UNIVERSITY FOR DEVELOPMENT STUDIES

CHEMICAL COMPOSITION, *IN VITRO* GAS PRODUCTION AND GROWTH PERFORMANCE OF SHEEP FED HAULMS OF FOUR VARIETIES OF GROUNDNUT

BY

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DECLARATION

This is to affirm that this thesis has been authored by me and has neither been submitted for a degree nor any aspect published by another person elsewhere. All cited literature in this text has been well referenced and any assistance received in writing this thesis is duly acknowledged.

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ABSTRACT

Two separate experiments were conducted; the first experiment was conducted specifically to identify the nutritive characteristics of haulms of 4 groundnut varieties and their impact on body weight and haematological profile of the experimental rams while the second experiment was conducted to determine the effect of supplementation of Napier grass with haulms of 4 different groundnut varieties on the nutrient composition and digestibility of Napier grass under *in vitro* gas production. The experimental diets were groundnut haulms of Obolo (ICGV 97049), Yenyawoso (ICGX SM 87057), Azivivi (RMP 12) and Manipinta varieties. Sixteen Djallonké rams (weigh 15.0 ± 3.0kg initially) were housed in a separate pens with concrete floors and fed groundnut haulms for *ad libitum* for 56 days; four rams were assigned to one variety of the haulm. Dried samples of haulms were milled and sieved (2mm) for dry matter (DM), crude protein (CP), neutral detergent fiber (NDF) and acid detergent fiber (ADF) analysis. The crude protein concentrations in the haulms of Azivivi (101.1g), Manipinta (92.0g) and Yenyawoso (102.9g) were insignificantly different (*P<0.05*) but lowest crude protein value was recorded in the haulms of Obolo (6.8%). Haulms of Obolo variety had the highest neutral detergent fibre and acid detergent fibre fractions (*P<0.05*). Rams fed haulms of Obolo varieties had the least daily CP intake (60.9g) and the highest daily NDF (481.7g) and ADF (448.5g) intake. Haulms of Yenyawoso variety had the highest NDF (69.2%DM) and ADF (68.4%DM) digestibility while the lowest NDF (55.8%DM) and ADF (58.8%DM) digestibility were found in the haulms of Obolo. Haulms of Yenyawoso variety had high effect on the final live weight (17.6kg) and live weight gain (2950kg) of rams. Rams fed haulms of the four different groundnut varieties did not show significant

(*P<0.05*) difference in White blood cells, Red blood cells, haemoglobin, haematocrit, Mean Cell Volume and Platelets. The replacement of 60% Napier grass with the GHM increases the crude protein values of Obolo + Napier, Manipinta + Napier, Azivivi + Napier and Yenyawoso +Napier by 0.9%, 32.9%, 40.6% and 72% respectively. Lowest NDF and ADF values were observed in the Yenyawoso +Napier treatment while Obolo + Napier treatment had the highest. The correlation analysis revealed a positive (P<0.01) relationship in the CP values of IVOMD, ME and asymptote gas production but the NDF and ADF had a negative (P<0.01) effect on IVOMD, ME and asymptote gas production.

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DEDICATION

This thesis is dedicated to my father, Yacub Zanabongo, my mother, Sirina Alhassan and my children.

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LIST OF ABBREVIATIONS

ADF: Acid Detergent Fibre

ANOVA: Analysis of variance

AOAC: Association of Analytical Chemists

ADWG: Average Daily Weight Gain

ADG: Average Daily Gain

BUN: Blood Urea Nitrogen

CP: Crude Protein

CRI: Crop Research Institute

CSIR: Council for Scientific and Industrial Research

DM: Dry Matter

DMD: Dry Matter Digestibility

DMI: Dry Matter Intake

FAO: Food and Agriculture Organization

H_2SO_4: Sulphuric Acid

HCL: Hydrochloric acid

IITA: International Institute of Tropical Agriculture

IVDMD: *In vitro* Dry Matter Digestibility

IVOMD: *In vitro* Organic Matter Digestibility

NDF: Neutral Detergent Fibre

NaOH: Sodium Hydroxide

CHAPTER ONE

1.0 INTRODUCTION

Groundnut, botanically known as *Arachis hypogaea* (L), is a very important legume crop grown in several countries in the world under a varying weather conditions (Upadhyaya *et al*., 2006) of which Ghana is inclusive. It has been reported that 48%-50% of the groundnut seed is made up of oil, 26%-28% is made up of protein and 11%-27% is made up of carbohydrate (El Naim *et al*., 2011; Ibrahim *et al.*, 2013). The groundnut being a source of food (seeds) for humans, the haulms are harvested and preserved as hay for sole feeding farm animals or being supplemented to other crop residues. Research Institutions worldwide have included yield performance of groundnut, duration of maturity of the groundnut and resistance of groundnut to pest or disease attack in the varietal enhancement programmes for groundnut production as some of the objectives (Pande *et al.*, 2003, Parthasarathy and Hall, 2003). But Larbi *et al*. (1999) have excluded yield performance and forage quality from the selection criteria for groundnut improvement programmes.

Larbi *et al*. (1999) observed variations in the nutritional value of groundnut haulms of different varieties but Etela and Dung (2011) did not find difference in the nutritional values of different groundnut haulms. However, significant variations in the body weight of Djallonké sheep fed different groundnut haulms was reported (Etela and Dung, 2011). Similarly, significant increase was observed on the live weight of lambs fed crop residues from non-legume source supplemented groundnut haulms (Abdou *et al*., 2011).

Growth performance studies which was conducted, indicated positive impact on the growth of livestock with groundnut haulms supplementation (Ikhatua and Adu, 1984;

Abdou *et al*., 2011). Cereal residues and legume residues are mostly used by middlemen to fatten rams for sale particularly in the dry season.

According to Devendra (1997) the nutritional value of forage lies on the biomass yield, forage intake, nutrient digestibility and rate of growth of the animal which can be excellently examined through sole feeding. There is a very little information on assessing the impact of sole feeding groundnut haulms to farm animals, this information is significant to smallholder ruminant farmers. However, it is reported by Etela and Dung (2011) that the nutrient intake and growth of Djallonké sheep was not compromised when fed groundnut haulm from 6 multi-purpose varieties as a sole diet.

Grass constitute the greatest carbohydrate source for ruminant livestock nutrition in the tropics yet nutrient digestibility in them is low because of the high amount of recalcitrant fiber in them and more importantly low concentration of nitrogen. However, Haulms of leguminous crops are major source of nitrogen for ruminant livestock nutrition. Haulms are preserved as hay by ruminant farmers and are fed to ruminant under extensive system as supplement or as a sole diet in the dry season where other crop residues are unavailable.

1.1 OBJECTIVES

The study was conducted mainly to identify the most desired nutrient characteristics among the haulms of the 4 multi-purpose groundnut varieties for intensive feeding of small ruminants during dry season.

1.1.1 Specific Objectives for the study

The study was carried out specifically:

i. To identify the nutritive characteristic of haulms of four varieties of groundnut and their impact on body weight and haematological profile of the experimental rams.

ii. To determine the effect of supplementation of Napier grass with haulms of four different groundnut varieties will impact on nutrient constituents and digestibility of Napier grass under the *in vitro* gas production.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 ORIGIN AND DISTRIBUTION OF SHEEP

The Djallonké sheep is believed to have evolved from ancient Egyptian sheep (*Ovis longipes palaeoegypticus*) which was extensively disseminated throughout the West African countries and Central African countries (Yapi-Gnaore *et al.*, 1997).

The bushy thin tailed type of sheep came from Western part of Asia and was introduced to Africa by Isthmus of Suez and Bab el Mandeb. This type of sheep was the sole breed in the Africa in the third millennium before Christ. Epstein (1971) reported differently that this breed of sheep reached Egypt and many countries in Africa by 5,000BC.

Mason (1951) reported that the Djallonké sheep are commonly found in countries south of the latitude 14°N which include Nigeria, Benin, Ghana, Ivory Coast, Guinea, Senegal, Cameroon, Gabon, Congo and Southern French Sudan. They are also be found in Angola and Botswana.

Djallonké sheep are usually found to be white coloured with black or red spot. Some have their bellies tanned with black colours. They have 40-60 cm standing height and thus, weighs 20-30 kg which give account for their little size (DAGRIS, 2005).

A report by AfDB (2001) described the WAD breed as a small animal weighing 25-30kg for adult males and 20-25kg for adult females which do not possess dwarfism traits but are known for their resilience and virility which make them suitable for all year round breeding.

The rams have crescent horns which are angular in shape while the ewes are either polled or with little scabs in the horn area on the head. Their eyes are large with straight back and their tail is justly bushy at the base where it ends at the hocks.

The Djallonké sheep are well acclimatized to the harsh tropical weather conditions and are resilient to trypanosomiasis (Osaer, 1998, 2000; DAGRIS, 2005). WAD sheep are small in size, but physically and sexually strong, their prolificacy in West Africa varies from 110% (Ginisty, 1976) to 161% (Dettmers and Hill, 1974) and they have good reproductive attributes which include the following: they lamb an early age of 18.8 months with an interval of 10 months and a median flock size of 1.22 (DAGRIS, 2005), with variation of 1.0 to 1.7 depending on country and breed type; for Senegal, it is 1.12 lambs and in Ghana it is 1.7 lambs, ewes have active production lifespan of 5.8 years (ILCA, 1982). From literature report (DAGRIS, 2005) the average lambing interval is 257.95 days which starts from 191 to 344 days.

Ryder (1999) asserted that the adaptive features of WAD sheep like resistant to stress and disease particularly trypanosomiasis; thus, they are able to withstand stress and the effect of rainfall and humidity of sub-equatorial and equatorial climates.

2.1.1 Sheep Distribution and Production in Ghana

The livestock sub-sector, together with poultry, is a vital part of Ghana's agricultural sector and providing sustenance to the farming families. According to a report (GSS, 2015) Ghana's agriculture sector grew by 5.2% while the livestock sub-sector grew by 5.3% in 2014.

From documented report (MoFA, 2014), the Economic growth of the activities within the livestock sub-sector grew by 4.5% from January to March of 2015 as against 1.3%

growth from October to December of 2014. These achievement in livestock sub-sector for the year 2015 is attributable to the interventions made in the sector by the credit- in-kind programme of Livestock Development Project and the Ghana's Broiler Re-vitalization Project, indicates that there is greater opportunity for expansion of the livestock sector in Ghana.

The most common system of rearing livestock in Ghana is the extensive system in which sheep roam freely to find feed for themselves. Animals from various household graze together and thus mating is uncontrolled. The advantage attached to this system is low cost investment with low benefits. The animals graze freely on available pastures which include grasses and open space around the villages as well as fallow farmlands. The dissemination of sheep and goats to African countries is not uniform and population of these animals are inclined to the drier areas of Africa. Thus, flock numbers are higher in drier areas than in the humid areas of Africa. Therefore, in some countries in West Africa flock numbers declines moving from northern to southern parts of these countries in West Africa (ILCA, 1979; Otchere *et al*., 1985). The production of sheep and goats in Ghana far exceed that of cattle with a recorded population of sheep being 3.5 million and that of goats 4.3 million(VSD, 2009). This put an important emphasis on sheep and goats production, being higher than cattle.

In Guinea, the population of Djallonké was estimated to be half a million but in Ghana the population of Djallonké was estimated to be 1.8 million (DAD-IS, 2005). The population of livestock are 1,657,000cattle, 4,335,000sheep, 6,044,000goats, 682,000pigs and 68,511,000poultry in 2014; increased from 2009 to 2014 at a rate of 15.2% for cattle, 19% for sheep, and 30.7 % for goats, 30.9% for pigs and 58.2% for poultry with an average growth rate of 2.8% for cattle, 3.5% for sheep, 5.5% for goats and pigs, and 9.6% for poultry in Ghana (SRID, 2014).

Table 1: Population of Sheep in Ghana from 2009 to 2014 in tonnes

Type of Livestock	2009	2010	2011	2012	2013	2014
Sheep	**3,642**	**3,759**	**3,887**	**4,019**	**4,156**	**4,335**

Source: SRID (2014).

Sheep production in Ghana increased each year between the periods of 2000 to 2014, and within the same period mutton production increased except in 2008 to 2009 where there was a decline from 220, 243 tonnes to 216, 614 tonnes; however, in 2014, it was reported that Ghana produced 4,335,000 live sheep but Mutton production was 254,712 tonnes in 2013 (FAO, 2015). From table (1) above, the population of sheep in Ghana increased from 2009 to 2014 by 3% on the average.

Leng (1997) reported that the unproductive digestion in the rumen and inept consumption of low quality feed resulting in the poor absorption of nutrients by livestock in the tropics.

2.1.2 Importance of Small ruminant

The significance of small ruminants which include nutrition, financial gain and intangible ends such as an insurance against emergencies, cultural and ceremonial purposes as well as saving for the general well-being of individuals in developing countries can't be overemphasized.

Small ruminants play vital part in the provision of food (meat) and incomes for large number of farming families (Lebbie, 2004). Sheep and goats are reared for numerous reasons like financial gains, religious events, food, hobby and insurance against as crop failure (Ozung *et al*., 2011). Sheep production have contributed significantly to food security and poverty reduction and thus, improve the livelihood of smallholder producers (Winrock International, 1992).

The livestock sub-sector of Agriculture in Ghana is key in the provision of food and nutritional security; meeting the protein requirement of the population. It is also a source of employment to many people especially in the rural area. It is an avenue for wealth generation boosting incomes of smallholder farmers, insurance against crop failure, and financial security in the periods of financial distress and thus, improvement in livelihoods of rural households (MoFA, 2008).

Charray *et al*. (1992) reported that live animals are offered as gifts which have more value than its carcass in terms of strengthening human relationship and also serve as a symbol of appreciation, and thus used to pay bride prices.

Sheep rearing in Ghana is principally for meat production exploitation the Djallonké and Sahellian Sheep and their cross breeds (Ockling, 1986; MoFA, 2000). The WAD sheep apart from being a source of meat and income to many people, has significant social purposes including religious and funeral ceremonies in West Africa.

In Ghana, more than 100,000 homes rely on livestock production and products from livestock for their sustenance in the many communities of northern Ghana (GSS, 2008).

The preference of investing in sheep to large ruminants include low investment, small risk of loss, high multiplicative efficiency and cost-effective use of accessible land (Omoike *et al*., 2006).

It is stress-free to increase the population of sheep than cattle because the reproductive turnover of sheep is higher; ewe can lamb every eight months with an interval less than two years when conditions are favourable. Also, the capital investment for sheep farming is relatively low with small land holdings and the small size of sheep makes them easy to control which is more suitable for smallholder family operations. In the extensive system, the ownership of sheep is generally for social prestige. In addition, the livestock breeders under the extensive system give more preference to the number of sheep that they owned to the benefit gained from the animal, even though they sell some of them to buy food and to slaughter some of them to celebrate ceremonies (Francis *et al*., 2009). Farmers also sell sheep in bad crop years to provide Food security. However, in the smallholder farming system, sheep production and cash income generation are more attractive than animal numbers. Thus, they raise sheep to increase their incomes (Sangaré *et al*., 2002; Ayatounde *et al*., 2007) by selling them in local livestock markets. Sheep manure are used as fertilizer in crop production and as fuel for cooking. Keeping sheep and eating mutton are activities which are virtually free from cultural and religious barriers (Animut *et al*., 2002; Attoh-Kotoku, 2003).

The production of West African Dwarf (WAD) sheep relative to their size is greater than that of cattle and they are better meat producers than N'dama cattle under comparable environmental conditions and management (Charray *et al*., 1992).

Livestock production is a source of reliable income to farming families when prices of crops have fallen, which stabilizes the socioeconomic capability of households (Oppong-Anane, 2013).

Sheep production is additionally a key capital quality for poor families, creating associate degree indirect contribution to rural impoverishment reduction. In addition, it offers rapid growth opportunities for income generation where the necessary internal market exists. This is because there is an expanding urban market as urbanization is usually related to increasing household incomes which affect the consumption lifestyles of households of which more food are consumed out homes (Delgado *et al*., 1999); which is the reason for the demand for food including livestock products.

Sheep and goats play a harmonizing role with other livestock for the consumption of accessible feed materials and provide a useful means of exhausting the immense parts of natural grassland in areas where crop production is impossible (Baker and Rege, 1994). Sheep produce meat and other useful products at comparatively lower cost using feed ingredients from marginal lands. Small ruminants are able to double the maximum amount of meat produced per animal unit within the tropics compared to cows. Sheep produce tender meat which compete favourable with grass-fed beef and thus, can be sold at a much younger age than other livestock. Mutton is more recognized in the livestock marketing systems than chevon. The meat of sheep and goats under one year of age are delicious, thus sheep can supply meat proficiently at a low cost of production (Terril, 1983). Mutton is widely consumed across all the regions in Ghana with no taboo associated with the consumption of the meat among the various ethnic groups.

Baiden and Obese (2010) reported that small ruminant production in Ghana is basically practiced under traditional extensive system where animals graze on low-quality fodder supplemented with household waste eg: peels of cassava, yam, plantain and cocoyam which don't seem to be perpetually out there in adequate amounts leading to low levels of productivity (reduced growth and generative performance) and loss of animals particularly lambs.

The world's average value in 1990-1992 of the meats and milks produced was estimated at 214.9 million dollars, higher than the value of the most sold cereals (corn and rice) in the developing countries (FAO, 2010). Where agricultural factories are developed for the transformation of milk and meat into finished products a lot of employment are generated (FAO, 1994). Consumption of meat and meat products in Ghana has been rising with an attendant increase in demand for feed by the livestock (FAO, 2005). The Guinea and Sudan Savanna Zone of Ghana together supply about 75% cattle, 35 % sheep and goat in Ghana (Oppong-Anane, 2006).

The production of livestock and its productivity are however, far below the Populations requirement for animal protein which has led to the surge of imported meat and meat products in the country to augment the supply chain (FAO, 2005).

2.1.3 Constraints of Small Ruminants Production

Contribution made by the livestock sub-sector including the fisheries to the total agricultural GDP is 17.4% (MoFA, 2010).

Residues from cereals have low digestibility, crude protein, minerals and vitamins (Owen, 1994).

Protein is usually a restrictive factor for growth and milk production in ruminant production systems (Minson, 1990). Oppong-Anane (2013) reported that feed shortages is a major challenge for the production livestock in Northern region of Ghana.

Awuma (2012) reported that compound farming around homestead in many rural communities have made feed inaccessible during the wet season which have impacted negatively on the production of livestock in Northern Ghana. Beside different restrictive factors, the feed shortage (or inaccessibility of feed) contribute considerably to low productivity in livestock.

Ruminant animals feeding on poor quality roughages exhibits decreased feed intake, weight loss, and increased susceptibility to health risk and reduced production performances (Aganga and Tshwenyane, 2003).

Annor *et al*. (2007) reported that slow growth rate, unstable weight gains related to seasonal imbalances of feeds and reproductive inefficiencies are the challenges facing small scale sheep and goats farmers in Ghana for not generating enough income from their stock.

Okai *et al*. (2005) observed that an average importation of 70% livestock and /or its products to satisfy Ghana's domestic requirements is a problem militating against livestock production in Ghana. 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).

It has been recognized that ruminants gain weight in the rainy season as there are abundant green natural pasture which are nutritionally rich, but lose weight during the dry season because they feed on low quality fodder which is compounded by their unavailability (Annor et al., 2007). This underscores the need for supplementation during the dry season to either maintain or improve weight of ruminants. Indeed, supplementation often relies on the energy rich grains. This is, however, often scarce and expensive and not economical to use (Karbo *et al*., 2002).

2.2 FEED RESOURCES FOR SMALL RUMINANT

2.2.1Agro-Industry by-products

Agro-industrial by-products are less hard to chew, more pondered, highly nourishing and less costly as compared to crop residues (Aguilera, 1989).

Agricultural by-products such as cassava peels, cocoa husks, maize cobs, and wheat offal are now widely used in feeding animals. These by-products are now considered as feed rather than a waste product, used to feed animals to produce meat for human consumption (Iyeghe-Erakpotobor *et al*., 2002).

Salifu (2004) reported that sheanut cake may be added to the diet of sheep by 15% without compromising the performance of livestock. Sheanut cake used to feed livestock have impacted positively on the nutrient intake (such as organic matter intake, organic and crude fibre intake), organic matter digestibility and nitrogen free extract (Bhatia and Pantayak, 1988). Lambs fed processed grains have improved body weight and feed efficiency ratio (Economides *et al*., 1990).

Cheeke (2005) reported that wheat bran has well balanced amino acid and high soluble vitamin except niacin which aid in preventing constipation and water holding capacity.

Varner and Wood (1975) observed that inclusion rate of 50% of wheat bran in ration formulation can decrease feed intake of livestock and thus, increase the lactate content in the rumen.

Yuangklang et al. (2005) reportable that low fibre-low macromolecule feeds square measure non-inheritable from renewable energy crops like sugarcane by-products and root crops. In addition, low fibre-low protein feeds mostly have high energy content but low protein content. Agro-industrial by-products also include oil palm slurry, molasses and by-products from fruit (citrus pulp, pineapple waste, tomato pomace) and cassava processing industry (Ngamsaeng, 2005). Low digestibleness may be a common characteristic of such feeds, as well as low macromolecule content and an occasional mineral content. After extraction of the oil from groundnut, groundnut cake obtained have high protein and high energy content which can be

used as a supplement in feeding cows that are lactating calves to produce more milk and also used for fattening livestock (Larbi *et al*., 1999).

Rice straw contains 32-43% cellulose, 19-25% hemicelluloses, 5-12% lignin, 18.8% ash (14-16%) and 10-12% nitrogen free extracts, which is the most abundant lignocellulose crop residues (Yoswathana and Phuriphipat, 2010). The localization of the processing factories in urban and peri-urban communities have led to the high rate of transport making processed feed very expensive (Sanon, 2007). Alawa and Umunna (1993) concluded that inclusion of low quality feedstuff to replace conventional energy source in production rations should not exceed 25-30%, whereas for maintenance rations in ruminants, these levels may be exceeded. Adegbola *et al*. (1989) indicated that sun-drying of cassava peels reduced cyanide level by 60% whereas ensiling (for 14 days after initial sun drying for two days leaves the cassava peels with 40%DM) reduced it by 83%. Palm kernel cake contains 14%-16% crude protein (ARC, 1980). Palm kernel meal is aflatoxin free, palatable and is potential source of carbohydrate and protein sources (Sundu *et al*., 2006).

Umunna *et al*. (1980) reported that the inclusion (0 to 65%) of palm kernel meal in the diet of Yankasa sheep have increased the growth phase of the sheep from 22.0 to 34.0 kg and also have increased the fattening phase from 31.0 to 38.4kg of the sheep. Alhassan *et al*. (1987) reported that maximum straw intake with 25% of molasses inclusion to millet straw fed to sheep and goats results in a corresponding marked improvement in growth rate gain. Ani (1980) reported a decrease in DM digestibility of roughage-based diets in cattle by increasing the level of sugar cane

molasses while Osuji (1993) concluded on the basis of sheep feed intake data that DM intake generally decreases when molasses contributes more than 50% of the dietary DM.

