UNIVERSITY FOR DEVELOPMENT STUDIES

EFFECTS OF ENSILLING GROUNDNUTS HAULMS ON FERMENTATION CHARACTERISTICS AND ON GROWTH PERFORMANCE OF DJALLONKE SHEEP

SULEMANA NUHU

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BY

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THESIS SUBMITTED TO THE DEPARTMENT OF ANIMAL SCIENCE, FACULTY OF AGRICULTURE, FOOD AND CONSUMER SCIENCES, UNIVERSITY FOR DEVELOPMENT STUDIES, IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF PHILOSOPHY DEGREE IN ANIMAL SCIENCE (PRODUCTION OPTION)

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DECLARATION

I hereby declare that except for references to the works of other researchers which have been fully and duly acknowledged, this work is the result of my own original research and that this dissertation has neither in whole nor in part been presented for any other degree here or elsewhere.

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Head of Department's Signature:……..…… Date……

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ABSTRACT

An experiment was carried out to assess the effects of ensiling on fermentation characteristics of groundnut haulms and also to evaluate the effects of conserving groundnut haulm as hay or silage on feed intake, nutrient composition and their effects on the growth performance of West African Dwarf (Djallonké) growing rams. Fresh groundnut haulms were either dried or ensiled in large silo bags and used to formulate two experimental diets. The diets were labeled dried groundnut haulm diet (DGH) and ensiled groundnut haulm diet (EGH). Twenty (20) growing Djallonke rams (14.65 ± 3.17kg) were assigned randomly to individual pens and each animal received a diet (DGH diet or EGH diet) fed for 70 days. Parameters measured where fermentation characteristics (pH, LAB, moulds and yeasts), growth parameters (DMI, IW, FWG, WG, ADG and FCE) and chemical analysis (DM, Ash, CP, EE, ADF, NDF and NH_3). Data were analyzed using the PROC MIXED procedure (SAS Inst. Inc., Cary, NC). Data on microbial population were transformed to $\log_{10}$ colony-forming units prior to statistical analysis with the bulk storage container as experimental unit for the dried and ensiled groundnut haulms. Differences in least squares means of all fixed effects were declared statistically significant at $P \leq 0.05$. Ensiling increased the CP content (4.1% against 6.6%) and decreased the NDF (37.9% against 35.0%) of the groundnut haulm compared to drying. There was no significant difference ($p>0.05$) among the diets on microbial count. The nutrient composition of the ensiled diet was better than the dried groundnut haulm diet. Ensiling also increased ($p<0.04$) ADG from 0.03kg/d to 0.05 kg/d compared to drying. Ensiling groundnut haulms increased the CP content (4.1 % against 6.6%) and decreased the NDF (37.9% against 35.0%) compared to drying. The nutrient composition of the ensiled diet was better than the dried groundnut haulm as ensiling increased ADG (0.03-0.05 kg/d) compared to drying.

DEDICATION

I dedicate this work to my late father Alhaji Sulemana, my sweet mother, Hajia Fatima, my lovely wife and kids and the whole Gbaane family.

