 ^{a}	35.31 ^{a}	15.05	16.83 ^{a}	1.76 ^{a}	19.56 ^{a}	43.61 ^{a}
	ATEBUBU	465.30 ^{a}	114.02 ^{b}	579.31 ^{a}	27.83 ^{a}	6.68 ^{b}	34.52 ^{a}	15.01	16.81 ^{a}	1.80 ^{a}	20.30 ^{a}	34.96 ^{a}
	SEM	6.510	4.951	7.580	0.401	0.267	0.435	0.069	0.129	0.140	1.550	6.582
Statistical interactions												
Feed		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001		0.0008	<0.0001	<0.0001	0.0207
Location		0.0593	0.0003	0.2670	0.1030	0.0001	0.2109		0.9043	0.7390	0.7390	0.3639
*Loc *Feed*		0.0166	0.0166	0.1904	0.0209	0.0125	0.5734		0.1515	0.4040	0.4040	0.5716

*Where; **BFI**=basal diet intake; **SFI**=supplement feed intake; **TFI**=Total feed intake; **ADG**=Average daily gain; **FCR** =Feed Conversion ratio; **INWT**=Initial weight; **FNWT**=Final weight, **WG**= Weight gain;* ***T1= Treatment 1 (base only); T2 = Treatment 2 (base supplemented with cowpea residues); T3 = Treatment 3 (base supplemented with groundnut residues)*** *LOC*FEED=Location by feed interaction*.

APPENDIX C:

GENERALIZED LINEAR MODEL PROCEDURE (GLM) TABLES FOR SHEEP AND GOATS DM INTAKE FOR SHEEP

DEPENDENT VARIABLE: BASAL FEED INTAKE

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Rep	5	5946.5127	1189.3025	1.56	0.2170
Loc	1	3049.4325	3049.4325	4.00	0.0593
Feed	2	811050.5911	405525.2955	531.55	<.0001
Rep*Loc	5	9941.6016	1988.3203	2.61	0.0569
Loc*Feed	2	7728.9399	3864.4700	5.07	0.0166

DEPENDENT VARIABLE: SUPPLEMENTAL FEED INTAKE

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Rep	5	3553.6285	710.7257	1.61	0.2028
Loc	1	8453.8830	8453.8830	19.16	0.0003
Feed	2	302193.2189	151096.6094	342.50	<.0001
Rep*Loc	5	4679.3218	935.8644	2.12	0.1048
Loc*Feed	2	4465.6489	2232.8244	5.06	0.0166

DEPENDENT VARIABLE: TOTINT

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Rep	5	8385.0064	1677.0013	1.62	0.2001
Loc	1	1348.6032	1348.6032	1.30	0.2670
Feed	2	125052.0139	62526.0069	60.45	<.0001
Rep*Loc	5	6384.6087	1276.9217	1.23	0.3299
Loc*Feed	2	3732.6061	1866.3030	1.80	0.1904

FEED INTAKE PER KILOGRAM LIVEWEIGHT OF SHEEP

DEPENDENT VARIABLE: BASAL FEED INTAKE/KILOGRAM LIVEWEIGHT					
Source	**DF**	**Type III SS**	**Mean Square**	**F Value**	**Pr > F**
Rep	5	11.347981	2.269596	0.79	0.5724
Loc	1	8.439025	8.439025	2.92	0.1030
Feed	2	3398.448622	1699.224311	587.85	<.0001
Rep*Loc	5	42.677892	8.535578	2.95	0.0373
Loc*Feed	2	27.298467	13.649233	4.72	0.0209

DEPENDENT VARIABLE: SUPPLEMENT FEED INTAKE/KILOGRAM LIVEWEIGHT					
Source	**DF**	**Type III SS**	**Mean Square**	**F Value**	**Pr > F**
Rep	5	14.766256	2.953251	2.31	0.0830
Loc	1	28.054678	28.054678	21.90	0.0001
Feed	2	1030.961039	515.480519	402.34	<.0001
Rep*Loc	5	12.806156	2.561231	2.00	0.1227
Loc*Feed	2	14.087339	7.043669	5.50	0.0125