2.2.2 Crop Residues

Crop residues are secondary products left on the field after harvesting the main products. Crop residues are unconventional feed resources that are obtainable locally from crop production which include straws of fine cereal grains (wheat, oat and rice), Stover of coarse cereal grains (maize, sorghum and millets) and vines /haulms from legumes obtained after harvesting the crops in the field and are used as feed livestock. Elginaid (1997) reported that crop residues are cheaply sourced feed during the dry season which is either eaten by the livestock on the field or gathered, transported and preserved for feeding the livestock. Singh *et al*. (2011) reported that cereal residues from cereal crops have low nutritional value which are less consumed by the livestock. Aregheore (2000) reported that rice straws and maize stovers have 36.4 - 45.3% crude fibre, 12.2 – 13.4 MJ/kg energy, 4.6 – 5.0% CP, high lignin concentrations, low vitamins and minerals. Alhassan *et al*. (1999) observed that feed available for ruminant livestock feeding during critical period of feed scarcity are residues from rice, maize, sorghum and millet which are high fibre-low protein feeds. Cereal straws are mostly grazed on the field but the haulms of legumes are collected, dried and sold to livestock farmers during the dry season or preserved as hay for stall-feeding (Tarawali and Hiernaux, 2002). Legume haulms are high in protein content and easily accessible on the field in contrast to cereal straws which are often destroyed after harvest. Alhassan *et al*. (1999) reported that cereal residues are poor in fermentable carbohydrates, have low organic matter digestibility and daily intake of less than 20gDM/kg when they are fed by small ruminants (Alhassan *et al*., 1999).

Konlan *et al*. (2016) characterized cereal and leguminous residues based on fibre content (greater than 700 g /kg DM), Metabolizable energy (less than 7.5MJ/kgDM), crude protein content (20–60gCP/kgDM) and digestibility (less than 30–45%OM). In West Africa, residues from cowpea, groundnut, maize, millet and sorghum are commonly used to feed livestock (Singh *et al*., 2003). De Leuw (1997) reported that when cowpea is intercropped with sorghum, the yield of cowpea haulms increased from 400 to 1,200kg/ha in Mali but increased from 200 to 500kg/ha in Burkina Faso. Savadogo (2000) recorded the 156g/kgDM (CP), 610g/kg (OM), 9.7 ME for cowpea haulm and 126g/kgDM (CP), 570g/kg (OM), 9.0 ME for groundnut haulms. Tesfayohannes (2003) asserted that the growth performance of livestock are poor when fed maize stover even though these stovers are the most abundant of all agricultural residues. Coxworth *et al*. (1977) reported high lignin content in maize stover which affected the voluntary intake and digestibility of nutrient in the stover. Maize stovers are low in protein which varies from 2.3% (Kabatange and Shayo, 1991) to 7.1% (Woyengo *et al*., 2008) which will requires supplementation with legume residues. Woyengo *et al*. (2008) reported that treating the stovers before feeding animals will improve the utilization of the stovers by animals.

Mosi and Butterworth (1985) reported that the extent of using crop residues to feed livestock has been restricted by the presence of lignocellulosic compounds and low nitrogen.

Supplementation of Legume crop residues aid in the production of which influences fibre digestion in the rumen (Silva and Ørskov, 1988).

Bauchop and Mountfort (1981) reported that adding legume crop residues as supplement towards the daily feeding of straw to ruminants is most likely to instigate annexation of straw by bacterium and fungi during the process of fibre breakdown in the rumen. Other factors may also account for this process in the rumen. Ørskov and Dolberg (1984) reported that when straws are supplemented with substrate there is an increment in the fermentation rate of cellulose which is likened to the animals fed ammonia treated straws. Leng (1990) reported that low quality forages have less than 55% digestibility and are deficient in crude protein less than 80g and low soluble sugars and starches (usually less than 100g/kg). Poor basal diets have low nitrogen and minerals which also contain anti nutritional elements such as tannins. These factors reduce rumen fermentation and, consequently decrease the intake and digestibility of feeds Therefore, poor animal performance is registered. Ansah *et al*. (2006) reported that about 91% of the sampled ruminant farmers in the Yendi Municipal of Northern region of Ghana use legume residues feed their livestock during the dry season. Forage legumes adequately supplied protein for livestock when fed, even when they are harvested at the matured stage of growth of the forage legumes (Delgado et al., 1999). It has been reported by (Otchere *et al*, 1977; Karbo *et al*., 2002), (Otchere *et al*, 1986) and (Addah, 1999) that rice straw, cocoa husk, cassava and groundnut haulms respectively are good supplementary feed for ruminants.

Attoh-Kotoku (2003) reported that conservation and use of crop residues and agro-by products are the cheapest way to reducing cost of feeding ruminants in the tropics.

Sundstol and Owen (1984) reported that most of the cereal crop residues have low nutritive value, moderately low digestibility less than 500gOM per kgDM, low CP less than 50 g/kgDM, low minerals content, low vitamins content and low intake value of less than 15gDM/kg which resulted in unpalatability of the crop residues. Groundnut haulm provides an alternative roughage to maize stover but are limited in supply, because the number of hectares cultivated locally in Ghana is less than maize.

2.3 CONSTRAINTS TO YEAR ROUND FEED SUPPLY

The grazing of livestock on natural unimproved pasture is the commonest feeding practice in Ghana, most especially Northern region. It is observed that in the wet season, there is abundance of fresh quality forage on most grazing lands, however, the use of these lands for food crop cultivation results in the clearing of the forages and tethering of animals which denies the animals' full access to the quality forage.

Animals are given free access to grazing lands in the dry season, but the forage available is usually of low poor crude protein, high lignin and silica content and poor digestibility (Olubajo and Oyenuga, 1971; Alhassan *et al.*, 1999).

Ansah and Issaka (2018) reported that the commonest food crop cultivated in Kumbungu was maize from which crop residue and crop by-products are generated and these are mostly left on the field as mulch or for animals to graze.

Jaleta *et al.* (2015) observed that some farmers may prefer to use maize stovers as fuel for cooking to reduce cost of buying fuel wood and charcoal because of the limitations in the nutritional values of maize stovers as feed for animal.

2.4 GROUNDNUT PRODUCTION

The groundnut is a very important legume crop in the tropics (Tarimo, 1997; ICRISAT, 2008) which is 13th in the World in terms of importance (Hatam and Abbasi, 1994).

Groundnut is widely grown in 109 countries in the world on about 22.2 million hectare of farm land; 13.69 million hectare of farm land are used for cultivation of groundnut in Asia (8 million ha are cultivated in India; 3.84 million ha are cultivated in China and other Asian countries cultivated groundnut on 1.85million ha of land), 7.39 million ha are used for cultivation of groundnut in the Sub-Saharan Africa while 0.7 million ha are used for the cultivation of groundnut in the Central and South America (Upadhyaya *et al*., 2006). Tsigbey *et al*. (2003) reported that groundnut are cultivated either in pure stands or intercropped with cereals on small scale by farm families in Ghana.

It has been reported (Peanut CRSP, 1990) that groundnut is cultivated as source of food which contained high protein content in the seed and for income by many people in the developing countries. Yields of groundnut are low due to unpredictable rainfall pattern, poor dissemination of technologies to farmers, predominance of pest and disease on crop production, inadequate seed knowledge, bad agronomical practices and increasing cultivation of groundnut on soils with

minimal nutrients (Konlan *et al*., 2013). Groundnut is still ranked first among the grain legume crops cultivated in all the regions of Ghana (Tsigbey *et al*., 2003; Naab *et al*., 2005). Ghana (with about 185,000ha cultivated for groundnut) is ranked 9th on the world production table and 4th on the African continent (FAO, 2003). Although 85% of the farm land are used for groundnut cultivation in the agro-ecological zones of Ghana; the bulk of groundnut produced come from the Guinea and Sudan savannah (Atuahene-Amankwa *et al*., 1990). The Guinea and Sudan savannah had annual rainfall of 800 mm to 1200 mm beginning from May to October. The production of groundnut in Ghana is hindered by unreliable rainfall, poor fertile land, prevalence of pest and diseases in crop production and poor crop management (Tsigbey *et al*., 2003). Groundnut is produced mostly by subsistence farmers in Ghana on a small scale. Groundnut is usually intercropped with sorghum, millet, maize, and cassava. Atuahene-Amankwa *et al*. (1990) reported that groundnuts are grown on flats and ridges in pure stands.

2.5 NUTRITIONAL QUALITY OF GROUNDNUT HAULM

Sarwatt *et al*. (2004) reported that the feedstuffs in the dry season have decline crude protein value (as low as 2 %) which greatly hampers animal production. Species of forage legumes across the regions was found to contain approximately 170g kg−1 DM compared to 115 g kg−1DM for grasses (Minson, 1990). Boukay (1999) reported 92% DM, 11.11%CP and 33.78 ADF for groundnut haulms

Table 2: Nutritional composition of Groundnut haulm

Nutrient (dry matter basis)	1	2	3	4	5	6	7	8
DM (%)	94.47	91.60	91.10	93.60				95.0
CP (%)	8.80	9.87	12.00	10.19	13.12	5.30	13.10	19.30
EE (%)	0.33	2.80	2.90	1.56	3.22	1.33		5.20
CF (%)	31.38	24.20	31.00	28.05	31.86	33.15	21.20	19.50
Ash (%)	14.32	5.00	3.00	6.69		6.37		11.50
NFE (%)	45.17	49.53	33.10		38.95	53.85	40.20	39.50
NDF				45.68			44.90	
ADF							38.80	

1; Ayoade *et al*. (1983), 2; Nyako (2015), 3; Malgwi *et al*.(2015), 4; Midau *et al*.(2011), 5; Murthy and Prasad (2002), 6; Singh *et al*.(2009), 7; Vara Prasad *et al*.(2000), 8;Goska *et al*. (2016).

The DM values recorded by Ayoade *et al*. (1983), Nyako (2015), Malgwi *et al*. (2015), Midau *et al*. (2011) and Goska *et al*. (2016) are within the range of 90% to 95%. However, Singh *et al*. (2009) recorded lower CP value of 5.30% while Goska *et al*. (2016) recorded the highest CP value of 19.30%. Melesse *et al*. (2013) reported 12.4% CP on dry matter basis for good nutritive value for groundnuts haulms. Groundnut haulms have been widely used in animal feeding with good responses; high nutritive value has been reported by Ayoade *et al*. (1983) and Ikhatua and Adu (1984). The fodder could be fed fresh, silage form or as hay. Hay is commonly used in areas where feed shortage is commonly experienced particularly in the tropics. Its high crude protein content which varies from 11.4- 16.7% in some cultivars (Alhassan, 1985) helps immensely in augmenting protein deficiencies in cereal residue based diets.

Carangal and Calub (1987) reported low crude protein for cereal stover and 13% - 19%CP for haulms of legume crops such as cowpea and groundnut. Thus, leguminous haulms are supplemented to improve the feeding value of cereals straw.

NDF is an interpreter of feed intake. Matured forage have increased NDF and therefore, low feed intake of forage. Forages with low ADF concentrations are usually higher in energy.

McDonald *et al*. (1987) reported that nutrient digestibility is influenced by the nutritional value of diets. Schneider and Flatt (1975) reported high crude fibre and low digestibility in forage.

Fadel Elseed *et al.* (2012) reported higher DMI of 74.20, 72.60 and 67.65 g/kg BW 0.75 for adult, non-productive sheep fed groundnut haulms supplemented with concentrate compared to 50 g/kg BW 0.75 DMI.

Mc Donald *et al*., (2002) stated that high energy diets have metabolically controlled feed intake when ruminant fed these diets.

The importance of a feed depends on its nutritive value which is determined by four factors; these are the concentration of the nutrients in the feed, the voluntary intake, the amount of the nutrients digested, and the efficacy of nutrient utilization by animals (Norton, 1994; Paya Hamid *et al*., 2007).

2.5 Effect of Groundnut haulm quality on Growth of Djallonké sheep

Growth is a significant natural occurrence comprising hormones, genes, nutrition and metabolic factors and how these factors interact to bring about variation in the growth of animals. The segregating of nutrients to different tissues in the body differs during the process of growth in animals. The rate of energy use for growing animals is affected by heat increment (McDonald *et al.*, 2011). Poor quality forages which have high lignin concentration have high heat increment. O'Hara *et al*. (2003) reported that higher emission of methane are associated with hard or poor quality diet. Abdou *et al*. (2011) reported increased live weight of sheep supplemented groundnut haulm to straw used for feeding sheep. Daily gains of 130.7g by lambs were reported by Adu and Lakpini (1983) when the lambs were fed chopped groundnut haulms. Ayantunde *et al*. (2008) reported an average daily weight gains of 27.5, 10.4, 30.8 and 35.7 g/day when sheep fed 0, 300, 600 and 900 g/day respectively of groundnut haulms without millet bran.

Rams lost significant amount of weight when fed cereal residues only compared to rams fed legumes residues only. The weight loss in rams fed residues from maize, sorghum and millet were 16%, 14% and 11% respectively compared to an increase in weight of the rams fed residues from cowpea and groundnut by 13% and 12% respectively. Singh *et al.* (2010) observed that rams consumed more maize residues than millet residues but lost more weight when fed maize residues only than millet only.

Oddy and Sainz (2002) reported that variations in ADG of the experimental sheep is attributable to disparity in nutrient composition in the diets. The level of protein and fibre are the determinant of the digestion of feed in ruminant.

Ngwa and Tawah (1992) reported that Djallonké sheep fed rice straw with supplementation recorded an average weight of 22 kg while those fed groundnut haulms, cotton seed and cowpea vines only recorded an average daily gain of 29.24 g, 48.98 g, 52.4 g and 49.19 g/day respectively. Ngwa and Tawah (1992) reported that when cross breed of Djallonké and Sahellian sheep were fed cassava peels and pigeon pea by products resulted in 87.0-130g daily weight gain of the crossed breed. Savadogo (2000) stated that appropriate amount and quality of feed for feeding livestock play a vital role in the growth and health condition of livestock.

2.6 VARIETAL EFFECTS ON GROUNDNUT HAULM QUALITY

Larbi *et al*. (1999) reported nutritional variations in the haulms of diverse groundnut varieties but Etela and Dung (2011) did not find difference in the nutrient constituents of haulms of six diverse groundnut varieties. However, varietal difference in the haulms of groundnut effects different rate of growth in the Djallonké sheep fed haulms of 6 multi-purpose groundnut varieties (Etela and Dung, 2011).

Adamu (2015) reported similar DM value for Samnut and Maizabo varieties but these varieties differ in the ADF values (table 3).

Etela and Dung (2011) did not find varied differences in DM, NDF and ADF of haulms of diverse groundnut varieties.

Frimpong et al. (2017) reported high ADF values for ICGV-IS 08837 variety which is higher than what Etela and Dung (2011) and Adamu (2015) reported.

Table 3: Nutrient composition of varietal groundnut haulms

		Nutrient (%)							
Authors	Varieties	DM	CP	EE	CF	Ash	NFE	NDF	ADF
1	SN22	94.27	18.56	2.13	31.48	11.32	36.16	30.67	45.03
	MZ	93.61	13.37	4.40	25.13	6.05	51.22	36.52	17.78
2	M170-80I	89.0	8.6					53.6	49.0
	M554-76	89.0	9.1					55.8	49.3
	M572-80I	87.0	8.5					51.9	48.8
	RMP-12	89.0	8.7					58.6	52.2
	UGA-2	86.0	8.9					53.2	50.0
	UGA-5	86.0	8.5					52.6	52.0
3	GAF 1665		11.4		24.8	7.37		58.2	50.7
	ICGV 00064		12.2		23.7	6.90		53.1	48.1
	NKATIE SARI		12.0		23.6	6.18		54.9	50.1
	GAF 1723		12.5		23.2	6.55		55.1	43.8
	ICGV-IS 08837		8.50		35.5	5.96		60.7	59.4
	ICGV-IS 13998		11.3		22.6	8.00		54.7	47.6

SN22= SAMNUT22, MZ= Maizabo. 1; Adamu (2015), 2; Etela and Dung (2011), 3; Frimpong *et al*. (2017)

While Frimpong *et al*. (2017) concluded that none of the varieties used in their study recorded CP value of 15% of the upper limit value reported in the literature.

Table 4: Nutrient Digestibility of haulms of different varieties Groundnut

Digestibility	Authors							
	A		B					
	Varieties		Varieties					
(%)	SAMNUT-22	Maizabo	M170-80I	M554-76	M572-80I	RMP-12	UGA-2	UGA-5
DM	46.45	30.54	62.3	50.8	54.6	51.5	56.1	58.0
OM	49.20	34.76	62.6	49.8	54.4	51.1	56.0	58.0
CP	59.78	56.68	58.8	53.0	53.9	48.8	54.8	57.3
EE	80.94	75.65						
CF	51.5	49.86						
NFE	59.18	54.24						
ADF	79.76	76.40	57.2	40.6	45.8	48.4	50.0	53.7
NDF	44.94	40.31	63.5	48.8	49.7	57.2	57.6	51.4

A; Adamu (2015), B; Etela and Dung (2011).

Adamu (2015) reported that Samnut and Maizabo varieties have similar CP, NDF and ADF digestibility but varied in DM digestibility. Etela and Dung (2011) on the other hand, found that M170-80I variety varied significantly from the other five varieties in DM, NDF and ADF digestibility.

Table 5: Effect of different Groundnut haulms on Growth performance of Djallonké rams

		Growth rate parameters(kg)			
Authors	Varieties	Initial	Final	Live weight changes	ADG
A	Maizabo	18.75	21.85	3.10	34.44
	SAMNUT-22	19.00	25.37	4 .37	59.72
B	M170-80I	22.5	25.7	46	
	M554-76	22.8	24.5	24	
	M572-80I	23.4	25.2	26	
	RMP-12	22.9	25.1	31	
	UGA-2	23.8	23.4	-6	
	UGA-5	22.7	25.4	38	

ADG: Average daily weight gain. A; Adamu (2015), B; Etela and Dung (2011).

Leng (1990) asserted that growth rate in ruminant is highly correlated with the energy and protein intake. Adamu (2015) reported the suitability of SAMNUT-22 variety providing energy and protein when fed to ram at inclusion level of 10% will result in high significant ADG.

Thus, Huber *et al*. (1994) observed that insufficient energy level in a diet of high protein level leads to waste of protein and increase energy cost of eliminating excess urea from the body.

Aduku (2011) reported 150g/day as the minimal ADG for normal daily gain by sheep. Larbi *et al*. (1999) reported that modifications in plant management, the ratio of leaf-to-stem, cell wall conformation or cultivar might have accounted for the variations in the protein and fibre contents.

2.7 HAEMATOLOGY AND SERUM METABOLITES OF SHEEP

Haematology has been defined as the morphology of the blood that is the red cells (erythrocyte), white cells (leucocytes), and the platelets (thrombocytes) and their use in diagnosing and monitoring of diseases (Etim *et al*., 2014). Blood is a significant means for evaluating the health status of livestock (Oduye and Adadevoh, 1976). The constituents of Blood are significant in the physical state, disease infection level and nutritional prominence of living organisms (Ewuola *et al*., 2012). Orheruata and Aikhuomobhogbe (2006) reported that blood constituents of animals gave an indication of the productivity of the animals and thus, aid in monitoring and evaluating the incidence of diseases in animals. Factors such as depleted nutritive value of pasture, stress, weather conditions and birthing seriously vary the blood values of goats and sheep (Anosa and Isound, 1979, Radostits et al., 1997). The hematological and biochemical indices are the key determinants to the effects of dietary treatment in terms of the variety and quantity of feed ingested by animals to meet its physiological and metabolically needs (Ewuola *et al*., 2004). According to Jain (1993) PCV value of 27.0-45.0% and Hb values of 9.0-15-0g/100ml is the normal for physiological performance of sheep. Etim *et al*. (2014) reported that a low level of MCH and MCHC is an indication of anemia while a high level indicates a normal condition. Red blood cells aid in respiration by transporting of oxygen and

carbon dioxide in the body. Aikhuomobhogbe and Orheruata (2006) reported that low values PCV result in conditions such as reduced oxygen carrying-capacity of blood, increased pulse rate and consequently heart failure in animals. Heath and Olusanya (1988) reported that mean white blood cell (WBC) count for clinical healthy sheep is in a range of 7.8 x103/µl to 8.0 x103/µl on supplemented diets and also different lymphocyte values indicate varying levels of immune status of farm. The normal Physiological ranges of lymphocyte is 40 –75 % and neutrophil counts is 10–50 % for healthy sheep (Jain 1993). Osueni (2001), Lazaro (2001), and Aikhuomobhogbe and Orheruata (2006), all that reported increasing neutrophils results in a decreased lymphocytes. Depressed levels of lymphocytes means low immune system or an high neutrophil level (Lazaro, 2001)

2.8 NUTRITIONAL VALUE OF NAPIER GRASS

Napier grass, also known as elephant grass is high yielding grass resilient to a varied array of weather in the tropics. Napier grass is an important fodder popular in cut-and-carry systems throughout the tropics (FAO, 2015).

Elephant grass is a grass commonly eaten by elephants in African as the name suggest (Cook *et al*., 2005). Elephant grass has high productive value which is particularly suited for cattle grazing. It has been reported that Elephant grass at the lush vegetative stage are grazed by animals and thus, the young leaves are mostly preferred by livestock (FAO, 2015). Skerman and Riveros (1990) reported that

elephant grass have 4-15% crude protein, 28-40% crude fibre, 10-16% ash, 0.9-3.8% fat and 39-49% nitrogen free extract for elephant grass.

Depending on the maturity stage, elephant grass contains high fibre and 55 to 75%NDF (Moran, 2010). Kozloski *et al*. (2005) did not find difference in the DM, OM, NDF and lignin when elephant grass hay were cut at 30, 50, 70, and 90 days of regrowth however, ADF and non-structural carbohydrates increased linearly. Moran (2010) reported that the elephant grass had high moisture content, low DM of 12%; even though the leaves had 16%DM and the stem had 9%DM. Elephant grass during the dry season have low protein but high lignin compared to elephant grass harvested during the rainy season (Evitayani *et al*., 2004; Pamo *et al*., 2007). Milford (1960) reported that the elephant grass is unaffected by frost which remained fresh, green and succulent throughout the winter and spring. Ansah *et al.* (2010) reported comparatively higher DM for 16763 and 16840 varieties and lower DM for the local and 16798 varieties in the humid zone of Ghana.

It is also reported that 16763 and 16840 had the higher lignin while the local and 16798 lower lignin but high cellulose.

Ansah *et al.* (2010) also reported that prolong days of harvest of these new varieties of elephant grass have increased DM, ADF, NDF and Acid Detergent Lignin (ADL) of these varieties. Bayble (2007) recorded increased DM, ADF, NDF and ADL of elephant grass when harvested at 60, 90 and 120-days. Bernes *et al*. (2008) reported positive results in the DM, ADF, NDF and ADL of Timothy grass (*Phleum pretense*) at an increasing maturity date. The CP of the elephant grass decline with increasing

date of harvest. It is reported in a literature that crude protein level from 60-days harvest to the 120-days declined by 27%; high cellulose and low CP values are recorded at the 60-days harvest. (Kranberger and Klemencic 2003; Bayble 2007; Peiretti, 2009). According to Orodho, (2006) when harvesting time is extended, CF, ADF, NDF and ADL percent in the elephant grass will increase. However, CP and ash content declined when the cutting interval was increased. The DM value of the elephant grass did not change with height at which the plant was cut but the CF decreases.