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LIST OF ABBREVIATIONS

AAFCO: Association of American Feed Control Officials

ADF: Acid Detergent Fibre

ADG: Average Daily Gain

AIBP: Agro-Industrial By-Products

ANOVA: Analysis of Variance

AOAC: Association of Analytical Chemists

ARC: Animal Research Council

CP: Crude Protein

CSIRO: Commonwealth Scientific and Industrial Research Organization

DE: Digestible Energy

DGH: Dried Groundnut Haulms

DM: Dry matter

DMI: Dry Matter Intake

DPLS: Digestible Protein Leaving the Stomach

EGH: Ensiled Groundnut Haulms

EE: Ether Extract

FAO: Food and Agriculture Organization

FCE: Feed Conversion Efficiency

FWG: Final Weight Gain

FOAFCS: Faculty of Agriculture, Food and Consumer Sciences

GH: Groundnut Haulms

HCL: Hydrochloric Acid

ICRISAT: International Crop Research Institute for the Semi-Arid Tropics

ILRI: International Livestock Research Institute

IW: Initial Weight

LAB: Lactic Acid Bacteria

LW: Live Weight

ME: Metabolizable Energy

MoFA: Ministry of Food and Agriculture

MRS: de Man-Rogosa-Sharpe

N: Nitrogen

NDF: Neutral Detergent Fibre

NRC: National Research Council

SARI: Savannah Agriculture Research Institute

SDA: Sabouraud's Dextrose Agar

TDN: Total Degradable Nitrogen

UDS: University for Development Studies

USDA: United States Department of Agriculture

WAD: West Africa Dwarf

WSC: Water-soluble Carbohydrates

CHAPTER ONE

1.0. INTRODUCTION

The production of small ruminants is a very important element of livestock production all over the world most especially in countries that are under developed (Ketema, 2007; Thornton *et al*., 2009). The major goal of any livestock enterprise is to convert feedstuffs into animal products at a faster and cheaper rate (Payne, 1990). In the savanna zone of Ghana, natural pastures are mostly unavailable for livestock grazing during the dry season because of bush fire outbreaks and the little left on the farms also loses their dietary value. This compels animals to drop body weights in these periods and generates a recurring body weight gain and loss in the wet and dry seasons in that order as narrated by Otchere *et al.* (1986).

Hag *et al.* (2001) indicated that the definite difficulties associated with sheep nutrition in rangeland environment is the climatic changes during the dry hot summer (February to June) causing feed shortage and nutrient deficiencies which are reflected in the seasonality of reproduction, declined conception, embryonic losses, declined lambing rate and increased mortality rate. In order to correct these drawbacks, several feed conservation and storage techniques have been adapted to increase feed availability over a longer period of time. These include ensiling and hay making. Hence drying and ensiling are the main methods of feed conservation in Ghana. A supplementary feeding regime has also been identified as a remedy for rectifying these drawbacks. The use of staple cereal grains however results in competition between humans and animals; this increases the cost of feed

supplementation making it unsustainable and unprofitable in livestock production (Karbo *et al.*, 2002).

Silage is a product produced when forage or materials of acceptably high moisture content prone to spoilage by aerobic microorganisms are stored anaerobically (Woolford, 1984). Silage is valued throughout the world as a source of animal feed during the lean months of the year (Ragothaman *et al.,* 2010). By controlled lactic acid fermentation, crops that have high moisture content like legumes may be stored for long period without losing much of its nutrients. Provided some essential principles of silage production are followed, high-quality feed production is assured and therefore the method mostly used is the conservation method according to McDonald *et al.* (1991). The importance of making silage instead of hay is evident. The crop is usually harvested at an early stage, resulting in a highly nutritious feed. The production and feeding of silage can also be mechanized more easily than that of hay. However, the significance may be that the harvest is less weather-reliant, which makes it likely to get high-quality feed even under reasonably humid weather conditions.

Forage that is matured while still green and nutritious can be stored through a natural 'pickling' method. When the sugars found in forage plants are being fermented by bacteria in an enclosed container or silo without any air present, lactic acid is formed. Forage preserved this way is called 'silage' and can be kept for up to three years without spoiling. The major objective of silage production is to store the plants in an anaerobic environment with less loss of nutritive value by fermentation of

soluble carbohydrates into organic acids, most especially lactic acid which decreases the pH (Saarisalo *et al.*, 2007). The fermentation qualities of silage have a significant influence on the intake of feed, use of nutrient and the production of milk in ruminants as reported by Huhtanen *et al.* (2003). The natural method of silage fermentation however continuous uncontrollably and quality silage production cannot be completely assured (Merry and Davies, 1999; Kung and Ranjit, 2001). This is mainly because of the difference in the populations and effectiveness of epiphytic lactic acid bacteria (Bolsen *et al*., 1992; Lin *et al*., 1992), the chemical makeup of the ensiled forage and the environmental conditions of ensiling (McAllister and Hristov, 2000; Hargreaves *et al*., 2009). If the fundamentals required for the fermentation of lactic acid in some way are not present, epiphytic organisms harmful to the silage process may increase rather than being deprived, resulting to low-quality silage. Yeasts are essential as they battle for existing substrate and play an important part in deterioration aerobically (Rammer *et al*., 1994).