DEPENDENT VARIABLE: TOTAL FEED INTAKE/KILOGRAM LIVEWEIGHT					
Source	**DF**	**Type III SS**	**Mean Square**	**F Value**	**Pr > F**
Rep	5	16.6305917	3.3261183	0.98	0.4557
Loc	1	5.6882250	5.6882250	1.67	0.2109
Feed	2	686.8450667	343.4225333	100.88	<.0001
Rep*Loc	5	28.9403917	5.7880783	1.70	0.1806
Loc*Feed	2	3.8936000	1.9468000	0.57	0.5734

DM INTAKE OF GOATS.

DEPENDENT VARIABLE: BASAL FEED INTAKE					
Source	**DF**	**Type III SS**	**Mean Square**	**F Value**	**Pr > F**
Rep	5	4485.8889	897.1778	1.87	0.1441
Loc	1	2433.7778	2433.7778	5.09	0.0355
Feed	2	443095.7222	221547.8611	462.90	<.0001
Rep*Loc	5	4195.5556	839.1111	1.75	0.1686
Loc*Feed	2	268.0556	134.0278	0.28	0.7587

DEPENDENT VARIABLE: SUPPLEMENT FEED INTAKE					
Source	**DF**	**Type III SS**	**Mean Square**	**F Value**	**Pr > F**
Rep	5	605.5833	121.1167	0.81	0.5582
Loc	1	1034.6944	1034.6944	6.89	0.0162
Feed	2	170103.1667	85051.5833	566.67	<.0001
Rep*Loc	5	341.1389	68.2278	0.45	0.8050
Loc*Feed	2	862.3889	431.1944	2.87	0.0800

DEPENDENT VARIABLE: TOTAL FEED INTAKE					
Source	**DF**	**Type III SS**	**Mean Square**	**F Value**	**Pr > F**
Rep	5	6579.47222	1315.89444	2.45	0.0695
Loc	1	294.69444	294.69444	0.55	0.4679
Feed	2	72381.55556	36190.77778	67.25	<.0001
Rep*Loc	5	3774.13889	754.82778	1.40	0.2658
Loc*Feed	2	2088.22222	1044.11111	1.94	0.1698

FEED INTAKE PER KILOGRAM LIVEWEIGHT OF GOATS

DEPENDENT VARIABLE: BASAL FEED INTAKE/KILOGRAM LIVEWEIGHT					
Source	**DF**	**Type III SS**	**Mean Square**	**F Value**	**Pr > F**
Rep	5	31.707892	6.341578	1.26	0.3179
Loc	1	13.950225	13.950225	2.78	0.1110
Feed	2	4259.295800	2129.647900	424.36	<.0001
Rep*Loc	5	29.578025	5.915605	1.18	0.3542
Loc*Feed	2	2.198467	1.099233	0.22	0.8052

DEPENDENT VARIABLE: SUPPLEMENT FEED INTAKE/KILOGRAM LIVEWEIGHT					
Source	**DF**	**Type III SS**	**Mean Square**	**F Value**	**Pr > F**
Rep	5	3.862822	0.772564	0.76	0.5892
Loc	1	9.548100	9.548100	9.39	0.0061
Feed	2	1252.234772	626.117386	615.79	<.0001
Rep*Loc	5	3.211100	0.642220	0.63	0.6779
Loc*Feed	2	5.082317	2.541158	2.50	0.1074

DEPENDENT VARIABLE: TOTAL FEED INTAKE/KILOGRAM LIVEWEIGHT					
Source	**DF**	**Type III SS**	**Mean Square**	**F Value**	**Pr > F**
Rep	5	43.8277889	8.7655578	1.47	0.2440
Loc	1	0.4096000	0.4096000	0.07	0.7960
Feed	2	972.3737722	486.1868861	81.46	<.0001
Rep*Loc	5	22.3184667	4.4636933	0.75	0.5972
Loc*Feed	2	12.5766167	6.2883083	1.05	0.3673