2.8.1 Factors affecting the digestibility of Fodder

Digestibility of fodder is important in determining the nutritional quality of the fodder (Ball *et al*., 2001). Digestibility of fodder is influenced by the environment (Crasta and Cox, 1996), the plant structure and development (Burns *et al*., 1997). The fodder is closely related to plant cell wall arrangement which form the base in determining consumption and feed digestibility (Toharmat *et al*., 2016). Factors such as feed consumption, rumen pH, form and volume of rumen microbes affect the rate of digestibility (Rasjid, 2012).

It was reported that rice straws and maize stovers are bulky but have high lignin content, 36.4 - 45.3% crude fibre, 12.2 – 13.4MJ/kg and 4.6 – 5.0% CP, low vitamins and minerals (Aregheore, 2000).

2.9 EFFECT OF SUPPLEMENTATION ON RUMEN MICROBES

Leng (1987) reported that supplementation add nutritive elements such as nitrogen, energy, minerals and vitamins that are unavailable or insufficient in forages to allow

the rumen microbes to better digest them. Preston and Leng (1984) made emphasis that supplementation of poor quality roughages on supply of nitrogen as recommendation for supplementation.

However, the supplementation should take into account the nutritional aspect and the socioeconomic considerations, namely the availability, the cost and the aptitude of the technique for being implemented by farmers. The supplements should supply nitrogen and energy to the animal in proportion according to production requirements without hindering the cellulolytic activity of the rumen.

The minimum supplementation can just ensure the animal maintenance; in this case, the minimum feed supplements enable rumen microbes to function well; ensuring good cellulolysis in the rumen. Supplements provide nutritive elements needed by rumen microbes for self-multiplication and carbohydrate degradation in the cell wall of poor quality forages. Van Soest (1994) recommended that supplemented fodder with a minimum of 1.2% of the nutrient composition is an important basal nutrient for effective digestion of fodder by rumen microbes. Leng (1997) reported that microbial growth on protein is about half of microbial growth on carbohydrates which have low protein: energy (P/E) ratios.

2.10 *IN VITRO* GAS MEASUREMENT AS A METHOD OF FEED EVALUATION

Gas production methods are used in determining the amount of reduction or decay of dry matter (DM) of feed material and how some anti-nutritional elements such as tannins influence the nutritional value of the feed materials. Large amount of feed samples are incubated and analyzed at the same time using the *in vitro* gas production technique. Large quantity of feeds are consumed by ruminants, more than half of the consumed passed out of the animals as waste. The nutritional status of animal feed is evaluated mostly by its digestibility which influence intake and or the extent to which animal will consume the feed. Thus, Digestibility and nutrient intake are the key determinants of livestock production performance such as for milk production or growth of the animals. Digestibility of feed materials can be determined by an in vitro techniques which is done out the animal rumen system which is able to stimulate the digestion process.

Njidda (2010) reported that the *in vitro* gas production method is used extensively in evaluating the nutritional estimate of different categories of forages. The *in vitro* gas production method is comparatively less costly, takes less time to analyzed and experimental conditions are more controlled than the vivo experimentations. The *in vitro* gas production method increases the amount of nutrient utilized and the accuracy in evaluating the digestibility in animal.

Substrate fermentation by microorganisms in the rumen produces volatile fatty acids (VFAs) in a short chain form, protein (microbial) and gases (Blummel *et al*., 1997).

Feed fermentation in the rumen is associated with the production of gas, principally carbon dioxide and methane. Digestibility and energy value of feed is linearly correlated to the quantity of gas produced from *in vitro* incubation of feedstuffs using the rumen fluid (Menke *et al*., 1979). The accuracy of the effects is a product of strictness and repeatability of the approach (Tilley and Terry, 1963). Thus, in a technique such as this a mistake at the beginning of the procedure can change the effect of the investigation. The two phase *in vitro* technique (Tilley and Terry, 1963) has been widely used in predicting forage digestibility for ruminants and for investigation of large numbers of forages in plant breeding programs. Blummel and Orskov (1993) reported that syringes containing samples are incubate in a water bath rather than a rotating incubator which is an alteration of the technique.

Theodorou et al. (1991, 1994) developed the pressure transducer technique (PTT) for measuring *in vitro* gas production of forages. The procedure is inexpensive and can handle large numbers of samples.

Table 6: Constitution of the media (g/l) used in different Gas Production techniques

Component	A	B	C	D
$Cacl_2 \cdot 2H_2O$	0.013	0.017	0.016	0.015
$MnCl_3 \cdot 4H_2O$	9.7×10^{-3}	0.015	0.012	0.011
$CoCl_3 \cdot 6H_2O$	0.97×10^{-3}	0.002	1.25×10^{-3}	1.11×10^{-3}
$FeCl_3 \cdot 6H_2O$	0.77×10^{-3}	1.43	9.96×10^{-3}	8.84×10^{-3}
Na_2HPO_4	1.09	1.55	1.42	2.09
KH_2PO_4	1.19	0.15	1.55	1.37
$MgSO_4 \cdot 7H_2O$	0.12	8.75	0.15	0.13
$NaHCO_3$	6.71	1.00	8.74	7.73
$(NH_4)HCO_3$	0.77	0.125	1.00	0.88

Reassuring	9.87 x 10^{-4}	0.52	1.25 x 10^{-3}	1.11 x 10^{-3}
Na_2S	0.23		0.016	2.79 x 10^{-4}
Trypticase	1.00		2.50	2.21
Cysteine Hydrochlorine			0.016	2.79 10^{-4}

Source: Rymer *et al*. (1998)

A: Menke and Steingass (1988), B: Steingass (1983), C: Goering and Van Soest (1970), D: Theodorou (1993)

2.11 INFERENCES FROM LITERATURE REVIEW

Most feeding trials conducted, groundnut haulms are used as a supplement to other crop residues; few studies have been conducted with haulms of groundnut used as a sole diet. Quality of Forage is the result of animal output performance when fed sole diet.

The major constraints in the production of animals are low nutritional quality of feed and inadequacy of feeds for all year round feeding.

Nurfeta (2010) reported that feed intake and digestibility of grass can be enhanced by concentrate supplementation. The high cost of conventional feed militate against their wide-scale use by small scale farmers. Furthermore, there is competitive demand for these conventional feed resources between livestock and man, and between monogastric and ruminants that have limited the adequacy for ruminant feeding. Population pressure due to urbanization is another factor that could further limit the availability of conventional feed resources for animal feeding. Legumes residues have higher protein content than grasses and other forages, these legume residues can be used to solve this limitation of feed availability to feed livestock in the tropics. Supplementation of legume residues to basal diets form fundamental feeding strategy to balance nutrients requirements in the rumen of animal (Lakpini, 2002).

To mitigate the issue of low protein in the fodder, other protein sources need to be considered without incurring additional cost.

Forages form a greater proportion of the ruminant diet but availability of these forages all year round is limited due to seasonal fluctuations in weather, overgrazing and increasing use of land for crop cultivation and for residential establishment.

Limitation to the use of conventional feeds for livestock feeding, it is better for farmers to resort to the use of feed resources that are cheap, less competitive and which are easily degradable by ruminant into useful outputs.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 INTRODUCTION

Two separate experimentations were carry out; first experiment was a feeding trial using four different varieties of groundnut haulms as a sole diet for the Djallonké rams, lasted for 56 days. The second was *in-vitro* digestibility of Napier grass supplemented with haulms of four dual purpose of groundnut varieties in different combinations for gas production in the rumen liquor.

3.2 LOCATION OF THE STUDY

The feeding trial was carried out at the livestock experimental unit of Animal Science department of Faculty of Agriculture of University for Development Studies (UDS) at the Nyankpala campus while the *in-vitro* gas experiments was carried out at the Forage Evaluation laboratory of the same department. Nyankpala is about 20km away from Tamale, capital city of Northern region of Ghana. Nyankpala is on longitude 0° 58′42″W and latitude 9° 25′41″N at an altitude of 183m above sea level, in the Guinea savannah zone. The area experiences one rainy season which starts from mid-May to October with annual rainfall of 1,091mm. It has an annual temperature of 28.2°C which fluctuate averagely between 26 °C (minimum) and 28.9°C (maximum). Mean annual day time relative humidity is 54% for Nyankpala (SARI, 2007).The area experiences the dry cold Harmattan winds from December to March and warm dry conditions starts from mid-March to May. Therefore, the dry season starts from late October to May.

3.3 EXPERIMENT ONE: FEEDING TRIAL

3.3.1 Experimental Animals

Sixteen Djallonké rams were used for the feeding trial. They were kept in a separate enclosures with concrete floor. The rams with preliminary weight of 15.0 ± 3.0kg were obtained from Animal Research Institute of Council for Scientific and Industrial Research (CSIR-ARI) at Nyankpala.

3.3.2 Source of Experimental diet

The experimental diet was groundnut haulms of Obolo, Yenyawoso, Azivivi and Manipinta varieties.

3.3.3 Design of the Feeding trial

The design used for the feeding trial is completely randomized design. There were sixteen rams used for this feeding trial, with each pen holding one ram (ref. plate 4) and these rams were unintentionally allocated to groundnut haulm (GHM); assigning four (4) rams to one varieties of groundnut haulm. The rams were intensively fed in the pen with concrete floor with groundnut haulm as a sole diet for the extended period of the experiment.

3.3.4 Feeding trial

The feeding trial was carried out for eight (8) weeks in which daily haulm intake and weekly weight of sixteen rams were measured for eight weeks. The rams (preliminary weight of 15 ± 3kg) were intensively kept in a separate wooden enclosures with concrete floor and fed dry groundnut haulms *ad libitum* daily for eight (8) weeks.

Refusals were collected daily and weighed, and then sampled the refusal for DM determination. A grace period of 7days was allowed for the rams to adjust to feeds given. The groundnut haulms were chopped into small pieces and then offered to the rams in their individual pens. Before refilling the feeding trough, the refusal were collected from each of the sixteen rams, daily feed samples of 100g was taken from each replicated animals and bulked together according to their varieties and further sampled (200g) in a duplicate, these are dried in an oven at 60 °C for 48 hours for DM determination. The weights of the sampled refusal and haulms given were used in the analysis of DM intake. Dried samples were milled and sieved through a 2mm screen which are used for chemical analysis.

Faecal collection bags were fitted to each rams, allowing 7 days adjustment period of the rams to the faecal bags (plate 3). The faeces were discharged from the faecal bags every day twice in the morning at 7:00 am and the evening at 5:00pm to take the weight of fresh faeces daily for the extended period of the experiment. A sample of 20g of the measured faeces taken from the individual animals was frozen at −4 °C until the end of the experiment. The daily faecal matter were bulked together based on the varieties of groundnut haulms used in this study and thus further sampled 200g in duplicate which are dried, milled and sieved (2mm screen) and then used for chemical analysis.

Total consumption of feed by each animal per week was determined by subtracting the weight of the refusal from the weight of the total feed offered in that week.

The total feed intake was calculated by adding all the feed intakes for each animals for the whole experimental period and then divide this figure by the number of days the experiment was conduct to determine the daily feed intake, expressed by dry matter basis to find the daily dry matter feed intake of each animals.

3.2.5 CHEMICAL ANALYSIS PARAMETERS

3.2.5.1 NDF and ADF

The procedure of Van Soest *et al.* (1991) was adopted in determining the NDF and ADF by using sodium sulfite and α-amylase without the residual ash and were run on the Ankom^{200}fiber analyzer by replicating each treatment 4 times for the NDF and ADF.

Sample from each treatment was weighed 0.45-0.55g directly into the filter bags (Ankom F57) and named; the filter bags were sealed with an electronic heat sealer within 4mm at the top. One blank filter bag was added in each run for the determination of blank bag correction. The bags containing the samples were put in the bag suspender and placed in the Ankom fiber analyzer vessel with the aid of the weight of the bag suspender keeping the filter bags containing the sample submerged. Solutions of NDF and ADF solution were added respectively.

For NDF solution preparation, 30.0g sodium dodecyl sulfate, USP; 18.61g Ethylenediaminetetraacetic disodium salt, dehydrate; 6.81g sodium borate; 4.56g sodium phosphate dibasic, anhydrous; and 10.0ml Triethylene glycol were dissolved in 1L distilled water. ADF solution was prepared by dissolving 20.0g cetyl trimethylammonium bromide (CTAB) in 1L of 1.00N H_2SO_4.

For the analysis of NDF; two litres of NDF solution was added to each of the 24 sample bags in the fiber analyser vessel and later, 20g (0.5g/50mL) of sodium sulfate and 4.0mL of α-amylase were also added to the solution in the vessel. The fiber analyser was run for 75 minutes. The sodium sulfate in the vessel was exhausted after 75 minutes and the content was rinse for three times with 2L of hot water (70-90°C) for 5 minutes and 4.0 ml of α-amylase added to the first and second rinses. After rinsing, the samples were placed in acetone for 3-5 minutes and then oven dried at 102°C for 2hrs and weighed.

The weight recorded after oven drying was used to compute for the NDF values using these equations and then convert them to dry matter basis:

$$\text{NDF (g/kg)} = \frac{(w3-(w1\ x\ c1))}{w2}\ \text{x}\ 100$$

Where w_1 = Bag tare weight, w_2 = Sample weight, w_3 = Dried weight of bag with fiber after extraction, c_1 = Blank bag correction factor (running average of final oven ─ dried weight divided by original weight).

The procedure was the same for ADF as in the case of NDF except that the fiber analyzer was allowed to run for only 60 minutes and also sodium sulfate and α-amylase was not added. The same equation used for computing for NDF was also used to compute for ADF.

3.2.5.2 Ash

The procedure of AOAC (2000) was followed in determining Ash content. About 2g of dried sample was added to a known weight of pre-dried crucibles. The sample in the crucibles were placed in a muffled furnace and heated to 550^{0}C for 4hrs. The crucibles were cooled in a desiccator and weighed subsequently.

The following equation was used to compute ash content

$$\text{Ash (g/kgDM)} = \frac{\text{weight of ash}}{\text{weight of sample}} \times 1000$$

3.2.5.3 Crude Protein

The method of AOAC (2000) was also used to determine the crude protein content. All the samples used in the analysis were replicated four times. After drying the samples in the oven, about 1g of the sample was added to the filter paper which is placed in the Kjeldahl digestion tubes.

Blank determination was done by digesting filter paper in each set of digestion. About 15ml of concentrated sulphuric acid (H_2SO_4) and two Kjeldahl tabs were added to the content of each digested tubes. The kjeldahl tabs contained potassium sulphate (K_2SO_4) and copper sulphate ($CuSO_4$) which increases the boiling point and act as a catalyst respectively.

The tubes were mounted on Kjeldahl digestion block with fume exhaust set (J.P> Selecta RAT 2, Spain) and heated gradually to 420^0C and maintained the heat for 3hrs. The tubes were allowed to cool to room temperature after removing them from digestion block. 50ml of distilled water was then added after cooling and then distilled with an automated kjeldahl distillation apparatus (J.P. Selecta, s.a, Pro-Nitro II).

The apparatus draws 50ml of previously prepared 35% sodium hydroxide (NaOH) into the digestion tubes and 25ml of 4% Boric acid (H_3BO_3) into a 25ml erlynmeyer flask to trap the liberated ammonia during the distillation period of 9 minutes per sample. The distillate was collected and titrated against 0.1N HCL (hydrochloric acid). The average titre values were recorded and used to calculate the percentages nitrogen (%N) and crude protein. The equations below were used to calculate the Nitrogen (%) and CP (%) was calculated:

$$\%Nitrogen = \frac{(T-B)\,x\,N\,x\,1.4}{weight\ of\ sample\ (g)}$$

% crude protein = % nitrogen x 6.25

Where T = Sample titre value, B = Blank titre value, N = Concentration of HCL

3.3.6 Growth Performance Data

Camry hanging scale (ISO9001:2008, China) was used to measure the weight of the animal from the beginning weekly to the end of the experiment. After grace period of two weeks of feeding the rams with GHM, their body weights were measured and were considered as the initial weight of the rams fed with the GHM diet.

The final weight per animal was calculated by subtracting the initial weight per animal from the final measured weight per animal. The final weight is divided by the number of days the experiment took place to get the average daily weight. Average daily weight gain is calculated by subtracting the initial weight per animal from the final weight per animal.

3.3.7 Haematological Data Collection

Blood samples (5ml) was drawn from the jugular veins of each animals at the beginning and at the end of the feeding trial using 10ml disposal syringes. The samples was emptied into a test tube containing Ethylene Diamine Tetra Acetic (EDTA) to prevent clotting and each of the test tubes (16) was labeled.

The blood samples was analyzed using the Wintrobes Microhematocrit, improved Neubauer hemocytometer and Cyanmethemoglobin methods (Baker and Silverton, 1990) for red blood cells (RBC), white blood cells (WBC) and haemoglobin (Hb) concentrations respectively.

3.3.8 Statistical analysis

Generalized Linear Model (Genstat 11th edition in a one-way analysis of variance) was used to analyze the differences in chemical composition, feed intake, weight gain, digestibility and hematology. The following model was used to analyze chemical composition:

$$Y_{ijk} = \mu + B_i + C_j + e_{ijk}$$

Where Y_{ijk} is an observation, μ is experimental mean, B_i is block effect, C_j is variety effect, and e_{ijk} is residual.

The following model was used to analyze live weight gain of rams using the initial live weight of each ram as a co-variate:

$$Y_{ij} = \mu + V_i (x_{ij} - \pi_i) + e_{ij},$$

Where Y_{ij} is an observation, μ is an experimental mean, V_j is a variety effect, x_{ij} is the observation of covariate under the i^{th} group, πi is the i^{th} group mean, and eij is the residual.

Duncan's Multiple Range Test at $P < 0.05$ was used to test the effect of treatment and significant differences between treatment means.

3.4 EXPERIMENT TWO: *IN VITRO* GAS PRODUCTION

3.4.1 Source of Sample material

The Local variety of Napier grass was harvested from an established pasture at the Faculty of Agriculture of the UDS in 2015. The haulms from the four groundnut varieties used in the experiment one are the same haulms that were supplemented to the Napier grass for this experiment. These varieties of groundnut used are Obolo, Yenyawoso, Azivivi and Manipinta.

3.4.2 Processing of Samples

Fresh whole Napier grass plants were harvested and cut to a stubble height of about 15 cm and dried (60^{o}C) for 48 h after which it was milled to pass through 2 mm sieve.
Dried GHM was milled to pass through 2mm sieve as like the Napier grass.

3.4.3 Treatment Allocation and Experimental Design

The milled Napier grass and GHM were mixed together in a proportion of 40% Napier and 60 % GHM and were assigned the following treatment names: Azivivi + Napier, Manipinta + Napier, Obolo + Napier and Yenyawaso + Napier. Sole Napier grass was included in the study as a control and was referred to as Napier grass only.

Completely randomized design was used for this experiment with 5 treatments and 4 replicates with duplicates samples per replicate.

3.4.4 *In vitro* Gas production

Theodorou *et al*. (1994) technique of the in vitro gas production was adopted with some modification in the source of rumen fluid. Approximately 200mg of oven dried samples from each treatments weighed into 50ml test tubes and incubated in the solution of McDougall's buffer under the conditions of anaerobic.

Due to the high management cost and welfare cost of maintaining rumen fistulated animals, the use of rumen fluid from slaughtered animals has been recommended (Mohamed and Chaudhry 2008). Rumen fluid (liquid and solid) was obtained from four different locations in the rumen of 3 different cattle after slaughter at the Tamale abattoir into a pre-warmed vacuum flask (Ansah *et al*., 2016; Mohamed and Chaudhry 2008).

The cattle were browsing on naturally growing forage and supplemented with leguminous crop residue hay. The rumen fluid was strung out using a four-layer cheese cloth. After which, the rumen fluid was mixed with the buffer in a ratio of 1:4. The buffered rumen fluid was obtained by continuous supplying of carbon dioxide to the mixture of the rumen fluid and the buffer. Buffered rumen fluid was dispensed by approximately 30ml using a 50ml syringes into each test that contain the samples and kept in a water bath at 39 °C. Measurement of Gas production was done indirectly by recording the pressure in the test tubes using a digital manometer (Traceable manometer/pressure/vacuum gauge, Fisher Scientific, UK) at 3, 6, 9, 12, 24 and 48 h.

The pressure readings were converted from psi to volume (ml /g DM) using the ideal gas law as:

Gp = $(Vh/Pa) * Pt$.

Where Gp is the volume of gas produced, Vh is the volume of head space (ml), Pa is the atmospheric pressure, and Pt is the pressure in the test tube at time "t" (psi).

The gas readings were then fitted to the exponential curve of Orskov and McDonald (1979) without an intercept using Sigma Plot 10th edition (Systat Software Inc. 2006). The degradation parameters (b and c) were derived from the exponential model:

$Y = b\,(1 - e^{-ct})$

Where Y is the gas volume at time t (ml), b is the asymptotic gas production (%), t is the time (h), c is the fractional rate of gas production (ml/h).

In vitro organic matter digestibility (IVOMD) was calculated using the equation

IVOMD (%) = 16.49 + 0.9042*GP + 0.0492*CP + 0.0387*ash by Menke and Steingass (1988), while metabolizable energy was calculated using the equation: ME (MJ/kg DM) = 2.20 + 0.136*GP + 0.057*CP according to Menke et al. (1979),

Where Gp is the gas production (ml/200 mg DM at 24 hours), CP is the crude protein (g/kg DM).

3.4.5 Statistical Analysis

The one-way analysis of variance (ANOVA) of Genstat 11th edition was used for analyzing the *in vitro* gas digestibility parameters.

The model used was in the analysis of *in vitro* digestibility:

$Y_{ij} = \mu + Vi + e_{ij}.$

Where Y_{ij} is an observation, μ is an experimental mean, V_j is a treatment effect and e_{ij} is a random error.

Means were separated at 5% significant level using the Tukeys mean separation method. The Pearson correlation was used to explore if there was any relationship between the nutrient composition and in vitro gas production parameters.

Where there was a significant relationship, simple regression analysis was used to derive the prediction equation. Means and standard deviations were computed from the chemical analysis data.

CHAPTER FOUR

4.0 RESULTS

4.1 EXPERIMENT ONE: FEEDING TRIAL

Table 7 below shows the results of the chemical compositions of groundnut haulms of four multi-purpose varieties used in the study.