On the other hand, severe wilting which results in a 50% in moisture loss is considered as normal with the intension that acidification by organic acid production cannot be the determining factor that influences the development of the microorganisms according to Nishino (2011). Nussio (2005) indicated that the rising significance of ensiling in both tropical and sub-tropical areas has as well promoted the essence of research in microbiology. Outcomes from unprocessed silage have shown that bacteria found in pre-ensiled crops often differ from those found in the silage (Li and Nishino, 2011a, b). Therefore, fermentation sequences are not well

estimated by bacterial profiling of ensiled forages. Using of silage additives like LAB inoculants is endorsed to achieve safe fermentation with less amount of DM loss and protein breakdown. The matter of aerobic spoilage prevention has not yet been completely figured out and is therefore considered as a great setback in silage microbiology study according to Wilkinson and Davies (2012). *Bacillus* spp., yeasts, *Acetobacter* spp. and *Enterobacter* spp. are considered as spoilage staring agents and no control is regarded as realistic with no inhibitory activities opposing them. Several LAB species have been revealed to demonstrate antifungal actions (Dalie *et al.*, 2010), examples include *Lactobacillus casei, Lactobacillus pentosus, Lactobacillus sakei, Lactobacillus cruvatus* and *Lactobacillus Lactis Subsp. Lactis* (Kim, 2005).

The use of agro-industrial by-products (AIBP) may be economically valuable as conventional feedstuffs are mostly expensive (Mirzaei-Aghsaghali and Maheri-Sis, 2008). The natural low concentration of fermentable nitrogen (N) and carbohydrates however restricts their feeding worth as reported Sarwar and Nisa (1999). Notwithstanding, groundnut haulm, an AIBP has a high amount of protein (11-18%) and the leaves contain more protein than the stem (Oteng-Frimpong *et al.*, 2017). Drying often leads to leaf losses (shattering). Losses in leaves and nutrient during drying may reduce the nutritional quality of forage stored by drying. However, silage-making is also difficult and improper fermentation can decrease feed intake. Intake of silage has been shown to be lesser than hay (Thiago *et al*., 1992; Seoane *et al*., 1993). The aim of this study therefore was to assess the effects of ensiling on the

fermentation characteristics of groundnut haulms, nutritive value and the growth performance of West African Dwarf (Djallonké) growing rams fed with them.

1.1. Study Objectives

1. To assess the effects of ensiling on fermentation characteristics of groundnut haulms.
2. To evaluate the effects of conserving groundnut haulm as silage or hay on feed intake, nutrient composition and its effects on growth performance of West African Dwarf (Djallonké) growing rams.

CHAPTER TWO

2.0. Literature Review

2.1. Ruminant Production in Ghana

Livestock serves as a key resource in Ghana's agriculture contributing greatly to the living standard of smallholder farmers and to consumers in general, through the provision of animal products, income, nutrients and traction. Sheep, goats and cattle are the ruminants mostly raised in Ghana. In Ghana, goat production constitutes the highest, followed by the production of sheep, then cattle, pig and the game meat production (Adzitey, 2013). Cattle, sheep, goat, and the game meat production increased by 11%, 36%, 52% and 98% respectively, between 2001 to 2010 (Adzitey, 2013). Live animal production increased each year except that of cattle and pig (Adzitey, 2013). Cattle production had a decrease of 1% in production between the year 2005 and 2006 but continues improvement in cattle production was seen in the rest of the years (Adzitey, 2013). According to Oppong-Anane (2001), small ruminants account for 7% of the Agricultural Gross Domestic Product in Ghana. The production of sheep is a major investment benefit for families that are poor, contributing to rural poverty reduction indirectly (Upton, 2004). Adding to that, it offers quick development opportunities, as the necessary internal market exists. Oppong-Anane (2011) reported that urban and peri-urban residents in Ghana rear roughly 25% of the total (13.3 million) small ruminants in the country.