GROWTH PERFORMANCE OF SHEEP

DEPENDENT VARIABLE: INITIAL WEIGHT					
Source	**DF**	**Type III SS**	**Mean Square**	**F Value**	**Pr > F**
Rep	5	0.21555556	0.04311111	0.49	0.7787
Loc	1	0.01777778	0.01777778	0.20	0.6574
Feed	2	0.18842222	0.09421111	1.07	0.3605
Rep*Loc	5	0.45555556	0.09111111	1.04	0.4223
Loc*Feed	2	0.12722222	0.06361111	0.73	0.4965

DEPENDENT VARIABLE: FINAL WEIGHT					
Source	**DF**	**Type III SS**	**Mean Square**	**F Value**	**Pr > F**
Rep	5	3.14222222	0.62844444	2.10	0.1082
Loc	1	0.00444444	0.00444444	0.01	0.9043
Feed	2	6.23388889	3.11694444	10.40	0.0008
Rep*Loc	5	1.32222222	0.26444444	0.88	0.5110
Loc*Feed	2	1.24388889	0.62194444	2.07	0.1518

DEPENDENT VARIABLE: WEIGHT GAIN					
Source	**DF**	**Type III SS**	**Mean Square**	**F Value**	**Pr > F**
Rep	5	2.59600000	0.51920000	1.48	0.2400
Loc	1	0.04000000	0.04000000	0.11	0.7390
Feed	2	5.95220000	2.97610000	8.49	0.0021

Rep*Loc	5	1.42000000	0.28400000	0.81	0.5560
Loc*Feed	2	0.66500000	0.33250000	0.95	0.4040

DEPENDENT VARIABLE: AVERAGE DAILY GAIN

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Rep	5	320.5010583	64.1002117	1.48	0.2400
Loc	1	4.9358028	4.9358028	0.11	0.7391
Feed	2	734.8705167	367.4352583	8.49	0.0021
Rep*Loc	5	175.2284139	35.0456828	0.81	0.5563
Loc*Feed	2	82.1475389	41.0737694	0.95	0.4038

DEPENDENT VARIABLE: FEED CONVERSION RATIO

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Rep	5	2981.556447	596.311289	0.76	0.5859
Loc	1	673.143025	673.143025	0.86	0.3639
Feed	2	7391.732872	3695.866436	4.74	0.0207
Rep*Loc	5	2897.929758	579.585952	0.74	0.6003
Loc*Feed	2	897.102650	448.551325	0.58	0.5716

GROWTH PERFORMANCE OF GOATS

DEPENDENT VARIABLE: INITIAL WEIGHT

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Rep	5	0.57583333	0.11516667	1.56	0.2171
Loc	1	0.08027778	0.08027778	1.09	0.3097
Feed	2	0.08666667	0.04333333	0.59	0.5656
Rep*Loc	5	0.09805556	0.01961111	0.27	0.9267
Loc*Feed	2	0.22888889	0.11444444	1.55	0.2369

DEPENDENT VARIABLE: FINAL WEIGHT

Source	DF	Type III SS	Mean Square	F Value	Pr > F

Rep	5	1.76472222	0.35294444	2.86	0.0419
Loc	1	0.10027778	0.10027778	0.81	0.3785
Feed	2	5.95388889	2.97694444	24.08	<.0001
Rep*Loc	5	0.29805556	0.05961111	0.48	0.7853
Loc*Feed	2	0.82055556	0.41027778	3.32	0.0569

DEPENDENT VARIABLE: WEIGHT GAIN					
Source	**DF**	**Type III SS**	**Mean Square**	**F Value**	**Pr > F**
Rep	5	1.18222222	0.23644444	3.39	0.0223
Loc	1	0.00111111	0.00111111	0.02	0.9008
Feed	2	4.70722222	2.35361111	33.73	<.0001
Rep*Loc	5	0.24555556	0.04911111	0.70	0.6272
Loc*Feed	2	0.20388889	0.10194444	1.46	0.2557

DEPENDENT VARIABLE: AVERAGE DAILY GAIN					
Source	**DF**	**Type III SS**	**Mean Square**	**F Value**	**Pr > F**
Rep	5	146.0491556	29.2098311	3.39	0.0223
Loc	1	0.1393778	0.1393778	0.02	0.9001
Feed	2	581.0583722	290.5291861	33.69	<.0001
Rep*Loc	5	30.3635556	6.0727111	0.70	0.6269
Loc*Feed	2	25.1834722	12.5917361	1.46	0.2559