Table 7: Chemical composition of experimental diet (%DM basis)

Item	Treatments (GHM varieties)					
	Azivivi	**Manipinta**	**Obolo**	**Yenyawoso**	**SEM**	***P*-value**
DM	49.7^a	57.2^b	48.9^a	60.8^b	1.9	<0.01
CP	11.2^b	10.3^b	6.8^a	11.4^b	0.5	<0.01
Ash	10.9	8.1	10.1	9.7	0.9	0.19
NDF	42.5^a	44.9^a	53.0^b	42.7^a	1.1	<0.01
ADF	39.0^a	36.7^a	49.5^b	36.6^a	1.5	<0.01

CP: Crude protein, DM: Dry Matter, NDF: Neutral Detergent fibre, ADF: Acid Detergent fibre.

SEM: standard error of means, means in the same row with different superscript point to differences in means at $P<0.05$.

Haulms of Manipinta and Yenyawoso did not show significant difference in DM (%) which varied significantly (P<0.05) to the haulms of Azivivi and Obolo as can be seen in table 7. Haulms of Obolo had the least CP value (6.8%) but higher NDF (53.0%) and ADF (49.5%) compared to the other varieties used in this study (table 7). Furthermore, haulms of Azivivi, Manipinta and Yenyawoso did not show significant ($P<0.05$) variation in the CP content in this study (table 7).

Table 8: Nutrient intake of rams fed with four varieties of groundnut haulms.

	Treatments (GHM varieties)					
Intake	**Azivivi**	**Manipinta**	**Obolo**	**Yenyawoso**	**SEM**	***P-value***
Total DM(kg)	50.6^a	50.0^a	50.6^a	50.4^a	0.3	0.9
Daily DM (g)	903.4^a	893.0^a	903.5^a	899.1^a	4.9	0.9

Daily CP (g)	101.1^{a}	92.0^{a}	60.9^{b}	102.9^{a}	0.9	<0.01
Daily NDF (g)	382.8^{b}	399.2^{b}	481.7^{a}	382.8^{b}	3.2	<0.01
Daily ADF (g)	353.0^{b}	327.3^{b}	448.5^{a}	329.6^{b}	3.4	<0.01

Means with different superscript differ ($P < 0.05$) within the row.

No significant ($P<0.05$) difference observed in the Total DM intake when the rams were fed haulms of the four groundnut varieties (table 8). Rams fed haulms of Obolo varieties had the lowest daily CP intake (60.9g) compared to those fed haulms of the other three varieties. No significant difference showed among those rams fed haulms of the Azivivi, Manipinta and Yenyawoso in the daily CP intake as well in the daily NDF intake while those fed haulms of Obolo variety recorded the highest daily NDF intake of 481.7g. There is no significance difference in the daily ADF intake among rams fed haulms of Azivivi, Manipinta and Yenyawoso varieties as seen in table 8. However, the higher daily ADF value of 448.5g was recorded for rams fed obolo haulms.

Table 9: Nutrient digestibility for the different groundnut haulms used in this study.

Parameters	**Treatments (GHM varieties)**				**SEM**	***P-value***
(% DM basis)	**Azivivi**	**Manipinta**	**Obolo**	**Yenyawoso**		
DM	71.4^{a}	77.8^{a}	65.9^{b}	79.9^{a}	4.8	0.2
CP	75.3^{b}	81.0^{a}	58.5^{ab}	84.5^{a}	6.7	0.1

NDF	56.6^{b}	65.3^{a}	55.8^{b}	69.2^{a}	5.9	0.3
ADF	61.2^{a}	65.2^{a}	58.8^{b}	68.4^{a}	5.4	0.6

Means with different superscript differ ($P < 0.05$) within the row.

The highest DM digestibility value was recorded for Yenyawoso (79.9%) while the Obolo (65.9%) had the lowest in DM digestibility.

However, there was no significant difference between Yenyawoso, Manipinta and Azivivi. The lowest crude protein digestibility value was recorded for Obolo (58.5%) compared to the other three varieties (table 9). But, the other three varieties show no significant difference in the crude protein digestibility as can be seen from table 9 above. No significant difference was found between Yenyawoso and Manipinta, similarly no significant difference can be found between Azivivi and Obolo as shown in the above table.

However, the highest NDF digestibility was recorded for Yenyawoso and the lowest NDF digestibility was found for Obolo. The lowest ADF digestibility value was found in Obolo while the other three varieties show no significant difference in ADF digestibility.

Table 10: Growth response of rams fed four different varieties of groundnut haulms.

Parameters	**Treatments (GHM varieties)**				**SEM**	***P-value***
	Azivivi	**Manipinta**	**Obolo**	**Yenyawoso**		
Initial live weight(kg)	15.3	14.0	16.0	14.6	1.8	0.85
Final live weight (kg)	15.9^{a}	16.0^{a}	16.9^{a}	17.6^{b}	1.7	0.87

Live weight gain (g)	600^{a}	2,000^{ab}	925^{a}	2,950^{b}	361.6	<0.01
ADWG (g)	10.7^{a}	35.7^{ab}	16.5^{a}	52.7^{b}	6.5	<0.01
Adjusted2 final live weight (kg)	15.6^{a}	16.9^{ab}	15.9^{a}	17.9^{b}	0.3	<0.01
Adjusted2 live weight gain (g)	619^{a}	1,935^{ab}	994^{a}	2,927^{b}	361.3	<0.01
Adjusted2 ADWG (g)	11.1^{a}	34.6^{ab}	17.8^{a}	52.3^{b}	6.4	<0.01

Means with different superscript differ ($P < 0.05$) within the row. [2]Adjusted initial live weight was used as a covariate. Initial live weight of rams was used as covariate.

With the exception of Yenyawoso, the rest of the other three varieties show no significant difference in the final live weight (table 10). Rams fed Yenyawoso (17.6kg) had the highest final live weight compared to the other varieties. The highest live weight gain was also recorded when rams fed Yenyawoso (2950g) which differ significantly among those fed the other three varieties. However, there was no significant (P<0.05) difference in the live weight gain of rams fed Azivivi and Obolo. Rams fed Yenyawoso (52.3g) variety had the highest ADWG while rams fed Azivivi (11.1g) variety had the least ADWG. Rams fed Azivivi and Obolo did not show significant difference in the adjusted final live weight but vary significantly from those that fed Yenyawoso and Manipinta. From the table 10, Ram fed Yenyawoso had the highest adjusted live weight gain (2,927g) which differ significantly from those that fed the other three varieties.

Table 11: Blood Parameters sample of sheep fed the four varieties of Groundnut haulms

Parameters	Treatments (GHM varieties)	SEM	P. value

	Azivivi	Manipinta	Obolo	Yenyawoso		
White Blood Cells (10^3/µl)	8.8^{a}	10.0^{a}	10.4^{a}	9.1^{a}	0.86	0.54
Red Blood Cells (10^6/µl)	4.1^{a}	4.3^{a}	4.4^{a}	4.5^{a}	0.46	0.92
Haemoglobin (g/dL)	15.7^{a}	16.8^{a}	16.3^{a}	17.2^{a}	1.84	0.94
Haematocrit(PCV) (%)	38.3^{a}	39.0^{a}	36.4^{a}	38.8^{a}	1.75	0.70
Mean Cell Volume (fL)	29.4^{a}	31.2^{a}	27.9^{a}	29.0^{a}	2.22	0.77
Platelets (10^3/µl)	27.2^{a}	29.0^{a}	27.5^{a}	28.5^{a}	0.76	0.32

[1]Four rams per GHM variety (total $n = 16$).

Rams fed haulms of the four different groundnut varieties did not show significant ($P<0.05$) difference in White blood cells, Red blood cells, Haemoglobin, Haematocrit, Mean Cell Volume and Platelets.

4.2 EXPERIMENT TWO: *IN VITRO* GAS PRODUCTION

Table 12: Chemical composition of Napier grass supplemented with four varieties of Groundnut haulms (GHM).

Treatment	DM	CP	NDF	ADF	Ash
Azivivi + Napier	900.5±9	89.3±4	506.5±2	377.1±7	92.8±4

Manipinta + Napier	902.3±5	84.4±3	520.3±2	363.6±3	76.9±4
Obolo + Napier	899.0±5	64.1±3	567.1±3	437.1±5	89.4±1
Yenyawaso + Napier	905.1±8	109.3±5	407.4±19	349.6±5	76.4±3
Napier grass only	948.2±6	63.5±3	658.2±8	383.6±1	92.3±4

DM =Dry matter, CP =Crude protein, NDF =Neutral detergent fiber, ADF =Acid detergent fiber

The mean (±SD) values for chemical composition of Napier grass supplemented with 4 varieties of groundnut haulm (n=2) is tabulated in the table 12. The DM of the treatments ranges from 899 to 948.2 with the highest recorded in Napier grass only. The replacement of 60 % Napier grass with the GHM increase the CP value of Obolo + Napier, Manipinta + Napier, Azivivi + Napier and Yenyawaso + Napier by 0.9 %, 32.9 %, 40.6% and 72% respectively. Whilst the lowest NDF and ADF were observed in treatments Yenyawaso + Napier, Obolo + Napier had the highest. The high ADF in the Obolo + Napier can account for a slow digestion rate which could ultimately affect intake.

Table 13: Effect of Napier grass Supplemented with four varieties of groundnut haulms in *In vitro* Gas Production

Treatment	24 h	48 h	b	c	IVOMD	ME
Azivivi + Napier	17.8^{b}	23.8^{b}	23.0^{b}	0.08^{b}	36.7^{b}	9.3^{b}
Manipinta + Napier	17.5^{b}	22.8^{b}	22.4^{b}	0.09^{b}	34.7^{ab}	8.9^{a}

Obolo + Napier	13.5[a]	18.0[a]	17.8[a]	0.08[b]	32.8[a]	7.5[a]
Yenyawaso + Napier	17.8[b]	23.9[b]	23.0[b]	0.08[b]	37.3[b]	9.5[b]
Napier grass only	15.3[a]	22.5[b]	23.8[b]	0.05[a]	34.6[ab]	7.8[a]
SEM	0.45	0.75	0.78	0.004	0.70	0.11
P.Value	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

In vitro gas production conducted at 24h and 48h: b =Asymptote gas production,

IVOMD =*In vitro* organic matter digestibility, ME =Metabolizable energy, c =rate of gas production, SEM =Standard error of means. Mean with different superscripts differ significantly at (P <0.01) with the Column.

Mean *in vitro* gas production, *in vitro* organic matter digestibility and metabolizable energy of Napier grass supplemented with 4 varieties of groundnut haulm (n=8) is shown in the table above (13).

The effects of treatments on the IVGP, IVOMD, b, c and ME showed significant difference when *in vitro* gas production conducted at 24h and 48h. Haulms of Obolo + Napier had low (P <0.01) values in the IVGP at 24 h and 48 h as well as asymptote gas production compared to the other treatments. It is observed (figure 1) that almost half of the gas produced by the treatments occurred at 12 h with the highest found in Yenyawaso + Napier.

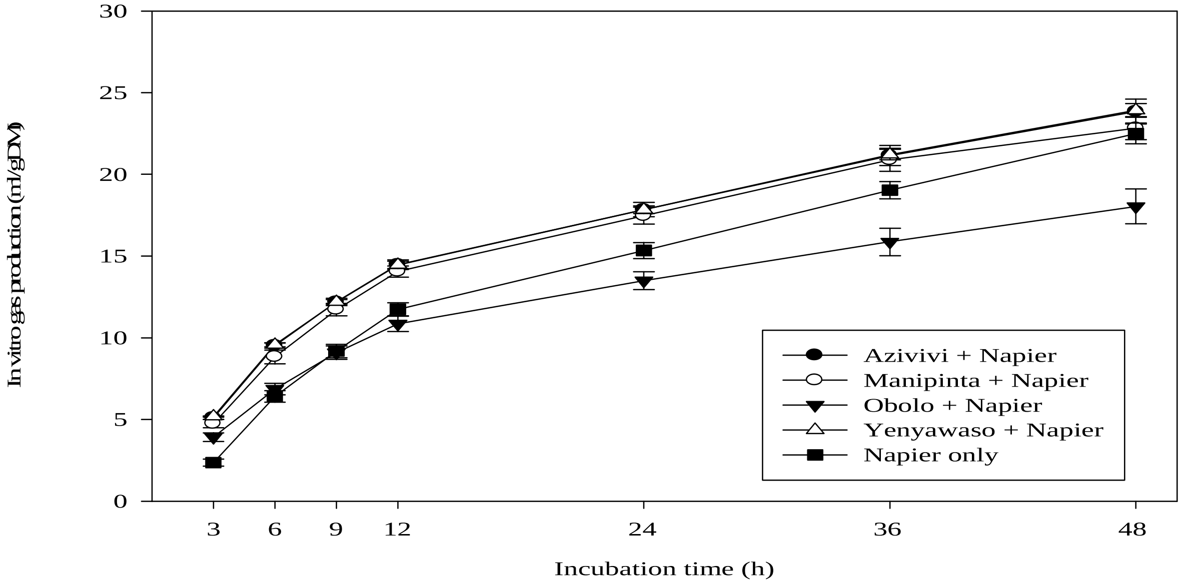

Fig1. Mean (±SE) cumulative *in vitro* gas production of Napier grass supplemented with 4 varieties of groundnut haulm.

Napier grass only had low rate of gas production (c) compared to the supplemented treatments. The IVOMD was similar between the supplemented treatments and the un-supplemented. However, significant differences were found between treatments Yenyawaso + Napier and Obolo + Napier with the former having the highest. The high IVOMD in the Yenyawaso + Napier than the Obolo + Napier was due to the superior nutrient concentration in the Yenyawaso + Napier treatment. It was found to have a higher CP and ME and the lowest ADF.

Table 14: Correlation Analysis of Napier grass supplemented with four varieties of Groundnut haulms in *in vitro* gas production

Gas production	CP	NDF	ADF
b	0.31*	-0.07	-0.46**
IVOMD	0.59**	-0.36	-0.40**
ME (MJ/Kg DM)	0.86*	-0.70	-0.55**
NDF	-0.81**	-	0.59**
ADF	-0.54**	0.591**	-

b=Asymptote gas production, IVOMD=*In vitro* organic matter digestibility, ME= Metabolizable energy, CP=Crude protein, NDF=Neutral detergent fiber, ADF=Acid detergent fiber, *$P<0.05$, **$P<0.01$

Pearson correlation between crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF) and constants of *in vitro* gas production of Napier grass supplemented with 4 varieties of groundnut haulm is tabulated in table 14.

The correlation analysis revealed a positive ($P<0.05$) relationship between CP values of *b*, IVOMD and ME (Table 14). On the other hand, NDF and ADF had a negative ($P<0.05$) relationship with asymptote gas production, IVOMD and ME.

CHAPTER FIVE

5.0 DISCUSSION

5.1 EXPERIMENT ONE: FEEDING TRIAL

5.1.1 Chemical Composition of haulms of four Groundnut varieties

The crude protein value of haulms of the four varieties of ground nut varied from 6.8% to 11.4%. Crude protein of haulms of Obolo variety (6.8%) was lower (table 4) than values reported by Etela and Dung (2011), haulms of the other three varieties were higher. Fadel Elseed *et al*. (2012) reported 10.28%CP which is within the range reported in this study for the haulms of the four groundnut varieties used in this study. Ayoade (1983) reported 8.8%CP which is lower than the crude protein of haulms of Azivivi (11.2%), Manipinta (10.3%) and Yenyawaso (11.4%) but slightly higher than haulms of Obolo (6.8%). Singh *et al*. (2011) reported 5.30% CP which showed no significant difference with what was recorded for Obolo (6.8%) in this study. Crude protein value (11.4%) reported for Yenyawaso in this study correspond to the crude protein value (11.4-16.7%) reported by Alhassan (1985) in some cultivars of groundnut haulms. But Adamu (2015) reported 18.56%CP for Samnut and 13.37% CP for Maizabo (table 4) which are higher than what was recorded for the varieties used in this study.

Similarly, Goska *et al.* (2016) and Malau-Aduli *et al*. (2015) recorded higher CP value of 19.3%CP and 15.63%CP respectively which is significantly different to all the four varieties used in this study. In addition, Vara Prasad *et al*. (2000), Murthy *et al.* (2002) and Melesse *et al*. (2013) recorded 13.1%CP, 13.12%CP and 12.4%CP respectively which are significantly different to all the varieties used in the study. However, Malgwi *et* *al*. (2015), Nyako (2015) and Melesse *et al*. (2013) reported CP value of 12.0% , 9.87% and 9.82% respectively which did not show significant difference with Azivivi, Manipinta and Yenyawaso. The crude protein content of haulms of Azivivi (11.2%) and Yenyawoso (11.4%) are within the minimum crude protein (11.1% to 13.0%) requirement for the upkeep and body weight enhancement of small ruminants (Van Soest, 1982; NRC, 2007). This indicates that haulms of Azivivi and Yenyawoso can be used as sole feeding of ruminants which will support the growth of small ruminants. The haulm of Obolo (6.8%CP) did not vary significantly to the minimum (7%) requirement for ruminant which suggests that this variety could be used as a basal diet for the purpose of maintenance and production of ruminant.

The NDF and ADF fractions recorded for the varieties used in this study vary 42.5 to 53.0% and 36.6 to 49.5% respectively. With the exception of Obolo, the other three varieties show insignificant variation in the NDF and ADF (Table 7), but lower than what Etela and Dung (2011) reported. NDF and ADF values of Manipinta (44.9% and 36.7% respectively) recorded in this study show no difference with what Vara Prasad *et al*.(2000) reported. The NDF value for Obolo (table 7) did not show significant variation with 52.28 % (Fadel Elseed *et al*. 2013). The ADF value of 45.03% recoded for Samnut by Adamu (2015) in table 4, did not show significant difference with Obolo (49.5%). The ADF value for Maizabo (17.78%) reported by Adamu (2015) in table 4 did show significant difference with all the four varieties used in this study.

It is suggested that genetic variation in these varieties resulted in a significant difference in the crude protein, Neutral Detergent Fibre and Acid Detergent Fibre contents of the haulms of these varieties.

This genetic variation largely affect the ability of the groundnut crops in nutrient absorption from the soil and thus carbohydrate production through photosynthesis.

Yenyawoso is a 90 days maturity variety which is relatively shorter to the varieties of Azivivi, Manipinta and Obolo (110 to 120 days maturity). (110 to 120 days maturity) The low cell wall fraction of the haulms (Yenyawoso varieties) could be credited to the short duration of this variety.

The dry matter values recorded for all the varieties used in the study (Table 7) are the lowest compared to 91.10% (Malgwi *et al.*, 2015), 91.60% (Nyako, 2015), 93.6% (Malau-Aduli *et al.*,2003), 94.47% (Ayoade, 1983), 95.0% (Goska *et al.*,2016) and 97.83% (Melesse *et al.*, 2013).

5.1.2 Nutrient Intake of Experimental Animals

The recorded low CP, high NDF and ADF values of haulms of Azivivi variety has influenced the nutrient intake of rams fed haulms of this variety; Low CP intake, high NDF and ADF intake). There was no significant ($P<0.05$) difference in the daily CP intake of rams fed haulms of Azivivi and Yenyawoso but which are higher than Obolo and Manipinta varieties. The highest daily NDF intake (481.7g) was observed when rams fed haulms of Obolo but there was no significant ($P<0.05$) difference in the daily NDF intake when rams fed haulms of Azivivi, Manipinta and Yenyawoso. Rams fed haulms of Azivivi variety with low CP, and high NDF and ADF values resulted in low CP intake, and high NDF and ADF intake of those rams fed this haulms. Also, the high ADF value of the haulms of Obolo variety indicates that structural carbohydrates content in the haulms of Obolo did not inhibit voluntary intake of rams fed.

The total daily DMI did not show significant (*P<0.05*) difference when rams fed haulms of the four groundnut varieties. Riaz *et al*. (2014) observed that high ADF concentration in feed is related to decrease voluntary feed intake in livestock resulting in a slow rate of digestion. Experimental rams consumed 3.50-4.38% of their body weight resulting in an improvement in the DMI of these rams which is a little higher than the 3% requirement noted by Devendra and McLerov (1982).for small ruminants reared in the tropics.

5.1.3 Nutrient Digestibility of Experimental Diets

The haulms of Yenyawoso had superior digestibility; DM (79.9%), CP (84.5%), ADF (68.4%) and NDF (69.2%). This implies it is appropriate for exclusive feeding without supplementation. However, haulms of Obolo had the lowest digestibility; DM (65.9%), CP (58.5%), ADF (58.8%) and NDF (55.8%). This variety need to be supplemented. Yenyawoso variety have high DM (79.9%) digestibility than Samnut (46.45%) and Maizabo (30.54%) digestibility (Adamu, 2015). Also, Yenyawoso variety have high CP (84.5%) digestibility than Samnut (59.78%) and Maizabo (56.68%) digestibility (Adamu, 2015). But Yenyawoso variety have lower ADF (68.4%) than Samnut (79.76%) while the NDF (69.2%) digestibility of Yenyawoso variety is higher than Samnut (44.94%) digestibility (Adamu, 2015). However, digestibility of Yenyawoso variety was higher than M170-80I (table 4) variety reported by Etela and Dung (2011). There was variability (*P<0.05*) in the nutrient digestibility of Azivivi, Manipinta, Obolo and Yenyawoso; which support the report (Larbi *et al*., 1999).

5.1.4 Growth response of Experimental rams fed Groundnut haulms

The final weight of ram was 17.6kg when fed haulms of Yenyawoso which was significantly (*P<0.05*) higher than the other three varieties. This implies that the Yenyawoso variety have greater impact on the growth of rams than the other three varieties. However, Adamu (21015) reported the weights of sheep when fed Samnut and Maizabo haulms as 21.85kg and 25.37kg respectively which are higher than 17.6kg weight of sheep when fed Yenyawoso haulms. Rams fed haulms of Yenyawoso had the highest ADWG while those fed haulms of Azivivi had the least (table 10). Lower ADWG was recorded when rams fed haulms of Obolo as a sole diet compared to what was reported for Djallonké rams reared under free range system without supplement (Baiden and Duncan, 2009; Ansah *et al.*, 2016). Rams fed haulms of Obolo and Azivivi varieties have shown slow growth rate which is credited to poor utilization of nutrient by rams fed these haulms.

It is observed that to achieve greater live weight gain in fattening rams for sale, these two varieties need to be supplemented. McDonald *et al.* (2011) reported that the extent to which energy is utilized by animals is measured by the amount of energy lost by animal as heat.

5.1.5 Effects of Groundnut haulms on some Haematological parameters

Haematological indices give a clue to the production value of animals which facilitate monitoring and evaluation of disease conditions in animals (Karesh and Cook, 1985; Orheruata and Aikhuomobhogbe, 2006).

RBC count is used in the characterization of anemic conditions in animals (Ikhimioya and Imaseun, 2007).

Values of RBC values obtained in this study vary from 4.1-4.5x10^6mm^{-3} which falls below the normal physiological range for a healthy sheep given as 9.0-15.0x10^6mm^{-3} (Jain, 1993). These low values indicate that these rams were susceptible to anemia-related disease conditions. Low RBC values obtained in the study could also be a result of the inherent anti-nutritional factors such as tannins in the experimental diets which were fed to these rams.