DEPENDENT VARIABLE: FEED CONVERSION RATIO					
Source	**DF**	**Type III SS**	**Mean Square**	**F Value**	**Pr > F**
Rep	5	676.334367	135.266873	1.61	0.2019
Loc	1	12.133611	12.133611	0.14	0.7075
Feed	2	7881.584600	3940.792300	47.04	<.0001
Rep*Loc	5	109.996822	21.999364	0.26	0.9282
Loc*Feed	2	41.036956	20.518478	0.24	0.7851

APPENDIX D: MANURE PARAMETERS OF SHEEP AND GOATS

				MEANS OF GOAT MANURE PARAMETERS						
Obs	**Loc**	**TRT**	**REP**	**MWT**	**C**	**N**	**CN**	**PH**	**K**	**Ash**
1	AMAN	1	1	220.00	31.72	1.32	24.03	0.46	0.90	8.00
2	AMAN	2	1	182.00	23.98	2.07	11.58	0.61	1.50	24.00
3	AMAN	3	1	191.00	25.34	2.50	10.14	0.50	1.45	14.00
4	AMAN	1	2	212.00	30.91	1.31	23.60	0.38	0.80	7.50
5	AMAN	2	2	178.00	22.99	2.04	11.30	0.56	1.40	22.50
6	AMAN	3	2	212.00	24.89	2.40	10.37	0.40	1.42	13.00
7	AMAN	1	3	248.00	30.10	1.30	23.15	0.30	0.70	7.00
8	AMAN	2	3	214.00	22.00	2.00	11.00	0.50	1.30	21.00
9	AMAN	3	3	199.00	24.43	2.30	10.62	0.30	1.39	12.00
10	AMAN	1	4	175.00	29.73	1.86	15.98	0.38	0.85	15.00
11	AMAN	2	4	168.00	27.33	1.85	14.77	0.50	1.54	14.00
12	AMAN	3	4	232.00	21.35	2.04	10.47	0.35	1.64	11.00
13	AMAN	1	5	193.00	29.42	1.81	16.25	0.35	0.83	14.00
14	AMAN	2	5	172.00	27.22	1.88	14.51	0.45	1.53	13.50
15	AMAN	3	5	221.00	21.19	2.02	10.49	0.33	1.62	11.50
16	AMAN	1	6	210.00	29.10	1.76	16.53	0.32	0.81	13.00
17	AMAN	2	6	158.00	27.10	1.90	14.26	0.40	1.52	13.00
18	AMAN	3	6	242.00	21.03	2.00	10.52	0.31	1.59	12.00

19	ATEB	1	1	241.00	36.11	1.90	19.01	0.86	3.20	18.00
20	ATEB	2	1	220.00	25.34	2.02	12.54	0.61	2.37	18.20
21	ATEB	3	1	146.00	20.15	2.08	9.69	0.78	2.09	11.00
22	ATEB	1	2	221.00	36.56	1.95	18.75	0.88	3.10	18.50
23	ATEB	2	2	241.00	25.67	1.96	13.10	0.56	2.38	17.60
24	ATEB	3	2	162.00	19.98	2.09	9.65	0.77	2.10	11.50
25	ATEB	1	3	214.00	37.00	2.00	18.50	0.90	3.00	19.00
26	ATEB	2	3	250.00	26.00	1.90	13.10	0.51	2.40	17.00
27	ATEB	3	3	176.00	19.80	2.10	9.43	0.76	2.10	12.00
28	ATEB	1	4	175.00	25.34	1.80	14.08	0.35	1.45	15.00
29	ATEB	2	4	192.00	25.74	2.23	11.54	0.57	2.55	23.00
30	ATEB	3	4	182.00	19.35	2.09	9.26	0.48	2.54	24.00
31	ATEB	1	5	182.00	24.67	1.70	14.51	0.34	1.48	14.50
32	ATEB	2	5	186.00	25.87	2.32	11.17	0.59	14.28	22.00
33	ATEB	3	5	212.00	19.18	2.05	9.38	0.48	2.37	23.00
34	ATEB	1	6	212.00	24.00	1.60	15.00	0.32	1.50	14.00
35	ATEB	2	6	221.00	26.00	2.40	10.83	6.00	26.00	21.00
36	ATEB	3	6	202.00	19.00	2.00	9.50	0.47	2.20	22.00