WBC counts vary from 8.8 to 10.4x10^3mm^{-3} for this study which is within the normal physiological range given by Jain (1993) for a healthy sheep as 4-12.0x10^3mm^{-3}. Heath and Olusanya (1988) stated 8.0x10^3mm^{-3} as ideal for clinically healthy sheep which corresponds with the value obtained for Azivivi (8.8x10^3mm^{-3}) in this study. The values of WBC count in this study indicate that rams will not be undernourished when fed haulms of these groundnut varieties.

Haemoglobin functions primarily in transporting oxygen from the lungs to the tissues. The Haemoglobin values obtained in this study vary from 15.7 to 17.2g/dL which is higher than 9.0 -15.0g/100ml (Jain, 1993). The high values of haemoglobin in these four varieties of groundnut haulms indicates high protein intake and that these haulms pose no danger of liver damage or parasite infection to the experimental rams. The high Haemoglobin values recorded suggested that these varieties of the groundnut haulms could be used to feed livestock as sole diet.

MCV values in this study fall within 28.0 -40.0µm (Jain, 1993). High MCV values increases the release of immature red blood cells in the circulatory system (MERCK, 1979).

PCV values in this study are within 27-45 % (Jain, 1993) for a healthy sheep, and they are higher than 32% recorded by Frandson (1986) for normal circulatory system in sheep. Aikhuomobhogbe and Orheruata (2006) reported that low PCV account for reduced oxygen carrying capacity of blood, increased pulse rate and consequently result in heart failure. The hematological values of rams used in this study are similar to those reported (Baiden *et al*., 2007; Bawala *et al*., 2007).

Haematological parameters of rams used in this study did not vary significantly ($P<0.05$) when haulms of groundnut varieties were used to feed them which is an indication that these haulms did not affect the health of the rams.

5.2. EXPERIMENT TWO: IN-VITRO GAS PRODUCTION

5.2.1 Chemical Composition of Napier grass supplemented with four varieties of groundnut haulms

The replacement of 60 % Napier grass with the GHM increases CP by 0.9 %, 32.9 %, 40.6% and 72% for Obolo + Napier, Manipinta + Napier, Azivivi + Napier and Yenyawaso + Napier respectively. The increases in CP was expected since the supplements used were all legumes and are noted for containing high levels of CP compared to the grass species (Meale *et al.,* 2012). The CP recorded for treatments Yenyawaso + Napier, Manipinta + Napier and Azivivi + Napier were above the 70 g/kg DM threshold (Hariadi and Santoso, 2010) required for microbial activity in the rumen.

The high ADF in the Obolo + Napier account for a slow digestion rate and ultimately affect intake. The NDF and ADF values in this study were similar to those reported by Ansah *et al.* (2016) and Meale *et al.* (2012) for some leguminous forage.

The difference in the margin of increase in nutrients of the treatments is an indication of the differences that these groundnut varieties possess and this could have been influenced by genetic composition of the groundnut varieties.

5.2.2 Effect of Napier grass Supplemented with four varieties of groundnut haulms in *In vitro* Gas Production

The Napier grass only treatment had a lower rate of gas production compared to supplemented treatments. Supplemented treatment and un-supplemented treatment had similar *in vitro* organic matter digestibility.

However, significant differences was found between treatments Yenyawaso + Napier and Obolo + Napier with the former having the highest. The high IVOMD in the Yenyawaso + Napier than the Obolo + Napier was due to the superior nutrient concentration in the Yenyawaso + Napier treatment; which had high CP and ME, but low ADF.

Crude protein is required in the diet of ruminants to supply rumen microbes the needed amount of ammonia nitrogen for fermenting carbohydrate. Acid detergent fibre suppresses the rate of microbial degradation of the structural carbohydrates in the rumen (Wilson and Hatfield, 1997). This will ultimately lead to a limited supply of fermentable carbohydrate and eventually result in a decrease in the overall organic matter digestibility.

5.2.3 Correlation Analysis of Napier grass supplemented with four varieties of Groundnut haulms in *In vitro* gas production.

The end products of microbial fermentation in the rumen are amount of gas produced and organic matter digestibility; thus, any restriction on the microbial activities in the fermentation process tend to affect these parameters negatively. The negative relationship of NDF and ADF is an indication of their ability to restrict rumen microbial fermentation especially with ADF. The relationship between CP, NDF and ADF and gas production has been confirmed by Larbi *et al.* (1998) in an earlier study.

CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

It is concluded that:

- ✓ Haulms of different groundnut varieties exhibit differences in crude protein, Neutral Detergent Fibre and Acid Detergent Fibre.
- ✓ Variations in the nutritional values of haulms of Yenyawoso, Azivivi and Manipinta influences the live weight gain of Djallonké ram fed these haulms as a sole diet; hence rams fed haulms of Yenyawoso had the highest live weight gain.
- ✓ There is inherent presence of tannins which is anti-nutritional factor from literature which results in the low RBC count.
- ✓ Rams fed with these varieties results in high protein intake as the values for Haemoglobin for this study was high and thus these varieties could be fed as a sole diet to sheep.

- ✓ This study has established that supplementing Napier grass with groundnut haulms improved the nutrient composition and digestibility. However, variety of groundnut influenced the extent of improvement in the nutrient composition and digestibility with variety Yenyawaso having the highest effect.
- ✓ The Obolo variety from this study does not appear to be useful as a feed material.

6.2 Recommendations

The haulms of Yenyawoso variety is recommended for a sole feeding for Djallonké rams which can enhanced growth performance of the Djallonké rams.

This study has great implication for the crop-livestock integration system particularly for livestock farmers who cultivate these varieties.

REFERENCES

Abdou, N. Nsahlai I.V. and Chimonyo, M. (2011). Effects of groundnut haulms supplementation on millet stover intake, digestibility and growth performance of lambs. Animal Feed Science Technology, 84: 169:176.

Addah, W. (1999). The effects of agricultural by-products supplementation on the dry season reproductive performance of Djallonke ewes. Bsc. (Agric. Techn) Dissertation, University for Development Studies, Tamale. pp. 25-38.

Adamu, Y.H. (2015). Assessment of two Groundnut (*Arachis hypogaea* L.) varieties for forage, Pod yield characteristics and effect of feeding the haulm to Yankasa rams. A thesis submitted to the school of postgraduate studies, Ahmadu Bello University, Zaria. In Partial fulfilment of requirements for the Award of a degree of Doctor of Philosophy in Animal Science.

Acquaah, G. (2012). Principles of Plant Genetics and Breeding: Second Edition. Principles of Plant Genetics and Breeding: Second Edition, 2012.

Adediran, A.S. (2002). Evaluation of the Nutritional value of Cowpea (Vigna unguiculata Linn) Shells using goats in Nigeria. A MS.C thesis submitted to the Department of Anim. SCI. A.B.U. Zaria.

Adegbola, A. A. Smith, O. R. and Asaolu, V.O. (1989).Response of the West African Dwarf sheep to diets based on processed cassava peels and Gliricidia septium. In: Said, A.N. and Dzowel, B.H (Eds). Overcoming Constraints to the Efficient Utilization of Agriculture by-products as Animal Feed Proceedings of the Fourth Annual Workshop of the African Research Network for Agricultural By-products, I.A.R., Mankon station, Bamenda, Cameroun. 20-27 October 1987. (ILCA) Addis Ababa, Ethiopia. Pp282-289.

Adegbola, T.A. (2002). Nutrient intake, digestibility and rumen metabolites in bulls fed rice straw with or without supplements. Nigerian Journal of Animal Production, 29(1): 40-46.

Adejinmi, J.O. Alayande, M.O. Sadiq, N.A. and Adejinmi, O.O. (2000). Clinical syndrome, haematological and biochemical parameters of goats naturally infested with mange (*Sarcoptes scabie*). Trop. Anim. Prod. Invest. 3: 29-34.

Adu, I.F. and Lakpini, C.A.M. (1983). The utilization of dried poultry litter as protein supplement for growing yankassa sheep. Journal of Animal Production Resource, 3: 49 – 56.

Adjebeng-Danquah J. (2014). Genetic Studies of Physiological And Morphological Traits Associated with Drought Tolerance in Cassava Genotypes, University of Ghana, 2014.

Adjebeng-Danquah J. Gracen, V. E. Offei, S. K. Asante, I. K. and Manu-Aduening, J. (2016). Agronomic performance and genotypic diversity for morphological traits among cassava genotypes in the Guinea Savannah Ecology of Ghana. Journal of Crop Science and Biotechnology, 19(1): 99–108.

Africa Development Bank (AfB) (2001). African Development Report: Africa in the World Economy Fostering Good Goverance in Africa Economic and Social Statistics on Africa. O1 BP1387 Abidjan 01 Côte d'Ivoire. Oxford University Press, Edition Economica for the African Development Bank.

Aganga A. A. and Tshwenyane S. O. (2003). Feeding values and anti-nutritive factors of forage tree legumes. Pakistani Journal Nutrition 2: 170-177.

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

Ahiabor, B. D. K. Fosu, M. Atsu, E. Tibo, I. and Sumaila, I. (2011). Integrated soil fertility management for increased maize production in the degraded farmlands of the guinea savanna zone of Ghana using devil-bean (crotalaria retusa) and fertilizer nitrogen in Innovations as Key to the Green Revolution in Africa, Dordrecht, Netherlands: 183–189.

Aikhuomobhogbe, P.U. and Orheruata, A.M. (2006). Haematology and blood biochemical indices of West African Dwarf goats vaccinated against *pestes des petit ruminants* (PPR). African Journal of Biotechnology, 5 (9): 743-748.

Ajala, O.O. Oyeyemi., M.O. Oke, A.O. and Alakpa, C.O. (2000). Haematological and biochemical parameters in West African Dwarf bucks fed diets containing *Milletiathonningii.* Afr. J. Biomed. Res. 3: 121-124.

Akinbamijo, O.O. Adediran, S.A, Nouala, S. and Saecker, J. (2004). Moringa fodder in ruminant nutrition in The Gambia. International Trypanotolerance Centre, Banjul the Gambia. Retrieved from **www.moringanews.org/documents/Fodder.doc**.

Alawa, J.P. and Umunna, N.N. (1993). Alternative feed formulation in the developing countries: Prospects for utilisation of agro–industrial byproducts. J. Anim. Prod Res. 13, 63–98.

Alli-Balogun, J.K. Lakpini, C.A.M. Alawa, J.P. Mohammed, A. and Nwata, J.A. (2003). Evaluation of cassava foliage as protein supplement for sheep. Nigerian Journal of Animal Production, 30(1): 37-46. 6.

Alli-Balogun, J.K. Lakpini, C.A.M. Alawa, J.P. Mohammed, A. and Nwanta, J.A. (2003). Evaluation of cassava foliage as a protein supplement for sheep. Nigerian Journal of Animal Production, 30: 37–46.

Amodu, J.T. and Otaru, S.M. (2004). Forage and Crop Research Programme. A training Manual, National Animal Production. Research. Institute, Shika. Pp. 23-27.

Armbruster, T. Peters, K.J. and Hadji-Thomas, A. (1991a). Sheep production in the humid zone of West Africa. III. Mortality and productivity of sheep in improved production systems in Côte d'Ivoire. Journal of Animal Breeding and Genetics. 108: 220-226.

Armbruster, T. Peters, K.J. and Metz, T. (1991b). Sheep production in the humid zone of West Africa. III. Growth performance and liveweight of sheep in improved and traditional production systems in Côte d'Ivoire. Journal of Animal Breeding and Genetics. 108: 210-219.

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.

Anonymous (2007). Economic Survey of Pakistan, Economic Adviser Wing, Finance Division, Government of Pakistan, Islamabad.

Anosa, V.O. and Isound, I.I. (1979). Haematological studies of domestic animals in Nigeria. ZBC Vet. 25: 64-66.

Ani, F.O (1980). The value of sugsr cane molasses as an energy supplement in rations for fattening cattle, M.Sc. Thesi. Ahmadu Bello University, Zaria.

Alhassan, W.S. Kallah, M.S. Bello, S.A. (1987). Influence of Duration of Stay on the Field on the Chemical Composition and Nutritive Value of Crop Residues. Tropical Agriculture (TRIANDAD) 64(1):61-64.

Alhassan, W.S. (1985). The potential of agro-industrial by-products and crop residues for sheep and goats production in Nigeria Proceedings of the National Conference on Small Ruminant Production, October 6-10, 1985, Zaria, Nigeria.

Alhassan, W.S. Karbo, N. Aboe, P.A.T. and Oppong-Anane, K. (1999). Ghana's Savanna Rangelands: Agroecology, current improvement and usage practices, research needs and sustainability criteria. National Agricultural Research Project. Council for Scientific and Industrial Research. Accra, Ghana, 134 – 156.

Animut, G. Merkel, R.C. Abebe, G. Sahlu, T. and Goestch, A.L. (2002). Effects of level of broiler litter in diet containing wheat straw on performance of Alpine doelings. Small ruminant Research. Volume 44, Issue 2, May 2002, pp125-133.

Ansah, T. and Issaka, A. C. (2018). Ruminant Livestock Feed resources in the Kumbungu District of Ghana. Ghanaian Journal of Animal Science, 9(1): 100-107.

Ansah, T, Wilkinson, R. G. and Dei, H.K. (2016). Effects of tanniferous browse plant supplementation on the nutrient digestibility and growth of Djallonké rams. Inter J Livest Prod., 7(12):122.

Ansah, T. Algma, H.A, and Dei, H.K. (2016).Variety and phosphate fertilizer dose effect on nutrient composition, in vitro digestibility and feeding value of cowpea haulm. J. of Anim. Sci. and Techno, 58:1.

Ansah, T. Addah, W. and Issaka, A. C. (2014). Feed resource availability for ruminants in Kumbungu District of Ghana. *Proceedings of the 32nd Biennial Conference of the Ghana Animal Science Association*, 1:53-60.

Ansah, T. Osafo, E.L.K. and Hanne, H.H. (2010). Herbage yield and Chemical composition of four varieties of Napier (*Pennisetum purpureum*) grass harvested at three different days after planting, Agriculture and Biology Journal of North America, 1(5): 923-929.

Ansah, T. Dzoagbe, G.S.K. Yahuza, R. and Adzitey, F. (2006). Knowledge of farmers in the utilization of crop residues and agricultural by-products for dry season feeding of ruminants. A case study in the Yendi District of Northern Region of Ghana, Savanna farmer, 7(2):13-19.

Antwi, C. E. L. Osafo, K. Donkoh, A. and Adu-Dapaah, H. K. (2014). Chemical composition, gas production and degradation characteristics of haulms of improved dual purpose Cowpea (*Vigna unguiculata* l. walp) cultivars Livestock

Research for Rural Development," Livestock Research for Rural Development, 26(11): 1–9.

AOAC (Association of Official Analytical Chemists) (1992). Official Methods of Analysis, Journal of the Association of Official Agricultural Chemists, Virginia, VA, USA.

AOAC (Association of Official Analytical Chemists) (1995). Official methods of analysis 16th edition. Association of Official Analytical Chemists. Arlington, Virginia, U.S.A.

AOAC (Association of Official Analytical Chemists) (2000). Official methods of analysis of Association of Official Analytical Chemists. 17th ed. 2000. Arlington, VA, USA.

ARC (Agricultural Research Council) (1980). The nutrient requirements of ruminant Livestock.Commonwealth Agricultural Bureaux, Farnham Royal, England.351 pp 361-373.

Aregheore, E. M (2000). Application of biotechnology to improve feed resources for ruminant livestock nutrition in the South Pacific. Journal of South Pacific Agriculture 15(2): 31 -38.

Arunyanark, A. Jogloy, S. and Wongkaew, S. (2009). Association between aflatoxin contamination and drought tolerance traits in peanut. Field Crops Research, 114(1):14-22.

Asibuo, J. Y. Akromah, R. Safo-Kantanka, O. Adu-Dapaah, H. K. Ohemeng-Dapaah, S. and Agyeman, A. (2008). Chemical composition of groundnut, *Arachis hypogaea* (L) landrace. African Journal of Biotechnology, 7: 2203–2208.

Asuming-Brempong, S. & Nyanteng, V.K. (2003). The role of agriculture in food security in Ghana. Paper Presented at Roles of Agriculture Project International Conference. Rome, Italy, 20-22 Oct., 2003.

Atakora, W. K. and Kwakye P. K. (2016). Measurement and modeling nitrous oxide emissions from ferric luvisols in the guinea savanna agro-ecological zone of Ghana. International Journal of Plant & Soil Science, 10(3): 1–8.

Atuahene-Amankwah, G. Hossain, M.A, Assibi, M.A. (1990). Groundnut Productionand Improvement in Ghana. First ICRISAT Regional Groundnut Meeting for West Africa, 13-16 Sept. 1988. Niamey, Niger, pp. 45-47.

Attoh-Kotoku, V. (2003). Stylosanthes Hamta Supplementation: Effects on degradation characteristic passage rate of rice straw and performance of lactating Djallonke ewes and their lambs. A thesis submitted to the Department of Animal Science, College of Agriculture and natural Resource, Kwame Nkrumah University of Science and Technology in Partial Fulfillment of the requirements for the degree in Animal nutrition, 2003.

Awad, O. A. and Elhadi, O. A. (2010). Seasonal variability in nutritive value of ruminant diets under open grazing system in the semi-arid rangeland of Sudan (South Darfur State). Agriculture and Biology Journal of North America, 1(3): 243-249.

Awuma, K. S. (2012). Description and diagnosis of crop – livestock systems in Ghana. Proceeding of Regional Workshop on Sustainable Intensification of Crop-Livestock Systems in Ghana for Increased Farm Productivity and Food/Nutrition Security, 27 – 28 August, 2012: 74-86.

Ayantunde, A. A., Delfosse, P., Fernandez-Rivera, S., Gerard, B., and Dan-Gomma, A. (2007). Supplementation with groundnut haulms for sheep fattening in the West African Sahel. In Trop Anim Health Prod 39:207-216.

Ayantunde, A. A. Fernandez-Rivera, S. and Dan-Gomma, A. (2008). Sheep fattening with groundnut haulms and millet bran in the West African Sahel. Revue D'élevage Et De Médecine Vétérinaire Des Pays Tropicaux, 61: 215–220.

Ayantunde, A.A., Hiernaux, P., Fernández-Rivera, S., van Keulen, H. and Udo, H.M.J. (1999). Selective grazing by cattle on spatially and seasonally heterogeneous rangeland in Sahel. Journal of Arid Environments, 42: 261–279.

Ayoade, J. A. Makhambera, P. E. Bodzalekani, M. Z. (1983). Evaluation of crop residues as feeds for goats. Part 1. Voluntary intakes, digestibility and nitrogen utilization of groundnut and bean haulms. South Afr. J. Anim. Sci., 13 (1): 12-13

Azab, M.E. and Abdel-Maksoud, H.A. (1999). Changes in some haematological and biochemical parameters during pre-partum and post-partum periods in female Baladi goats. Small Ruminant Research, 34: 77-85.

Babayemi, O.J. and Bamikole, M.A. (2006). Supplementary value of *Tephrosia bracteolata, T. candida, Leucaena leucocephala and Gliricidia sepium* hay for WAD goats kept on *Panicum maximum.* Journal of Central European Agriculture, 7(2): 323.

Badve, V. C. Nisal, R. A. Josh, L. and Rangnekar, D. V. (1994). Genotype and environment effects on sorghum stover production and quality. In variation in quantity and quality of Fibrous Crop Residues (eds. L. Joshi, P. T. Doyle, S. J.

Oosting). Proceedings of Baif Development Research Foundation, 1994, Pune, India.p.9

Baiden, R.Y. and Duncan, J.L. (2009). Performance of Djallonké lambs raised under various management systems in Ghana. Livest. Res. Rural Dev. pp. 21:193.

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. Livest Res for Rural Develop, 19(3).

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.

Ball, D. M., Collins, M., Lacefield, G. D., Martin, N. P., Mertens, D. A., Olson, K. E., and Wolf, M. W. (2001). Understanding forage quality. *American Farm Bureau Federation Publication*, *1*(01).

Baker, R.L. Rege, J.E.O. (1994). Genetic resistance to diseases and other stresses in improvement of ruminant livestock in the tropics. In: Proceedings of the Fifth World Congress on Genetics Applied to Livestock Production, vol. 20, University of Guelph, Canada, 7-12 August, 1994, pp. 405-412.

Baker, F.J. Silverton, R.E. (1990). Introduction toMedicalLaboratory Technology, 6th edition, Butterworth and Co. Ltd, London. pp. 305-329.

Bauchop, T. (1981). The role of anaerobic fungi in rumen fibre digestion. Agriculture and Environment, 6: 333-348.

Bauchop, T. and Mountfort, D.C. (1981). Cellulose fermentation by a rumen anaerobic fungus in both the absence and the presence of rumen methanogen. Applied Environmental microbiology. 1981. Dec, 42(6):1103-10.

Bawala, T.O. Adegoke, E.O. Ojekunle, A.O. Adu, I.F. and Aina, A.B.J. (2007). Utilization of cassava peel and rumen epithelial waste diets by West African dwarf sheep. Asset Series A; 7:168–180.

Bayble, T. Melaku, S. and Prasad, N. K. (2007). Effects of cutting dates on nutritive value of Napier (*Pennisetum purpureum*) grass planted sole and in association with Desmodium (*Desmodium intortum*) or Lablab (*Lablab purpureus*). Livestock Research for Rural Development, 19(1), 120-136.

Belewu, M.A. and Ojo-Alokomaro, K.O. (2007).Haematological indices of West African Dwarf goat fed leaf meal based diets. Bulgarian Journal of Agricultural Science 13: 601-606.

Bellof, G. Wolf, A. Schuster, M. and Hollwich, W. (2003). Nutrient composition of the muscle, fat, and bone tissue of carcasses during the development of lambs of the Merino breed with different feeding intensities. J Anim. Physiol., 87(9-10): 347-358. Biochemical approach. 3rd Ed., McGraw Hill Book Co. Inc., New York, USA.

Bernes, G., Hetta, M., and Martinsson, K. (2008). Effects of harvest date of timothy (Phleum pratense) on its nutritive value, and on the voluntary silage intake and live weight gain of lambs. *Grass and Forage Science*, *63*(2), 212-220.

Bhatia, D.R. and Patnayak, B.C. (1988). Replacement of sesame cake by cotton seed cake in diet of growing lambs. India. J. of Anim. Sci. 58, 4: 514-516.

Black, J.L. Pearce, G.R. and Tribe, D.E. (1978). Protein requirements of growing lambs. British Journal of Nutrition, 30(11): 45 – 60.

Blair, G.J. (1989).The diversity of potential value of shrubs and tree fodders. In: C Devendra, ed., Shrubs and Tree Fodders for Farm Animals. Proceedings of a workshop in Denpasar, Indonesia, 24-29 July, 1989. p. 2-9.

Blummel, M., Steingass, H. and Becker, K. (1997). The relationship between in *in vitro* gas production, *in vitro* microbial biomass yield and 15N incorporation and its implications for the prediction of voluntary feed intake of roughages. Brtish Journal of Nutrition, 77:911-921.

Blummel, M. and Orskov, E.R. (1993). Comparison of *in vitro* gas production and nylon bag degradability of roughages in predicting feed intake in cattle. Anim. Feed Sci. Technol., 40: 109-119.

Boukary, A.R. (1999). Utilisation des techniques de la production de gaz in vitro, in sacco et de la spectrométrie dans le proche infrarouge pour l'évaluation de la valeur alimentaire des aliments du bétail au Niger. Thèse de fin de fin de cycle de spécialisation Production Animale, option: Alimentation-Nutrition. Institut National Agronomique de Tunis.

Bowman, J. G. P. and Asplund, J. M. (1988). Evaluation of mixed Lucerne Caucasian bluestem hay diets fed to sheep. Anim. Feed Sci. Technol., 20: 19.

Brooker, J.D. Lum, D.K. Miller, S. Skene, I. and O'Donovan, L. (1995). Rumen microorganisms as providers of high quality protein. Livestock Research for Rural Development 6(3): **http://www.lrrd.org/lrrd6/3/1.htm**.

Burns, J. C. Pond, K. R. Fisher, D. S. and Luginbuhl, J. M. (1997). Changes in forage quality, ingestive mastication, and digesta kinetics resulting from switch grass maturity. Journal of Animal. Science. 75:1368-1379.

Carangal, V. R and Calub, A. D. (1987). Crop residues and fodder crops in Rice-based systems. In: Dixon, R. M (ed). Ruminant feeding systems utilizing fibrous agricultural residues. Proc. of 6th Annual workshop of the Australian-Asian Fibrous Agricultural Residues Research Network held in the University of Philipines at Los Banos, 1-3 April, 1986. IDC, Canberra.

Charray, J. Humbert, J. M. and Levif, J. (1992). Sheep farming in humid tropical Africa. CAB International, Wallingford, UK. 187pp.

Cheeke, R. Peter (2005). Applied Animal Nutrition Third Edition. Pearson. New Jersey.

Church, J.P. Judd, J.T. Young, C.W. Kebay, J.L. and Kin, W.W. (1984). Relationships among dietary constituents and specific serum clinical components of subjects eating self-selected diet. American Journal of Clinical Nutrition, 40: 1338-1344. Co. Inc. Rahway, New Jersey, USA. pp.81.

Cook, B. G., Pengelly, B. C., Brown, S. D., Donnelly, J. L., Eagles, D. A., Franco, M. A., and Schultze -Kraft, R. (2005). Tropical forages: an interactive selection tool. *Lablab purpureus.* CSIRO, DPI and F (Qld), CIAT, and ILRI, Brisbane, Australia.

Coles, E.H. (1986). Veterinary clinical pathology. 4th edition (ed. E.H. Coles) W.B. Saunders and Co. Philaldelphia.

Coulibaly, M. A. Ntare, B. R. Gracen, V. E. Danquah, E. Y. Ofori, K. and Mahamane, A. S. (2017). Phenotyping groundnut genotypes to identify sources of earliness in

Niger. International Journal of Innovations in Engineering Research and Technology (IJIERT), 4(238): 242.

Crasta, O. R. and Cox, W. J. (1996). Temperature and soil water effects on maize growth, development, yield and forage quality. Crop Science. 36:341-348.

Culbreath, A. K. Todd, J. W. and Gorbet, D. W. (1999). Response of early, medium, and late maturing peanut breeding lines to field epidemics of tomato spotted wilt. Peanut Science, 26(2): 100–106.

Dacie, J.V. and Lewis, S.M. (1991). Practical haematology 7th edition Churchill Livingston, Edinburgh, Melbourne and New York. pp 24-36.

DAD-IS (2005):http://dad.fao.org/en/home.htm

DAGRIS (2005):http://dagris.ilri.cgiar.org.

Dakora, F. D. Aboyinga, R. A. Mahama, Y. and Apaseku, J. (1987). Assessment of N_2 fixation in groundnut (Arachis hypogaea L.) and cowpea (Vigna unguiculata L. Walp) and their relative N contribution to a succeeding maize crop in Northern Ghana. Mircen Journal of Applied Microbiology and Biotechnology, 3(4): 389–399.

Dan-Gomma, A. (1998). Influence du type de four rage et de different niveaux de supplement en son de mil sur les performances de croissance et a l'abattage des ovins au Niger. (MSc thesis, Institut Agronomique et Veterianaire Hassan II, Rabat).

Daramola, J.O. Adeloye, A.A. Fatoba, T.A. And Soladoye, A.O. (2005). Haematological and biochemical parameters for West African Dwarf goats. Livestock Research for Rural Development, Vol. 17#8. Retrieved from: http://www.cipav.org.co/lrrd/lrrd 17/8/dara17095. htm

Dargie, J.D. and Allonby, E.W. (1975). Path physiology of single and challenge infections of *Haemonchus contortus* in Merino sheep; studies of red cell kinetics and self-cure phenomenon. International Journal of Parasitology, 5(15): 147-157.

Delgado, C. Rosegrant, M. Steinfeld, H. Ehui, S. and Courbois, C. (1999). Livestock to 2020: the next revolution, food, agriculture, and the environment discussion. International Food Policy Research Institute. Paper 28. 1999. Retrieved March 27, 2006 from the U of MN website:http://agecom.lib.umn/cgi-bin/pdf

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. (1997). Crop residues for feeding animals in Asia: technology development and adoption in crop/livestock systems. In: Renard C, editor. Crop residues in sustainable mixed crop/livestock farming systems. CAB International; 322.Edition), London, Butterworth Publication, pp 481-494.

Devendra, C. (1991). Technologies currently used for the Improvement of straw utilization in ruminant feeding systems in Asia; In: Roney, D.K., Ørkow, E.R. and Gill, M., Eds., Processing of the NRI/MARDI workshop on the utilization of straw in ruminant production systems, 7-11 October, 1991, Natural resources Institute and Malaysian Agricultural Research and Development Institute, Kuala Lumpur, 1-9.

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.

De Leew, P.N. (1997). Crop residue in Tropical Africa: Trends in supply, demand and use. Pp.41-77 in: Crop residues in sustainable mixed crop-livestock farming systems, edited by C. Renard. International Livestock Research Institute (ILRI), and CAB International, Wallingford, UK.

Duncan, A.J. York, L. Lukuyu, B. Samaddar, A. and Stűr, W. (2012). Feed Assessment Tool (FEAST). **www.ilri.org/feast**.

Dutta, N. Sharma, K. and Hassan, Q. Z. (1999).Effect of supplementation of rice straw with leucocephala and Prosopis cineraria leaves on nutrient utilization by goats Asian – Australia Journal of Animal Science. 12 (5)742-746.

Economides, S. Koumas, A. Georghiades, E. and Hadjipanayiotou, M. (1990). The effect of barely sorghum grain processing and from of concentrate mixture on performance of lambs, kids and calves. Amin. Feed. Sci. and Teach. 13(1-2): 105-116.

Egbe-Nwiyi, T.N. Nwaosu, S. C. and Salami, H.A. (2000). Haematological values of apparently healthy sheep and goats as influenced by age and sex in arid zones of Nigeria. African J.Biomed. Res. 3: 109-115.

El Naim, A.M. Eldouma, M.A. Ibrahim, E.A. and Moayad, M.B.Z. (2011). Influence of plant spacing and weeds on growth and yield of peanut (*Arachis hypogaea* L) in Rain-fed of Sudan. Advances in Life Science, 1(2): 45-48.

Elginaid, E.M. (1997). Feeding potential of important natural pasture and crop residues in Butana, Eastern Sudan. Ph.D. Dissertation. University Goetingen. Germany.

Eniolorunda, O.O. and Fasina, O.E. (2006). Haematological studies and biochemical measuerements of goats fed *Cynodonnlemfuensis* or *Spondias mombin* or *Gmelinaarborea* based diets. Proceedings of the 31st Annual Conference of the Nigerian Society for Animal Environment, 48: 263–271.

Epstein, H. (1971). The origin of the domestic animals of Africa. Africana Publishing Corporation. New York. London. Munich, 2: pp 53-56 2nd Edition.

Esonu, B.O. Emenalom, O.O. Udedibie, A.B.I. Herbert, U. Ekpor, C.F. Okoli, I.C. and Iheukwumere, F.C. (2001). Performance and blood chemistry of weaner pigs fed raw mucuna bean (velvet bean) meal. Trop. Anim. Prod. Invest. 4: 49-54.

Etela I. and Dung D.D (2011). Utilization of stover from six improved dual-purpose groundnut (*arachis hypogaea* l.) Cultivars by west African dwarf sheep,African Journal of Food, Agriculture, Nutrition and Development, 11:4538-4545.

Etim, NseAbasi N. Williams, Mary E. Akpabio, U. and Offiong, Edem E.A. (2014). Haematological Parameters and Factors affecting their values. Agriculture science, volume 2, issue 1(2014), 37-47. Published by Science and Education centre of North America.

Evitayani, L. W., Fariani, A., Ichinohe, T., Abdulrazak, S. A., and Fujihara, T. (2004). Comparative rumen degradability of some legume forages between wet and dry season in West Sumatra, Indonesia. Asian-Australia. Journal. Animal. Science, 17(8)

Ewuola, E.O. Falayan, O.A Cibore, F.A. Adebunmi, A.I. Akanji, R.A. Ogunlade, J.T. and Adeneye, J.A. (2004). Physiological response of growing west African Dwarf goats fed groundnut shell-based diets as concentrate supplements. BOWEN J. Agric 1 (1): 61-69.

Ewuola, E.O. Folayan, O. A. Gbore, F. A. Adebunmi, A. I. Akanji, R. A. Ogunlade, J. T. Hamidou, F. Ratnakumar, P. and Halilou, O. (2012). Selection of intermittent drought tolerant lines across years and locations in the reference collection of groundnut (*Arachis hypogaea* L.). Field Crops Research, 126: 189–199.

FAO. (2003). Food and Agricultural Organization Production year Book. FAO. Rome, Italy.

FAO. (Food and Agriculture Organization of the United Nations). (2005). Fertilizer use by crop in Ghana. http://www.fao.org/docrep/008/a0013e/a0013e00.htm (retrieved June 10, 2012).

FAO. (Food and Agricultural Organization) (2006). FAO STAT (2006). Nigerian statistics for meat and milk production, live animal and milk imports for the period 1996-2005.

FAO (Food and Agriculture Organization of the United Nations). (2010). Nutrition country profiles – Ghana. Agriculture and Consumer Protection Department. **http://www.fao.org/ag/agn/nutrition/gha_en.stm**. (retrieved April 3, 2013).

FAO (2012). World agriculture towards 20130/20150: the 2012 revision, by N. Alexandratos & J. Bruinsma. ESA Working Paper No. 12-03 **http://www.fao.org/economic/esa/esag/en/**.

FAO, FAOSTAT (2014) **http://faostat.fao.org/site/339/default.aspx**.

FAO (2015). The State of Agricultural Commodity Markets. Trade and food secur ity: achieving a better balance between national priorities and the collective good. Rome. **http://www.fao.org/3/a-i5090e.pdf**.

FAO. (1994). The state of food and agriculture 1994. Retrieved from Rome, Italy.

Fadel Elseed, A.M. Danil, T. Balgee, A. Elmanan, E. A. Ali O.H. (2013). Effects of Fenugreek (Trigonella foenum-graecum) Seeds saponin on Dgestibility, N-Retention, Haematological parameters and Blood Metabolites in rabbits. World's Vet. Journal, 3(4):65-73, 2013.

Fadel Elseed, A.M. Elawad S.M, Dousa, B.M. Abdel Atti, A. Khadiga, Tamador, A. Algam. (2002). Effect of dietary raw chick pea (Cicer arientinum L.) seeds on Broiler performance and Blood constituents. International Journal of Poultry Science, 11(4): 294-297.

Fadiyimu, A.A. (2000). Chemical composition, dry matter degradability and preference by WAD goats of some multipurpose trees in Nigeria. In: Proc. the 25th Annual Conf. Nig. Soc. Anim. Prod., March 19-23, Umudike, Imo State, Nigeria. pp 76-77.

Fasae, O.A. Alokan, J.A. and Onibi, G.E. (2005). Feed intake and digestibility in Yankasa sheep fed diets containing varying levels of *Leucaena leucocephala* leaf residues. Nigerian Journal of Animal Production 32(1): 88 -93. Febiger, Philadelphia pp. 15-81.

Fernández-Rivera, S. Hiernaux, P. Williams, T.O. Turner, M. D. Schlecht, E. Salla, A. Ayantunde, A.A. and Sangaré, M. (2005). Nutritional constraints to grazing ruminants in the millet-cowpea-livestock farming system of the Sahel. In: A.A. Ayantunde, S. Fernández-Rivera and G. McCrabb (eds), Coping with Feed Scarcity in Smallholder Livestock Systems in Developing Countries, (International Livestock Research Institute (ILRI), Nairobi, Kenya), 157–182.

Forbes J. M. (1986). The Voluntary Food Intake of Farm Animals, Butterworth & Co. Ltd, London, UK, 1986.

Francis, A. Gouro, A.S. Ndlovu, L. Nuru, H. Lameta, K. and Judith, F. (2009). Improving Livestock Development in ACP countries: The role of Science, Technology and Innovation in addressing the challenges to food security and economic empowerment. In CTA, 2009.

Frandson, R.D. (1986). Blood and other body fluids. In: Anatomy and Physiology of Farm Animals, 4th ed. Lea and Ferbiger, Philadelphia, pp. 233-257.

Frimpong, R.O. Konlan, S. P. and Denwar, N. N. (2017). Evaluation of selected Groundnut (*Arachis hypogaea* L.) Lines for Yield and Haulm Nutritive Quality Traits. International Journal of Agronomy, Volume 2017, Article ID 7479309, p.9

Gabrovska, L. and Ganovski, K.H. (1986). Effect of feeding various types of rations on the growth of lambs. Vet. Med. Nauki, 23(1): 58-64.

Gidamis, A.B. Panga, J.T. Sarwatt, S.V. Chove, B.E and Shayo, N.B. (2003). Nutrients and antinutrient contents in raw and cooked leaves and mature pods of *Moringa oleifera*, Lam. Ecology of Food and Nutrition, 42:1-13.

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.

Glatzle, A. (1992). Feed resources in the Sahel. Animal Research and Development, 35: 43–58.

Goering, H.K. and van Soest, P.J. (1970). Forage fiber analyses (apparatus, reagents, procedures and some applications).

Goska, D.Y. Kibon, A. Alawa, C.B.I. Lamidi, O.S. Madziga, I.I. Alphusus, C. and Mbahi, T.F. (2016). Nutrient Utilization By Bunaji Bulls Fattened On Varying Inclusion Levels Of Groundnut Haulms And Maize Offal In Feedlot. Journal of Animal Prod. Res. 28(2):135-143.

GSS. (2008). Ghana Living Standards Survey Report of the Fifth Round (GLSS 5). Ghana Statistical Service, Accra, Ghana.

Ghana Statistical Service. (2015). Revised 2014 Annual Gross Domestic Product, Accra: GSS, April 2015 edition.

Gutteridge, R.C. and Shelton, H.M. (1994). The role of forage tree legumes in cropping and grazing systems. In: Forage tree legumes in tropical agriculture. Gutteridge, R.C. and Shelton, H.M. (ed.) CAB International, pp. 3-11.

Hamidou, F. Rathore, A. Waliyar, F. and Vadez, V. (2014). Although drought intensity increases aflatoxin contamination, drought tolerance does not lead to less aflatoxin contamination. Field Crops Research, 156: 10–110.

Hariadi, B.T and Santoso, B. (2010). Evaluation of tropical plants containing tannin on in vitro methanogenesis and fermentation parameters using rumen fluid. J. Sci. Food Agric. 90:456-461.Inc., Arlington, Virginia, USA.

Hatam, M. and Abbasi, G. Q. (1994). History and economic importance of groundnuts (Arachis hypogaea L.). In: Crop production. Bashir, E. and Bantel, R. (Eds). Pub NBF., pp:350-351

Hawkey, C. Hart, M.G. Samour, H.J. Knight, J.A. and Hutton, R.E. (1984). Health and Production 8:131-136.

Heath, E. and Olusanya, S. (1988). Haematology. In: Anatomy and Physiology of Tropical Livestock. Longman Publishers, Singapore. pp 30-33.

Hiernaux, P. and Ayantunde, A.A. (2004). The Fakara: a semiarid agro-ecosystem under stress, Report of research activities of International Livestock Research Institute (ILRI) in Fakara, South-western Niger, between 1994 and 2002 (Desert Margins Programme, ICRISAT Niamey, Niger).

Hiernaux, P. (1998). Effects of grazing on plant species composition and spatial distribution in rangelands of the Sahel. Plant Ecology, 138, 191–202.

http://faostat.fao.org/site/569/Desktop efault.aspx, Retrieved August 20, 2008.

http://www.isrvma.org/article/58-2_3.htm.

Ibrahim, U. Ayinde, B.T. Dauda, H. and Mukhtar, A.B. (2013). Socio-economic factors affecting groundnut production in sabongari local government state, Nigeria. Int J Food Agric Econ, 1:41e8.

ICRISAT. (2008). ICRISAT West Africa programs' Annual report. 2007.

Ikhatua, U.J. and Adu, I.F. (1984). A comparative evaluation of the utilization of groundnut haulms and Digitaria smutsii hay by Red Sokoto goats. J Anim Prod Res 1984; 4:145e52.

Ikhimioya, I. and Imasuen, J.A. (2007). Blood profile of West African dwarf goats fed *Panicum maximum* supplemented with *Afzelia africana* and *Newbouldia laevis.* Pakistan Journal of Nutrition, 6 (1): 79-84.

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

International Livestock Centre for Africa (ILCA) (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

Iyeghe-Erakpotobor, G.T. Otchere, E.O. Tegbe, T.S.B. Jegede, J.O. and Abeke, F.O. (2002). A review of some Agro- industrial by-producs in the nutrition of pigs. National Animal Production Research Institute Ahamdu Bello University Shika-Zaria, Nigeria.

Jain N.C. (1993). Essentials of Veterinary Haematology. Lea and Ferbeiger, Pennsylvania, U.S.A. pp 7.

Jain, N.C. (1986). Schalms Veterinary Haematology. 4th ed., Lea and Febiger, Philadelphia, USA.

Jaleta, M. Kassie, M., and Erenstein, O. (2015). Determinants of maize stover utilization as feed, fuel and soil amendment in mixed crop–livestock systems, Ethiopia. Agricultural Systems 134:17–23.

Jayarasuriya, M.C.N. (2002). Principles of ration formulation for ruminants. In: Development and field evaluation of animal feed supplementation packages. Proceedings of the final review meeting of an IAEA Technical Cooperation Regional AFRA Project held in Cairo, Egypt 25 – 29 Nov., 2000.

Jurgen, M.H. (1997). Animal feeding and Nutrition 8th edition. Kendaii/Hunt publishing company DDubuque., 6:lowa,USA.

Kabatange, M. A. & Shayo, C. M. (1991). Rumen degradation of maize stover as influenced by Leucaena hay supplementation. Liv. Res. Rural Devel. 3.

Karbo, N. and Agyare, W.A. (2002). Improving livestock systems in the dry savannas of West and Central Africa (Eds)Tarawali G and Hiernaux P. Crop-Livestock Systems in the Dry Savannas of West and Central Africa, 22–27.

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.

Karbo N. Alhassan, W. S. Adongo, S. A., and Bruce, J. (1997). Small holder lamb fattening based on crop residues and agro-industrial by-products in northern Ghana. Ghana Journal of Agricultural Science, 30: 31–38.

Kathaperumal, V. Murugan, M. and Thirumali, S. (1988). Evaluation of rain tree fruit meal as feed for sheep. Indian Veterinary Journal, 65: 404 – 406.

Kiran, S. and Schiere, J. B. (1995). Indo-Dutch Project on Bioconversion of Crop Residues, Indo-Dutch Project on Bioconversion of Crop Residues, New Delhi, India, 1995.

Kochapakdee, S. W., Pralokarn, S. Laapetchara, A. S. and Norton, B. W. (1994). Grazing management studies with Thai goats. Productivity of female goats grazing newly established pasture with varying levels of supplementary feeding. Asian-Aust. J. Anim. Sci., 7: 289-293.

Konlan, S. P. Ayantunde, A. A. Addah, W. and Dei, K. H. (2016). Evaluation of Feed Resource Availability for Ruminant Production in Northern Ghana. International Journal of Livestock Research, 6(6): 39-59.

Konlan, S. P. Ayantunde, A. A. Dei, H. K. and Avornyo, F. K. (2014). Evaluation of Existing and Potential Feed Resources for Ruminant Production in Northern Ghana, International Livestock Research Institute, 2014.

Konlan, S. P. Karikari, P. K. and Ansah, T. (2012). Productive and blood indices of dwarf rams fed a mixture of rice straw and groundnut haulms alone or supplemented with concentrates containing different levels of shea nut cake. Pakistan Journal of Nutrition, 11(6): 566–571.

Kosgey, I. S. and Okeyo, A. M. (2007). Genetic improvement of small ruminants in low-input, small-holder production systems: technical and infrastructural issues: Small Ruminant Research, 70(1): 76-88.

Kozloski, G. V., Perottoni, J., and Sanchez, L. B. (2005). Influence of regrowth age on the nutritive value of dwarf Elephant grass hay (*Pennisetum purpureum* Schum. cv. Mott) consumed by lambs. *Animal feed science and technology*, *119*(1), 1-11.

Lakpini, C.A.M. (2002). Feeds and feeding strategies for small ruminants in various physiological states. A paper presented at the small ruminants production training workshop held at National Animal Production Research Institute (NAPRI), ABU Zaria 13th-18th January, 2002, Pp40-47.

Lamb, G. N. (1981). Manual of Veterinary Laboratory Technique. CIBA-GEIGY, Kenya. pp 96-97.

Lamidi, O. S. Osinowo, O.A. Adamu, A.M. and Afolayan, R.A. (1998). Performance and nutrient utilization by WAD sheep fed *Ficus* leaves. Nigerian Journal of Animal Production, 25(1): 63-67.

Larbi, A. Smith, J.W. Kurdi, I.O. Adekunle, I.O. Raji, A.M.M. and Lapido, D.O. (1998).Chemical composition, rumen degradation and gas production characteristics of some multipurpose fodder trees and shrubs during the wet and dry seasons in the humid tropics. Anim. Feed Sci. Techno. 72: 81-96.

Larbi, A. Dung, D.D. Olorunju, P.E. Smith, J.W. Tanko, R.J. Muhammad, I.R. and Adekunle, I.O. (1999). Groundnut (Arachis hypogaea) for food and fodder in crop-livestock systems: forage and seed yields, chemical composition and Trop Anim Health Prod (2007) 39:207–216 215 rumen degradation of leaf and stem fractions of 38 cultivars. Animal Feed Science and Technology, 77: 33–47.

Latham, M. (1999). Crop residues as a strategic resource in mixed farming systems. In: Renard C. (ed), Crop residues in sustainable mixed crop/livestock farming systems. CAB International, Wallingford, UK, ICRISAT (International Crops Research Institute for the Semi-Arid Tropics), Patancheru, Andhra Pradesh, India, and ILRI (International Livestock Research Institute), Nairobi, Kenya. pp. 181-196.