Where Obs*=Observations;* ***Loc****=Location;* ***AMAM****=Amantin;* ***ATEB****=Atebubu;* ***TRT****=Treatments;* ***REP****=Replications;* ***MWT****=Manure weight;* ***C****=Carbon;* ***N****=Nitrogen;* ***CN****=Carbon:Nitrogen ratio;* ***pH****=Level of Acidity;* ***K****=Potassium.*

				MEANS OF SHEEP MANURE PARAMETERS						
Obs	**Loc**	**TRT**	**REP**	**MWT**	**C**	**N**	**CN**	**PH**	**K**	**Ash**
1	AMAN	1	1	422.00	29.73	1.96	15.17	0.44	0.82	9.00
2	AMAN	2	1	323.00	18.55	1.79	10.36	0.44	1.55	28.00
3	AMAN	3	1	412.00	23.74	2.21	10.74	0.83	1.69	31.00
4	AMAN	1	2	375.00	29.87	1.98	15.08	0.42	0.81	9.50
5	AMAN	2	2	220.00	18.78	1.80	10.46	0.44	1.53	26.50
6	AMAN	3	2	428.00	23.87	2.11	11.34	0.82	1.64	30.00
7	AMAN	1	3	382.00	30.00	2.00	15.00	0.40	0.80	10.00
8	AMAN	2	3	412.00	19.00	1.80	10.56	0.43	1.50	25.00
9	AMAN	3	3	432.00	24.00	2.00	12.00	0.80	1.59	29.00
10	AMAN	1	4	372.00	26.53	1.72	15.42	0.46	0.74	20.00
11	AMAN	2	4	342.00	23.34	1.97	11.85	0.40	1.13	26.00
12	AMAN	3	4	365.00	27.73	2.19	12.66	0.42	1.65	20.00
13	AMAN	1	5	402.00	26.72	1.76	15.18	0.48	0.73	19.50
14	AMAN	2	5	320.00	22.72	1.99	11.45	0.45	1.17	26.50
15	AMAN	3	5	385.00	27.92	2.20	12.77	0.47	1.68	20.50
16	AMAN	1	6	400.00	26.90	1.80	14.94	0.50	0.72	19.00
17	AMAN	2	6	298.00	22.10	2.00	11.05	0.50	1.21	27.00

18	AMAN	3	6	372.00	28.10	2.20	12.77	0.51	1.70	21.00
19	ATEB	1	1	355.00	33.32	2.30	14.49	0.75	3.17	30.00
20	ATEB	2	1	382.00	22.94	2.16	10.62	0.88	3.81	4.00
21	ATEB	3	1	402.00	27.73	2.08	13.33	0.69	2.55	17.00
22	ATEB	1	2	323.00	31.66	2.25	14.07	0.73	3.09	28.50
23	ATEB	2	2	398.00	22.42	2.33	9.62	0.89	3.85	4.05
24	ATEB	3	2	472.00	27.02	1.98	13.68	0.43	1.99	20.50
25	ATEB	1	3	375.00	30.00	2.20	13.64	0.70	3.00	27.00
26	ATEB	2	3	414.00	21.90	2.50	8.76	0.90	3.88	4.10
27	ATEB	3	3	455.00	27.10	1.98	13.69	0.44	1.90	20.00
28	ATEB	1	4	402.00	26.53	1.68	16.08	0.70	1.51	14.00
29	ATEB	2	4	320.00	28.93	2.32	12.47	0.68	2.21	16.00
30	ATEB	3	4	314.00	26.93	1.97	13.67	0.42	2.07	21.00
31	ATEB	1	5	398.00	26.37	1.56	16.95	0.65	1.51	13.45
32	ATEB	2	5	412.00	28.47	2.32	12.30	0.64	2.16	15.00
33	ATEB	3	5	482.00	26.92	1.99	13.53	0.59	2.48	16.40
34	ATEB	1	6	413.00	26.20	1.46	17.95	0.60	1.50	12.90
35	ATEB	2	6	420.00	28.00	2.31	12.12	0.60	2.10	14.00
36	ATEB	3	6	415.00	26.10	1.90	13.74	0.50	2.40	15.80

***Where Obs**=Observations; **Loc**=Location; **AMAM**=Amantin; **ATEB**=Atebubu; **TRT**=Treatments; **REP**=Replications; **MWT**=Manure weight; **C**=Carbon; **N**=Nitrogen; **CN**=Carbon:Nitrogen ratio; **pH**=Level of Acidity; **K**=Potassium.*

APPENDIX E:
GENERALIZED LINEAR MODEL PROCEDURE (GLM) TABLES OF MANURE PARAMETERS

MANURE PARAMETERS OF SHEEP

DEPENDENT VARIABLE: MANURE WEIGHT					
Source	**DF**	**Type III SS**	**Mean Square**	**F Value**	**Pr > F**
REP	5	13381.55556	2676.31111	1.55	0.2201
Loc	1	6669.44444	6669.44444	3.86	0.0636
TRT	2	18897.72222	9448.86111	5.47	0.0128
REP*Loc	5	9548.22222	1909.64444	1.10	0.3890
Loc*TRT	2	11217.72222	5608.86111	3.24	0.0602

DEPENDENT VARIABLE: CARBON

Source	DF	Type III SS	Mean Square	F Value	Pr > F
REP	5	8.0859556	1.6171911	0.21	0.9529
Loc	1	42.1201000	42.1201000	5.55	0.0288
TRT	2	187.7308722	93.8654361	12.37	0.0003
REP*Loc	5	8.7868000	1.7573600	0.23	0.9442
Loc*TRT	2	29.0275167	14.5137583	1.91	0.1737

DEPENDENT VARIABLE: NITROGEN					
Source	**DF**	**Type III SS**	**Mean Square**	**F Value**	**Pr > F**
REP	5	0.12464722	0.02492944	0.76	0.5888
Loc	1	0.09100278	0.09100278	2.78	0.1113
TRT	2	0.32428889	0.16214444	4.95	0.0180
REP*Loc	5	0.18951389	0.03790278	1.16	0.3646
Loc*TRT	2	0.55742222	0.27871111	8.50	0.0021

DEPENDENT VARIABLE: CARBON: NITROGEN (C/N) RATIO					
Source	**DF**	**Type III SS**	**Mean Square**	**F Value**	**Pr > F**
REP	5	16.5014806	3.3002961	5.47	0.0025
Loc	1	3.9402250	3.9402250	6.54	0.0188
TRT	2	115.0226389	57.5113194	95.40	<.0001
REP*Loc	5	4.2732583	0.8546517	1.42	0.2607
Loc*TRT	2	3.8387167	1.9193583	3.18	0.0630

DEPENDENT VARIABLE: pH					
Source	**DF**	**Type III SS**	**Mean Square**	**F Value**	**Pr > F**
REP	5	0.11193333	0.02238667	1.85	0.1483
Loc	1	0.18490000	0.18490000	15.30	0.0009
TRT	2	0.00815000	0.00407500	0.34	0.7178
REP*Loc	5	0.01743333	0.00348667	0.29	0.9138
Loc*TRT	2	0.34661667	0.17330833	14.34	0.0001

DEPENDENT VARIABLE: POTASSIUM

Source	DF	Type III SS	Mean Square	F Value	Pr > F
REP	5	3.15445556	0.63089111	3.47	0.0202
Loc	1	14.08751111	14.08751111	77.56	<.0001
TRT	2	2.53642222	1.26821111	6.98	0.0050
REP*Loc	5	1.86418889	0.37283778	2.05	0.1145
Loc*TRT	2	2.09128889	1.04564444	5.76	0.0106