Lazzaro, J. (2001). Normal blood chemistry values for adult goats. Retrieved from **www.saanendoah.com/bloodvaluesw.htm**.

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

Leng, R.A. (1990). Factors Affecting Utilization of Poor Quality Forages by Ruminants Particularly under Tropical Conditions. Nutrition Research Reviews, 3, 277-303. **http://dx.doi.org/10.1079/NRR19900016**.

Leng, R.A (1997).Tree foliage in ruminant nutrition. FAO Animal Production and Health Paper 139, FAO Rome, Italy.

Leng, R.A. (1987). Nutritional role of concentrate feeds and perspectives for their substitution based on recent advances in nutritional science. In Proceedings of the FAO Expert Consultation on the substitution of imported concentrate feeds in animal production systems in developing countries. FAO Animal Production and Health.

London, J.C. and Weniger, J.H. (1996). Investigations into traditionally managed Djallonké-sheep production in the humid and subhumid zones of Asante, Ghana. V. Productivity indices. Journal of Animal Breeding and Genetics. 113(6): 483-492.

Mahajan, J. M., Chauhan, D. S. and Tomar, V. P. S. (1976). Effect of supplementary feeding to grazing on growth and wool production in sheep. Indian J. Anim. Res., 10: 90-92.

Mahgoub, O. Lu, C. D. and Early, I. R. J. (2000). Effects of dietary energy density on feed intake, body weight gain and carcass chemical composition of Omani growing lambs. Small Rumin. Res., 37(1-2): 35-42.

Makkar, H.P.S. and Becker, K. (1996). Nutritional value and anti-nutritional components of whole and ethanol extracted *Moringa oleifera* leaves. Animal Feed Science and Technology, 63: 211-228.

Makkar, H.P.S. and Becker, K. (1997). Nutrients and antiquality factors in different morphological parts of the *Moringa oleifera* tree. Journal of Agricultural Science, 128: 311-322.

Malgwi, I.H. Mohammed, I.D. Jeremiah, K. and Nyako, H.D. (2015). Nutrient evaluation of total mixed rations used in ruminant feeding using maize bran, cowpea husk, poultry litter and groundnut haulms in a semi-arid environment of Nigeria. Annals of Biological Research, 2015, 6(4):14-18.

Manh, L.H. Dung, N.N.X and Ngoi, T. P. (2005). Introduction and evaluation of *Moringa oleifera* for biomass production and as feed for goats in the Mekong Delta. Livestock Research for Rural Development 17 (9). Retrieved from **http://www.lrrd.org/lrrd17/9/manh17104.htm**.

Manyuchi, B. Deb, Hovell, F.D., Ndlovu, L.R., Topps, J.H. and Tigere, A. (1997). The use of groundnut hay as a supplement for sheep consuming poor quality natural pastures hay. Animal Feed Science and Technology, 69: 17–26.

Marfo, K. O. and Padi, F. K. (1999). Yield stability of some groundnut accessions in northern Ghana. Ghana Journal of Agricultural Science, 32(2): 137–144, 1999. View at Publisher.

Martey, E. Wiredu, A. N. and Oteng-Frimpong, R. (2015). Baseline Study of Groundnut in Northern Ghana, LAP Lambert academic publishing, 2015.

Mason, I.L. (1951). The classification of West African livestock. Edinburgh. Commonwealth Bureau of Animal Breeding and Genetics, Technical Communication No. 7.

McDonald, P. E. Edward, R.A. Greenhalgh, J.F.D. Morgan, C.A. Sinclair, L.A. (2011). Animal Nutrition 7th Edition. Prentice Hall, UK.

McDonald, P. Edward, R.A, Greenhalgh, J.F.D. (1987). Animal Nutrition 4th Edition. ELBS/Longman Scientific and Technical, UK, pp. 452 – 524.

McDonald, P. Edwards, R.A. Greenhalgh, J.F.D. Morgan, C.A, Sinclair, L.A. Wilkinson, R.G. McDonalds, P. Edward, R.A. Greenhalgh, J.F.D (1988). Animal Nutrition (4th edition) Longman, U.K.

McMahon, L.R. Majak, W. McAllister, T.A. Hall, J.W. Jones, G. Popp, J.D. and Cheng, K.J. (1999). Effect of sainfoin on in vitro digestion of fresh alfalfa and bloat in steers. Canadan Journal of Animal Science 79:203–212 Van SOEST, P.J. Nutrition ecology of the ruminant. Ithaca: Comstock Publishing Associates, 1994. pp. 476.

McNitt, J.I. (1983). Livestock Husbandry Techniques, Low priced edition. Granada publishing company, London, UK.

Meale, S. J. Chaves, A.V. Baah, J. and McAllister, T.A. (2012). Methane production of different forages in in-vitro ruminal fermentation. Asian-Aust. J. Anim. Sci. 25(1): 86-91.

Melesse, A. Steingass, H. Boguhn, J. Rodehutscord, M. (2013). ***In vitro*** fermentation characteristics and effective utilizable crude protein in leaves and green pods of ***Moringa stenopetala*** and ***Moringa oleifera*** cultivated at low and mid-altitudes. J. Anim. Physiol. Anim. Nutr., 97 (3): 537-546

Menke, K. H. and Steingass, H. (1988). Estimation of the energetic feed value obtained from chemical analysis and in vitro gas production using rumen fluid. Anim. Res. and develop. 28: 755.

Menke, K.H. Raab, L. Salewski, A. Steingass, H. Fritz, D. and Schneider, W. (1979). The estimation of the digestibility and metabolizable energy content of ruminant feedstuffs from the gas production when they are incubated with rumen liquor in vitro. J. of Agric. Sci, Cambridge, 92:217–222.

Menke, K.H. Rabb, L. Salewski, A. Steingass, H. Fritz, F. and Schneider, W. (1979). The estimation of the digestibility and metabolizable energy content of ruminants feeding stuffs from the gas production when they are incubated with rumen liquor in vitro. Journal of Agricultural

MERCK (1979).The Merck Veterinary Manual. 5th edition. Siegmund O. H. (ed.), Merck & Co. Inc. Rahway, New Jersey, U.S.A. pp 1672.

MERCK and MINITAB (2000).Minitab Statistical Software, Release 10.2. Minitab Inc., State College, PA, USA.

Midau, A. Augustine, C. Yakubu, B. Yahaya, S. M. Kibon, A. and Udoyong, A. O. (2011). Performance of broiler chicken fed enzyme supplemented cassava peel meal based diets. International Journal of Sustainable Agriculture, 3(1): 1-4.

Milford, R. (1960). Nutritional values for 17 subtropical grasses. Australian Journal of Agricultural Research, 11(2), 138-148.

Ministry of Food and Agriculture (MoFA). (2000). 1997/ 1998 annual report, Livestock planning and information unit, Accra Ghana.

Ministry of Food and Agriculture (MOFA). (2011). Agriculture in Ghana: facts and figures (2010). Statistics, Research and Information Directorate (SRID). http://mofa.gov.gh/site/wp-content/uploads/2011/10/AGRICULTURE-IN-GHANA-FF-2010.pdf (retrieved February 1, 2013).

Ministry of Food and Agriculture (MoFA). (2010). Medium Term Agriculture Sector Investment Plan (METASIP) 2011 – 2015. Ministry of Food and Agriculture, Accra, Ghana.

Ministry of Food and Agriculture (MoFA) (2014). "Agriculture in Ghana: facts and figures, Minist," in Ministry Of Food and Agriculture / Statistics Research Information Directorate. pp. 1–53.

Ministry of Food and Agriculture (MoFA) (2008). Annual Progress report 2008-2012. Ministry of Food and Agriculture, Accra.

Minson, D.J. (1990). Forage in Ruminant Nutrition, (Academic Press, San Diego).

Mohamed, R. and Chaudhry, A.S. (2008). Methods to study degradation of ruminant feeds. Nutrition Research Reviews, 21:1-14.

Mokgehle, S. N. Dakora, F. D. and Mathews, C. (2014). Variation in N2 fixation and N contribution by 25 groundnuts (*Arachis hypogaea L.*) varieties grown in different agro-ecologies, measured using 15N natural abundance. Agriculture, Ecosystems and Environment, 195: 161–172.

Moran, J. (2010). Improving the utilisation of Napier grass by dairy cows through fractionating the stems into juice and fibrous residue. *Successes and Failures with Animal Nutrition Practices and Technologies in Developing Countries*, 97.

Mosi, A.K. and Butterworth, M.H. (1985). The Voluntary Intake and Digestibility of Combination of Cereal Crop Residues and Legume Hay for Sheep. Animal Feed Science and Technology, 12, 241-251.

Murthy, U. G. K. Prasad, J. R. (2002). Evaluation of legume hay based complete rations in sheep. Indian J. Anim. Nutr., 19 (4): 315-319

Naab, J. B., Tsigbey, F. K., Prasad, P. V. V., Boote, K. J., Bailey, J. E. and Bradenberg, R. L. (2005). Effects of sowing date and fungicide application on yield of early and late maturing peanut cultivars grown under rainfed conditions in Ghana. Crop Protection 24(1): 107-110.

Naab, J. B. Seini, S. S. and Gyasi, K. O. (2009). Groundnut yield response and economic benefits of fungicide and phosphorus application in farmer-managed trials in Northern Ghana. Experimental Agriculture, 45(4): 385–399.

Ngere, L.O. (1983). The small ruminants of West Africa. OAU/STRC/IBAR, Nairobi, Kenya. Second OAU Expert Committee Meeting on Animal Genetic Resources in Africa. 24-28 November 1983: Bulawayo, Zimbabwe. pp. 113-121.

Ngwa, A.T. and Tawah, C.L. (2002). Effect of supplementation with leguminous crop residues or concentrates on the voluntary intake and performance of kirdi sheep. Tropical Animal Health and Production Journal.20002 Feb; 34(1): 65-73.

Ngwa, A. T. and Tawah, C. L. (1992). Effect of legume crop residues and concentrate supplementation on voluntary intake and performance of kirdi sheep fed a basal diet of rice straw. In FAO ILCA. The complementarity of feed resources for animal production in Africa.

Ngamsaeng, A. (2005). Effects of supplementing local plants on rumen fermentation, microbialprotein synthesis, digestibility and voluntary feed intake in beef cattle steers. M.Sc. Thesis. A MscKhon Kaen University, Thailand.

Nigam, S. N. and Blummel, M. (2010). Cultivar-dependent variation in food-feed-traits in groundnut (Arachis hypogaea L.). Animal Feed Science and Technology,10: 39–48.

Njidda, A.A. Nasiru. (2010). In vitro gas production and dry matter digestibility of tannin-containing forages of semi-arid region of north-eastern Nigeria. Park Journal of Nutrition, 2010; 9: 60-66.

Norton B.W. (1994).Tree legume as dietary supplements for ruminants. In: R. C. Gutteridge and P. M. Shelton (eds.) Forage tree legumes in tropical agriculture. CAB International, Wallingford. pp 202 – 215.

Ntawuruhunga, P. and Dixon, A. G. O. (2010). Quantitative variation and interrelationship between factors influencing cassava yield, Journal of Applied Biosciences, 26: 1594–1602.

Nyako, H.D. (2015). Effect of feeding supplements on theperformance of Yankasa rams offered a basal diet of cowpea hay in the semi-arid region of Nigeria. Journal of biology, Agriculture and Health care. ISSN 2224-3208(Paper) ISSN 2225-093X (Online) Vol., No.6, 2015.

NRC. (1985). Nutrient Requiremets of Beef Cattle Ruminants. National Academy Press, Washington, DC, USA.

NRC (National Research Council) (2007). Nutrient requirements of small ruminants. Sheep,goats, cervids and New World Camelids. Washington: National Academy of Science.

Ntare, B. R. and Williams, J. H. (1998). Heritability and genotype × environment interaction for yield and components of yield model in segregating populations of groundnut under semi-arid conditions," African Crop Science Journal, vol. 6, pp. 119–127, 1998. Nutr Dev 2011; 11:4538e45.

Nurfeta, A. (2010): Feed intake, digestibility, nitrogen utilization and body weight change of sheep consuming wheat straw supplemented with local agricultural and agro-industrial by-products. Tropical Animal Health and Production, 42: 815–824.

Nutsugah, S. K. Abudulai, M. Oti-Boateng, C., Brandenburg, R. L. and Jordan, D. L. (2007). Management of leaf spot diseases of peanut with fungicides and local detergents in Ghana. Plant Pathology Journal, 6(3): 248–253.

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.

Oddy, V.H. and Sainz, R.D. (2002) Nutrition for Sheep-Meat Production. In: Freer, M. and Dove, H., CSIRO Plant Industry Canberra Australia, Eds., Sheep Nutrition, CABI Publishing, CAB international, Oxon, UK, 237-263. **https://doi.org/10.1079/9780851995953.0237**.

Odee, D. (1998). Forest biotechnology research in dry lands of Kenya: the development of *Moringa* species. Dryland Biodiversity, 2: 7-8.

Odeyinka, S.M. and Ademosun, A.A. (1995). The effects of the levels of feed offer on the intake, digestibility and growth rate of West African dwarf goats fed *Gliricidia sepium* and *Leucaena leucocephala.* Nigerian Journal of Animal Production, 22(2): 164-168.

Oduye, O.O. (1976). Haematol. Value of an AIgeria goats and sheep. Trop. Animal. Health .and prod. 8:131-136.

Oduye, O.O. and Adadevoh, B.K. (1976).Biochemical values in apparently normal Nigerian goats. J. Nig. Vet. Med. Assoc., 5:51-55.

O'Hara, P. Freney, J. and Ulyatt, M. (2003). Abatement of agricultural non-carbon dioxide greenhouse gas emissions – a study of research requirements, a report prepared for the Ministry of Agriculture and Forestry, New Zealand.

Okai, D.B. Abora, P.K.B. Davis, T. and Martin, A. (2005). Nutrient composition, available, current and potential uses of "DUSA": A cereal by-product obtained from "KOKO" (Porridge) production. Journal of Science and Technology, Volume 25, no. 1, 2005.

Okoli I.C, Anunobi, M.O. Obua, B.E. and Enemuo, V. (2003). Studies on selected browses of southeastern Nigeria with particular reference to their proximate and some endogenous anti-nutritional constituents. Livestock Research for Rural Development 15(9): http://www.lrrd.org/lrrd15/9/okol159.htm

Okoli, O. Onyenweaku, C. E. and Ikeorgu, J.E.G. (1995). Report on southeastern zone livestock sub – sector.Paper presentation at the National Agricultural Strategy plan for Nigeria, Zaria, Nigeria.

Olubajo, F. Oyenuga, V.A. (1971). The measurement of Yield, Voluntary intake and animal production of the tropical pasture mixtures. Journal of Agric. Science. Volume 77, Issue 1, August 1971, pp.1-4.

Olusanya, S.K. Edewor, E.E. and Health, E. (1976). Studies on the Blood chemistry and other haematological parameters in a buffaloes in a ranch in Nigeria. Nigeria Veterinary Journal 5 (1): 27-31.

Omoike, A. (2006). Nigeria. Journal of Agriculture and Social Research, Vol. 6, No. 2, pp.23-31.

Opara, M. N. Udevi, N. and Okoli, I. C. (2010). Haematological parameters and blood chemistry of apparently healthy West African Dwarf (WAD) goats in Owerri, South Eastern Nigeria. New York Science Journal 3 (8): 68-72.

Oppong-Anane, K. (2001). Country Pasture/Forage Resource Profiles, Ghana.Food and Agriculture Organization of the United Nations (FAO), Rome.

Oppong-Anane, K. (2006). Country pasture/forage resources profiles: Ghana. Food and Agriculture Organization of the United Nations (FAO). http://www.fao.org/ag/AGP/AGPC/doc/Counprof/PDF%20files/Ghana-English.pdf (retrieved December 20, 2012).

Oppong-Apane, K. (2013). Cassava as Animal Feed in Ghana: Past, Present and Future, Food and Agriculture Organisation of the United Nations, Accra, Ghana.

Orheruata, A.M., Osueni, J.E. and Aperua-Yusuf, A.O. (2004). Studies on the haematological indices of West African Dwarf goats in different locations in Edo State, Nigeria.

Orodho, A. B. (2006). The role and importance of Elephant grass in the smallholder dairy industry in Kenya. *Food and Agriculture Organization, Rome) Retrieved August*, *24*, 2011.

Orr, R. J. and Treacher, T. T. (1989). The performance of ewes offered diets containing different proportions of perennial rye grass and white clover silage in late pregnancy. Anim. Prod., 51: 143-153

Ørskov, E.R. and Dolberg, F. (1984). Recent advances in ruminant nutrition and their relevance to milk production in developing countries. In: *Milk Production in Developing Countries*. Proceedings of a conference held in Edinburgh, Centre for Tropical Veterinary Medicine, 2–6 April, 1984, (Rowett Research Institute, Aberdeen), 177-192.

Ǿrskov, E.R. and McDonald, I. (1979). The estimation of protein degradability in the rumen from incubation measurements weighted according to rate of passage. J. of Agric. Sci.Cambridge, 92:499-503.

Osaer, S. Goossens, B. Eysker, M. and Geerts, S. (2000). The effects of prophylactic anthelmintic treatment on the productivity of traditionally managed Djallonké sheep and West African Dwarf goats kept under high trypanosomosis risk. Acta Tropica. 74(1): 3-24.

Osaer, S. Goossens, B. Jeffcoate, I. Jaitner, J. Kora, S. and Holmes, P. (1998). Effects of Trypanosoma congolense and nutritional supplements on establishment and outcome of pregnancy in trypanotolerant Djallonké ewes. Animal Reproduction Science. 51(2): 97-109.

Osakwe, I. I. Steingass, H. and Drochner, W. (2004).*Daniella oliveri* as a fodder tree for small ruminant and the interaction of its tannin with ruminal ammonia. Nigerian Journal of Animal Production, 31(1): 56 – 54.

Osueni, J.E. (2001). Variation in zoometric and haematological indices of West African Dwarf goats from different locations in Edo State. MSc Thesis, Ambrose Alli University, Ekpoma, Nigeria.

Osuhor, C.U. Alawa, J.P. and Lufadeju, E.A. (1998). Overnight manure production from red Sokoto goats in Zaria, Nigeria. Proceedings of the Silver Anniversary of the Conference of the Nigeria Society of Animal Production. Gateway Hotel. Abeokuta. Nigeria. 21-26 March, 1998. p. 51- 52.

Osuji, P.O. Nsahlai, T.V. and Khalili, H. (1993). Feed evaluation. ILCA Manual 5. ILCA (International Livestock Center for Africa), Addis Ababa, Ethiopia. pp. 40.

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. Adanse-Pipim, K.A. and Barnes, A.R. (1986). Digestibility and feedlot performance of sheep fed cocoa husk-based diets. Journal of Animal 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.

Owen, E. and Jayasuriya, M.C.N. (1989). Use of crop residues as animal feeds in developing countries - a review. Research and Development in Agriculture, 6: 129 – 138.

Owen, E. (1994).Cereal crop residues as feed for goats and sheep, Livestock Research for Rural Development, 6:1–15.

Ozyigit, Y. and Bilgen, M. (2013). Forage potential of some groundnut (*Arachis hypogaea* L.) cultivars. Romanian Agricultural Research, pp. 57–63.

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.

Padi, F. K. (2008).Genotype x environment interaction for yield and reaction to leaf spot infections in groundnut in semiarid West Africa: Genotype x environment interaction and leaf spot resistance in groundnut. Euphytica, 164(1):143–161.

Pamo, E. T., Boukila, B., Fonteh, F. A., Tendonkeng, F., Kana, J. R., and Nanda, A. S. (2007). Nutritive value of some grasses and leguminous tree leaves of the Central region of Africa. Animal Feed Science and Technology, 135(3), 273-282.

Pande, S. Bandyopadhyay, R. Blümmel, M. Narayana, R.J. Thomas, D. and Navi, S.S. (2003).Disease management factors influencing yield and quality of sorghum and groundnut crop residues. Field Crops Res. 84: 89-103.

Parthasarathy, R.P. and Hall, A.J. (2003). Importance of crop residues in crop-livestock systems in India and farmers' perception of fodder quality in coarse cereals. Field Crops Res.84: 189-198.

Paya Hamid, Taghizadeh Akbar, Jammohammadi Hossein and Moghadam Gholam Ali (2007). Nutrient Digestibility and Gas Production of some Tropical feeds in ruminant diets estimated by the *in vivo* and *in vitro* Gas production techniques. American Journal of Animal and Veterinary science. 2(4): 108-113, 2007.

Payne, R. W. Murray, D. A. Harding, S. A. Baird, D. B. and Soutar, D. M. (2009). Genstat for Windows, Edition Introduction, VSN International, Hemel Hempstead, 12th edition, 2009.

Peanut CRSP. (1990). The peanut CRSP: improving global production and use of peanut. Research Summary, 1982-1990. University of Georgia, Griffin. 16pp.

Pen, B. Sar, C. Mwenya, B. Kuwaki, K. Morikawa, R and Takahashi, J (2006). Effects of Yucca schidigera and Quillaja saponaria extracts on in vitro ruminal fermentation and methane emission. Anim Feed Sci Technol, 129:175e86.

Peiretti, P. G. (2009). Effects of growth stage on chemical composition, organic matter digestibility, gross energy and fatty acid content of safflower (*Carthamus tinctorius* L.). Livestock Research for Rural Development, 22, 12.

Prasad, K. V. S. V, Khan, A. A. and Vellaikumar, S. (2010). Observations on livestock productivity in sheep fed exclusively on haulms from ten different genotypes of groundnut. Animal Nutrition and Feed Technology, 10: 121–126.

Preston, T.R. (1995). Tropical Animal Feeding. A Manual for Research Workers. FAO Animal Production and Health, Rome, Paper No. 126, 305.

Preston, T.R. and Leng, R.A. (1984). Supplementation of diets based on fibrous residues and byproducts. In: Straw and other fibrous byproducts as feed (Editors: F. Sundstol and E. Owen). Elsevier Press, Amsterdam, pp 373–413.

Preston, T.R. and Leng, R.A. (1987). Matching ruminant production systems with available resources in the tropics and sub-tropics. Penambul Books, Armidale pp 22 – 42. Production, 12th -15th March, 2006, Kano, Nigeria, pp: 429-433. Publishing CO. PVT limited, New Delhi.

Rademacher-Schulz, C. Schraven, B. and Mahama, E. S. (2014). Time matters: Shifting seasonal migration in Northern Ghana in response to rainfall variability and food insecurity, Climate and Development. 6(1): 46–52.

Radostits, O.M. Blood, O.C. and Gay, C.C. (1997). Veterinary Medicine: A Textbook of the diseases of cattle, sheep, pigs, goats and horses. 8th Edition. W.B Saunders Company Ltd. London. pp 17-63.

Ramaswamy, S. and Sanders, J.H. (1992). Population pressure, land degradation and sustainable agricultural technologies in the Sahel. Agricultural Systems, 40, 361–378. Red Sokoto goats in Zaria, Nigeria. Proceedings of the Silver Anniversary Conference of Nigerian Society for Animal Production, 21 – 26th March, 1998. Abeokuta, Nigeria. pp. 434 – 435.