DEPENDENT VARIABLE: ASH					
Source	**DF**	**Type III SS**	**Mean Square**	**F Value**	**Pr > F**
REP	5	12.9308333	2.5861667	0.06	0.9969
Loc	1	299.2900000	299.2900000	7.34	0.0135
TRT	2	126.8587500	63.4293750	1.56	0.2355
REP*Loc	5	18.5975000	3.7195000	0.09	0.9927
Loc*TRT	2	829.6587500	414.8293750	10.17	0.0009

MANURE PARAMETERS OF GOATS

DEPENDENT VARIABLE: MANURE WEIGHT					
Source	**DF**	**Type III SS**	**Mean Square**	**F Value**	**Pr > F**
REP	5	3198.888889	639.777778	1.02	0.4318
Loc	1	1.777778	1.777778	0.00	0.9581
TRT	2	848.388889	424.194444	0.68	0.5195
REP*Loc	5	407.888889	81.577778	0.13	0.9837
Loc*TRT	2	8656.722222	4328.361111	6.91	0.0052

DEPENDENT VARIABLE: CARBON					
Source	**DF**	**Type III SS**	**Mean Square**	**F Value**	**Pr > F**
REP	5	46.7063583	9.3412717	1.00	0.4424
Loc	1	5.4990250	5.4990250	0.59	0.4516
TRT	2	496.1222167	248.0611083	26.59	<.0001
REP*Loc	5	35.9190250	7.1838050	0.77	0.5824
Loc*TRT	2	32.3912167	16.1956083	1.74	0.2018

DEPENDENT VARIABLE: NITROGEN					
Source	**DF**	**Type III SS**	**Mean Square**	**F Value**	**Pr > F**
REP	5	0.01084722	0.00216944	0.04	0.9987
Loc	1	0.09302500	0.09302500	1.90	0.1829
TRT	2	1.33575556	0.66787778	13.67	0.0002
REP*Loc	5	0.00975833	0.00195167	0.04	0.9990
Loc*TRT	2	0.27686667	0.13843333	2.83	0.0826

DEPENDENT VARIABLE: CARBON: NITROGEN (C/N) RATIO					
Source	**DF**	**Type III SS**	**Mean Square**	**F Value**	**Pr > F**
REP	5	26.0155583	5.2031117	1.02	0.4347
Loc	1	25.8911361	25.8911361	5.05	0.0360
TRT	2	437.2651500	218.6325750	42.66	<.0001

REP*Loc	5	1.2443139	0.2488628	0.05	0.9983
Loc*TRT	2	11.3260056	5.6630028	1.11	0.3506

DEPENDENT VARIABLE: pH					
Source	**DF**	**Type III SS**	**Mean Square**	**F Value**	**Pr > F**
REP	5	3.22431389	0.64486278	0.71	0.6249
Loc	1	2.16580278	2.16580278	2.37	0.1390
TRT	2	1.98370556	0.99185278	1.09	0.3562
REP*Loc	5	3.77571389	0.75514278	0.83	0.5447
Loc*TRT	2	1.03473889	0.51736944	0.57	0.5759

DEPENDENT VARIABLE: POTASSIUM					
Source	**DF**	**Type III SS**	**Mean Square**	**F Value**	**Pr > F**
REP	5	74.00976667	14.80195333	0.85	0.5278
Loc	1	81.96284444	81.96284444	4.73	0.0417
TRT	2	81.72061667	40.86030833	2.36	0.1202
REP*Loc	5	71.07395556	14.21479111	0.82	0.5492
Loc*TRT	2	67.46763889	33.73381944	1.95	0.1687

DEPENDENT VARIABLE: ASH					
Source	**DF**	**Type III SS**	**Mean Square**	**F Value**	**Pr > F**
REP	5	21.9391667	4.3878333	0.24	0.9402
Loc	1	157.5025000	157.5025000	8.60	0.0082
TRT	2	185.2550000	92.6275000	5.06	0.0167
REP*Loc	5	67.8058333	13.5611667	0.74	0.6020
Loc*TRT	2	26.4050000	13.2025000	0.72	0.4984