Rasjid, S. (2012). The Great Ruminant Nutrisi, Pakan dan Manajemen Produksi. *Cetakan Kedua. Brilian Internasional, Surabaya*.

Riaz, M.Q. Südekum, K.H. Clauss, M. Jayanegara, A. (2014). Voluntary feed intake and digestibility of four domestic ruminant species as influenced by dietary constituents: a meta-analysis. Livest Sci.162:76 e85.

Ribadiya, N. K. Savsani, H. H. and Patil, S. S. (2015). “Effect of feeding varying levels of groundnut haulms on feed intake and growth performance in broiler chickens,” Veterinary World, 8(2): 139–142.

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.

Rymer, C. Moss, A.R. Deaville, E.R. and Givens, D.I. (1998). Factors affecting the amount of indirect gas produced by the in vitro gas production technique. In: Deaville, E.R., Owen, E., Adesogen, A.T., Rymer, C., Huntington, J.A., Lawrence, T.L.J. (Eds.), In Vitro Techniques for Measuring Nutrient Supply to Ruminants. BSAS, Edinburgh, UK. pp. 89–91, BSAS Occ. Publ. No. 22.

Russo, S.L. (1990). The use of crop residues for livestock feed by small farmers in the Gambia pp 165-185 in: Dzowela B.H Asrat Wendem- Agenehu and Ketegile J. A.(eds). Utilisation of research results on forage and agricultural by-product materials as animal feed resources in Africa. Proceedings of the first joint workshop, held 5-9 Decenber 1988, Lilongwe, Malawi. PANESA/ARNAB, International Livestock Centre for Africa, (ILRI) Addis Ababa, Ethiopia.

Salifu, M. Y. (2004). Preliminary Study on the response of sheep to shea nut cakebased diet. BSc. (Agric Tech) Dissertation, Department of Animal Science, University for Development Studies, Tamale, pp 20-28.

Sangaré, M. (2002). Optimisation de l'utilisation des resources alimentaires disponibles pour l'alimentation du bétail et du recyclage des elements nutritifs au Sahel, (PhD thesis, Institut de Medecine Tropicale Prince Leopold, Antwerp).

Sanon, H.O. (2007). The Importance of Some Sahelian Browse Species as Feed for Goats. Doctoral thesis 84, slu, Uppsala, Sweden.

Savanna Agricultural Research Institute (SARI) (2007). Meteorological department records. Annual Report. Nyankpala, Tamale, Ghana.

Sarwar, M. and Nisa, M. U. (1999). In situ digestion kinetics of Mott grass (Pennisetum purpureum) on its chemical composition, dry matter intake, ruminal characteristics and digestibility in buffalo bulls. Asian-Australian. Journal. Animal. Science, 9, 910-914.

Sarwatt, S. V. Milang'ha, M. S. Lekule, F. P. and Madalla, N. (2004). *Moringa oleifera* and cottonseed cake as supplements for smallholder dairy cows fed Napier grass Livestock Research for Rural Development. Volume 16 Article # 38. Retrieved June 2006 from **http://www.cipav.org.co/lrrd/lrrd16/6/sarw16038.htm**

SAS (1999). (Statistical Analysis Systems) Institute Inc.Users Guide, version 8 for Windows. Statistical Analysis System Institute Inc. North Carolina, U.S.A.

SAS (1987). (Statistical Analysis System) Institute, SAS/STAT for Personal Computers, (SAS Institute, Inc., Cary, NC).

Savadogo, M. (2000). Crop residue management in relation to sustainable land use: A case study in Burkina Faso, (PhD thesis, University of Wageningen, Wageningen).

Schiere, J. B. Ibrahim, M. M. and Van Keulen, H. (2000). The role of livestock for sustainability in mixed farming: criteria and scenario studies under varying resource allocation. Agri., Ecosyst. Eniron., 90(2):139-153. Science, Cambridge, 93, 217–222.

Schneider, B.H. and Flatt W.P. (1975). T W.P. The Evaluation of Feeds through Digestibility Experiments. Univ. of Georgia Press, Athens.

Singh, A. K. Dwivedi, S. L. Pande, S. Moss, J. P. Nigam, S. N. and Sastry, D. C. (2003). Registration of rust and late leaf spot resistance peanut germplasm lines. Crop Sci. 43, 440–441.

Singh, B.B. Larbi, A. Tabo, R. Dixon, A.G.O. (2004). Trends in development of crop varieties for improved crop-livestock systems in West Africa, pp. 371-388. In: Williams T.O, Tarawali SA, Hierneux P, Fernandez-Rivera S (eds.). Sustainable crop-livestock production for improved livelihoods and natural resource management in West Africa. Proc. ofIntl. Conference, held at IITA, Ibadan, Nov.19-21, 2001. Published byILRI, Nairobi and CTA, The Netherlands. 2004.

Singh, B. Yadav, C. M. (2009). Effect of soybean straw on voluntary intake, nutrient utilization and rate of passage in sheep and goats. Indian J. Small Rum., 15 (2): 262-265

Singh, K.K. Das, M.M. (2009). Effect of fibrolytic enzyme treated wheat straw on rumen fermentation and nutrient utilization in calves. Indian Veterinary Journal, 86: 380-382.

Singh, S. Nag, S. K. Kundu, S. S. Maity, S. B. (2010). Relative intake, eating pattern, nutrient digestibility, nitrogen metabolism, and fermentation pattern and growth performance of lambs fed organically and inorganically produced cowpea hay-barley grain diets. Trop. Grassl., 44: 55-61

Singh, B. B. Musa, A. Ajeigbe, H. A. and Tarawali, S. A. (2011). Effect of feeding crop residues of different cereals and legumes on weight gain of Yankassa rams. International Journal of Livestock Production, 2: 17–23.

Singh, K. and Chaudhary, B. (1979). Biometrical Methods in Quantitative Genetics Analysis, Kalyani Publishers.

Silva, T.A. and Ǿrskov, E.R. (1988). The effect of five different supplements on the degradation of straw in sheep given untreated barley straw. Animal Feed science and Technology. Volume 19, Issue 3, February 1988, pp289-298.

Skerman, P.J. and Riveros, F. (1990). *Tropical Grasses*. FAO Plant Production and Protection Series 23. Food and Agriculture Organization of the United Nations, Rome, 832 pp.

Soltan, Y. A., Morsy, A. S., Sallam, S. M. A., Louvandini, H., and Abdalla, A. L. (2012). Comparative *in vitro* evaluation of forage legumes (prosopis, acacia, atriplex, and leucaena) on ruminal fermentation and methanogenesis. *Journal of Animal and Feed Sciences*, *21*(4).

SPSS, (1989). Statistical Package for Social Sciences. SPSS for window. Release 7.5.1. Procedure and facilities for release. McGraw Hill Book Co. NY.

SRID. (2014). Agriculture in Ghana. Facts and Figures. Statistical Research and Information Directorate, Ministry of Food and Agriculture, Accra, Ghana.

Steingass H (1983). Bestimmung des energetischen Futterwertes von wirtschaftseigenen Futtermitteln aus der Gasbildung bei der Pansenfermentation in vitro. Ph.D. thesis, University of Hohenheim, Germany.

Sundu, B. Kumar, A. Dingle, J. (2006). Palm kernel meal in broiler diets: Effect on chicken performance and health. Volume 62. World's Poultry Science Journal.

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

Swenson, M.J. (1977). Physiological properties and cellular and chemical constituents of blood. In: Dukes' Physiology of Domestic Animals. Swenson, M.J. (Ed.). 9th Edition Comstock Publishing Associates, Ithaca. pp. 3-14.

Taiwo, V.O. and Ogunsanmi, A.O. (2003). Heamatology , plasma, whole blood and erythrocyte biochemical valuesof clinically healthy captive-reared grey duiker (*Sylvicapra grimmia)* and West African dwarf sheep and goats in Ibadan Nigeria. Isreali J. VET. Med.

Tambuwal, F.M., Agaie, B.M. and Bangana, A. (2002). Haematological and Biochemical values of apparently healthy Red Sokoto goats. Proceedings of the 27th Annual Conference of the Nigerian Society for Animal Production, 17-21 March, 2002, Akure, Nigeria, pp: 50-53.

Tarawali, G. & Hiernaux, P. (2002). Improving crop-livestock systems in the dry savannas of West and Central Africa. Anonymous. Reports from the workshop on crop-livestock systems in the dry savannas of West and Central Africa, 22-27 November 1998. IITA, Ibadan, Nigeria,

Tarimo, A. J. P. (1997). Physiological response of groundnut to plant population density. African Crop Science Journal, Vol. 5. No. 3, pp. 267-272

Teferedegne, B (2000). New perspectives on the use of tropical plants to improve ruminant nutrition. Prod. Nutr. Soc. 59:209-214.

Terrill, C. E. (1983). Reproduction des ruminants en zone tropicale. Pointe-a-Pitre (F. w. I), 8-10.

Tesfayohannes, S. T (2003). Effect of urea-ammonization of dietary roughage and concentrate ratio on ruminal microbial activity in jersey cows. M.Sc.

Tilley, J. M. and Terry, R. A. (1963). A two-stage technique for the in vitro digestion of forage crops. Grass and forage science, 18(2), 104-111.

Timbó, A. L. D. O., Davide, L. C., Pinto, J. E. B. P., and Pereira, A. V. (2010). Protoplast production from Elephant grass and pearl millet triploid hybrids. *Ciênciae Agrotecnologia*, *34*(5), 1219-1223. Thesis University of Natal Pietermaritzburg.

Theng Kouch, Preston T.R. and Ly, J. (2003). Studies on utilization of trees and shrubs as the sole feedstuff by growing goats; foliage preferences and nutrient utilization. Livestock Research for Rural Development 15(7): Retrieved from **http://www.lrrd.org/lrrd15/7/kouc157.htm**

Theodorou, M.K. Barbara, A.W. Dhanoa, M.S. McAllan, A.B. and France J. (1994). A simple gas production method using a pressure transducer to determine the fermentation kinetics of ruminant feeds. Anim. Feed Sci. and Techno 48:185-197.

Theodorou, M. K. (1993). A new laboratory procedure for determining the fermentation kinetics of ruminant feeds. Ciencia e investigaci on agrarian, 20:332–344.

Theodorou, M.K. Williams, B.A. Dhanoa, M.S. McAllan, A.B. and France, J. (1991). A simple gas production method using a pressure transducer to determine the fermentation kinetics of ruminant feeds. Anim. Feed Sci. Technol., 48:185-197.

Timbó, A. L. D. O. Davide, L. C. Pinto, J. E. B. P. and Pereira, A. V. (2010). Protoplast production from Elephant grass and pearl millet triploid hybrids. Ciênciae Agrotecnologia, 34(5), 1219-1223.

Toharmat, T., E. Nursasih, R. Nurzilah, N. Hotimah, T.Q. Noerzihad, N.A. Sigit and Y. Retnani, (2016). Sifat Fisik Pakan Kaya Serat dan Pengaruhnya terhadap Konsumsi dan Kecernaan Nutrien Ransum pada Kambing. Media Peternakan, *29*(3): 146-154.

Toum, K. Chhay, T. Bounthong, B. and Preston T.R. (2004). Effect of method of offering foliages of *Gliricidia sepium* and *Stylonsanthes guianensis* CIAT 184 to goats on intake and digestibility. Livestock Research for Rural Development Vol. 16(31). Retrieved from **http://www.lrrd.org/lrrd16/5/toum16031.htm**

Tripathi, M.K. Mondal, D. and Karim, S.A. (2008). Growth, haematology, blood constituents and immunological status of lambs fed graded levels of animal feed grade damaged wheat as substitute of maize. Journal of Animal Physiology and Animal Nutrition 92(1): 75-85.

Tsigbey, F. K. Brandenburg, R. L. and Clottey, V. A. (2003). Peanut production methods in northern Ghana and some disease perspectives. European Journal of Agronomy, 34: 36–47.

Tuah, A.K. Obese, F.Y. Osei, S.A. Okai, D.B. Adomako, D. Boye-Frempong, E. Amaning, K.O. and Said, A.N. (1999). Effects of levels of cocoa pod husk and NaOH-treated corncob on the reproductive performance of Djallonké sheep. Tropical Agriculture. 76(2):131-135.

Upadhyaya, H. D. Reddy, L. J. Gowda, C. L. L. and Singh, S. (2006). Identification of diverse groundnut germplasm: Sources of early maturity in a core collection. Field Crops Research, 97(2-3): 261–271.

Vadez, V. Berger, J. D. and Warkentin, T. (2012). Adaptation of grain legumes to climate change: A review. Agronomy for Sustainable Development, 32(1): 31–44.

Van Soest, P.J. (1982). Nutritional ecology of the ruminant. Corvallis, Oregon: O & B Books,Inc. p. 374.

Van Soest, P.J. Robertson, J.B. and Lewis, B.A. (1991). Methods for dietary fiber, neutral detergent fiber, and non-starch polysaccharides in relation to animal nutrition. J. Dairy Sci. 74(35): 83–97.

Van Soest, P.J. (1994). Nutritional ecology of the ruminant. Ithaca, NY: Cornell University Press pp 476.

Vara Prasad, P. V. Craufurd, P.Q. Summerfield, R.J. Wheeler, T.R. (2000): Effects of short episodes of heat stress on flower production and fruit-set of groundnut (Arachis hypogaea L.). J. Exp. Bot. 51, 777-784

Varner, L.W. and Wood, W. (1975). Influence of wheat variety upon in vivo and in vitro lactate levels. J. Amin. Sci. 41: 900-908.

Ventura, M. Moore, J.E. Ruelke, O.C. and Franke, D.E (1975). Effect of maturity and protein supplementation on voluntary intake and nutrient digestibility of pangola digitgrass hays Journal of Animal Science, 40:769-774.

VSD (2009). Veterinary Services Directorate of Ministry of Food and Agriculture Annual report.

Wangchuk, K. Krishna, R. Harilal, N. Thukten, C.D. and Durba, M. (2015). Forage growth, yield and quality responses of Napier hybrid grass varieties to three cutting intervals in the Himalayan foothills. Tropical Grasslands – Forrajes Tropicales 3:142−150.

Washington, D.C. Arigbede, O.M. Olanite, J.A. and Bamikole, M.A. (2005). Intake, performance and digestibility of West African Dwarf goats supplemented with graded levels of *Grewia pubescens* and *Panicum maximum.* Nigerian Journal of Animal Production, 32(2): 293 – 300. 9.

Williams, T.O. Fernàndez-Rivera, S. and Kelley, T.G. (1997). The influence of socio-economic factors on the availability and utilization of crop residues as animal feeds. In: C. Renard (ed.), Crop Residues in Sustainable Mixed Crop/Livestock Farming Systems, (CAB International, Wallingford), 25–39.

Wilson, R.T. (1991). Small ruminant productions and the small ruminant genetic resource in tropical Africa. FAO Animal Production and Health Paper. no. 88. FAO, Rome (Italy). p. 231.

Wilson, J.R and Hatfield, R.D. (1997). Structural and chemical changes of cell wall types during stem development: consequences for fiber degradation by rumen microflora. Austra. J. of Agric. Res, 48: 165-180.

Winrock International. (1992). Assessment of animal agriculture in Sub-Saharan Africa. Retrieved from Morrilton, Arkansas, USA: **http://hdl.handle.net/10947/186**.

Woyengo, T.A Guenter, W. Sands, J.S. Nyachoti, C.M. Miraz, M.A. (2008). Nutrient utilization and performance responses of broilers fed a wheat based diet supplemented with phylase and Xylanase alone or in combination. Animal Feed Science Technology. 146:113-123.

Yapi-Gnaore, C.V. Oya, A. Rege, J.E.O. and Dagnogo, B. (1997a). Analysis of an open nucleus-breeding programme for Djallonke sheep in the Ivory Coast. 1. Examination of non-genetic factors. Animal Science (UK). 64(2):291-300.

Yapi-Gnaore, C.V. Rege, J.E.O. Oya, A. and Alemayehu, N. (1997b). Analysis of an open nucleus-breeding programme for Djallonke sheep in the Ivory Coast. 2. Response to selection on body weights. Animal Science (UK). 64(2):301-307.

Yuangklang, C. Wanapat, M. and Wachirapakorn, C. (2005). Effects of pelleted sugarcane tops on voluntary feed intake, digestibility and rumen fermentation in beef cattle. Asia- Australasian Journal of Animal Science, 1: 22.

Yoswathana, N. and Phuriphipat, P. (2010). Bioethanol production from rice straw. Energy Research Journal 1: 26-31.

APPENDIX

A.P 1: ANOVA Tables for Chemical composition of Haulms of different varieties of Groundnut

Variate: CP(g/kg)					
Source of variation	d.f	s. s	m. s	F	P
VAR	3	55.9	18.7	16.9	0.01
Error	12	13.3	1.1		
Total	15	69.3			

Variate: NDF(g/kg)					
Source of variation	d.f	s. s	m. s	F	P
VAR	3	295.7	98.6	22.5	0.01
Error	12	52.6	4.4		
Total	15	348.3			

Variate: ADF(g/kg)					
Source of variation	d.f	s. s	m. s	F	P
VAR	3	451.8	150.6	17.7	0.01
Error	12	102.0	8.5		
Total	15	553.9			

Variate: Dry matter(g/kg)					
Source of variation	d.f	s. s	m. s	F	P
VAR	3	404.0	134.7	9.1	0.01
Error	12	177.3	14.8		
Total	15	581.3			

Variate: Ash					
Source of variation	d.f	s. s	m. s	F	P
VAR	3	16.7	5.6	1.8	0.2
Error	12	36.8	3.1		
Total	15	53.5			

A.P. 2 ANOVA Tables for Growth

Variate: Average daily weight gain(g)					
Covariate: Initial weight(kg)					
Source of variation	d.f	s. s	m. s	F	P
Initial weight	1	3677.9	3677.93	3.28	0.0916
Error	14	15690.4	1120.74		
Total	15				

Variate: Final weight gain(g)					
Covariate: Initial weight(kg)					
Source of variation	d.f	s. s	m. s	F	P
Initial weight	1	11.5	11.5	3.3	0.1
Error	14	49.2	3.5		
Total	15				

Variate: Final weight(kg)					
Covariate: Initial weight(kg)					
Source of variation	d.f	s. s	m. s	F	P
Initial weight	1	83.5	83.5	23.8	0.01
Error	14	49.2	3.5		
Total	15				

A.P. 3 ANOVA Tables for Nutrient Digestibility

Variate: Crude Protein Intake Digestibility(g/kg)					
Source of variation	d.f	s. s	m. s	F	P
VAR	3	4361.9	1453.9	10.5	0.01
Error	12	1661.2	138.4		
Total	15	6023.1			

Variate: Neutral Detergent fibre Intake Digestibility					
Source of variation	d.f	s. s	m. s	F	P
VAR	3	26835.0	8944.9	6.4	0.01
Error	12	16847.2	1403.9		
Total	15	43682.2			

Variate: Acid Detergent fibre Intake Digestibility					
Source of variation	d.f	s. s	m. s	F	P
VAR	3	41049.6	13683.2	8.7	0.0
Error	12	18941.8	1578.5		
Total	15	59991.4			

Variate: Total Feed Intake Dry matter					
Source of variation	d.f	s. s	m. s	F	P
VAR	3	3.5	1.2	0.1	0.9
Error	12	139.9	11.7		
Total	15	143.4			

A.P. 4 ANOVA Tables for Digestibility Coefficient

Variate: Dry matter					
Source of variation	d.f	s. s	m. s	F	P
VAR	3	483.6	161.2	1.7	0.2
Error	12	1116.4	93.0		
Total	15	1600.0			

Variate: Neutral detergent fibre					
Source of variation	d.f	s. s	m. s	F	P
VAR	3	522.2	174.0	1.3	0.3
Error	12	1656.6	138.0		
Total	15	2178.8			

Variate: Acid detergent fibre					
Source of variation	d.f	s. s	m. s	F	P
VAR	3	219.2	73.1	0.6	0.6

Error	12	1415.7	117.9		
Total	15	1634.9			

Variate: Crude protein					
Source of variation	d.f	s. s	m. s	F	P
VAR	3	1598.8	532.9	2.9	0.1
Error	12	2157.6	179.8		
Total	15	3756.4			

A.P 5 ANOVA Tables for Haematology

Variate: White blood cell (x 10^9L)					
Source of variation	d.f	s. s	m. s	F	P
Varietal	3	6.7	2.2	0.8	0.5
Error	12	35.6	2.9		
Total	15	42.3			

Variate: Red blood cell (x 10^9L)					
Source of variation	d.f	s. s	m. s	F	P
Varietal	3	0.4	0.1	0.2	0.9
Error	12	9.9	0.8		
Total	15	10.4			

Variate: Haemoglobin(g/dL)					
Source of variation	d.f	s. s	m. s	F	P
Varietal	3	5.063	1.6875	0.12	0.9438
Error	12	162.575	13.5479		
Total	15	167.638			

Variate: HCT					
Source of variation	d.f	s. s	m. s	F	P
Varietal	3	17.522	5.8406	0.48	0.7035
Error	12	146.627	12.2190		
Total	15	164.149			

Variate: MCV					
Source of variation	d.f	s. s	m. s	F	P
Varietal	3	22.745	7.5817	0.39	0.7652

Error	12	235.795	19.6496		
Total	15	258.540			

Variate: MCH					
Source of variation	d.f	s. s	m. s	F	P
Varietal	3	59.91	19.972	0.13	0.9432
Error	12	1909.68	159.140		
Total	15	1969.59			

Variate: MCHC					
Source of variation	d.f	s. s	m. s	F	P
Varietal	3	89386	29795.2	1.67	0.2253
Error	12	213661	17805.1		
Total	15	303046			

Variate: PLT					
Source of variation	d.f	s. s	m. s	F	P
Varietal	3	8.8669	2.95562	1.29	0.3223
Error	12	27.4725	2.28938		
Total	15	36.3394			

A.P. 6 ANOVA Tables for in vitro organic matter digestibility

Variate: IVOMD					
Source of variation	d.f	s. s	m. s	F	P
Treatment	4	104.040	26.010	6.51	<.001
Residual	35	139.740	3.993		
Total	39	243.780			

Variate: ME					
Source of variation	d.f	s. s	m. s	F	P
Treatment	4	27.51510	6.87877	76.16	<.001
Residual	35	3.16132	0.09032		
Total	39	30.67642			

Variate: SCFA					
Source of variation	d.f	s. s	m. s	F	P
TRT_Name	4	0.00012511	0.00003128	3.10	0.027

Residual	35	0.00035264	0.00001008		
Total	39	0.00047775			

Plate 1: Hanging a ram on the scale for measurement.

Plate 2: Discharging faecal matter from the faecal bag attached to the ram.

Plate 3: Putting the faecal bag around the anus of the ram for faecal matter collection.

Plate 4: Experimental ram in an experimental pen.

Plate 5: Experimental diet in a feeding trough (box) in the pen