There are three main systems under which animal production is done in Ghana; they include the intensive, semi-intensive and extensive systems. Commercial farmers

mainly practice the intensive system, whereas the extensive system (free range) is usually practiced by smallholder farmers in rural settlements. The animals either are slaughtered by persons in their houses or certified persons in slaughter slabs belonging to the community or government and by certified professionals in slaughter houses or abattoirs owned by government.

Livestock production is a major source of income in several rural settlements in the Northern Regions of Ghana, especially in the dry seasons. The northern regions account for close to 75% of the cattle production in Ghana (Adzitey, 2013). Ghana imports mostly ruminants from neighboring countries. Live animals and meat importation offers a signal that there are great chances to increase the production of animals with readily existing market (Adzitey, 2013).

The Guinea and Sudan Savannah vegetation zones of the northern regions hold the highest livestock population, accounting for about 75% of the total cattle population in Ghana while around 15% represents that of the coastal savannah zone the south (Asafu-Adjei and Dantankwa 2001). Due to the prevalence of tsetse flies, which transmit the dangerous disease called trypanosomiasis, the transitional and humid forest zones are mostly meager with cattle population. Poor nutrition remains the most widespread technical constraint to good animal performance in sub-Saharan Africa (Saleem and Fitzhugh, 1995).

Throughout the country, there is even distribution of ruminants (Asafu-Adjei and Dantankwa 2001). In the last decade, domestic livestock production has improved

gradually. Between 1991 and 2000, the levels of production of beef, sheep and goats have improved by 13, 26 and 35%, respectively. The off-take rate for goats and sheep are close to 30% whereas that for cattle is around 11% and is comparable to the 8% for cattle and the 25% for sheep in solely pastoral approach of producing livestock in sub-Saharan Africa (Sabri *et al.*, 2001).

Table 1: Average Live Production of some Selected Animal Species in Ghana (from 2001-2010)

Type of Animal	Production Averages
Cattle	1,373,700
Goat	3,958,560
Sheep	3,269,460
Pig	404,600
Chicken	33,252

(FAOSTAT, 2012)

From table 1, the production of ruminants (cattle, sheep and goat) stands to be higher than monogastrics (pig and chicken). The table indicates that there is much production of small ruminants in the country from 2001-2010.

Table 2: Live Ruminant Imports by Type

Year	Cattle	Sheep	Goats
2007	8,891	6,594	4,498
2008	1,081	1,401	1,514
2009	10,119	4,987	6,098
2010	11,389	4,843	3,711
2011	9,384	2,835	2,495
2012	23,622	9,840	10,008
2013	21,131	16,738	16,953
2014	20,948	22,188	32,012
2015	17,968	15,763	20,004

(Adapted from VSD-MoFA, 2012).

From table 2, importation of live ruminants increased yearly from 2007 to 2012, but at the end of 2015 the figures indicate a reduction in the number of imports. The importation of cattle, sheep and goats were 17968, 15763 and 20004, respectively.

2.2 Origin, Appearance and Importance of the West African Dwarf Sheep (Djallonke Sheep)

In Ghana, the predominant breed of sheep is the West African Dwarf commonly referred to as Djallonke sheep though there are a whole lot of other breeds in the world all over. This breed is well known and preferred for its ability to acclimatize to the prevailing unfavorable weather conditions. According to Yapi-Gnaore *et al.* (1997), the West African Dwarf (WAD) sheep are extensively distributed all over the West and Central Africas and they are thought to have evolved from the earliest Egyptian sheep breed, *Ovis longipes palaeoaegypticus*. The Djallonke is the prevailing breed of sheep in Ghana as stated by Karbo and Bruce (2000). The WAD sheep is sexually and physically strong but has a small body size. Charray (1992) pointed out that these adaptive features help the WAD sheep to lessen heat trauma and to conquer the effects of humidity and rainfall of sub-equatorial and equatorial weather. Their productivity in West Africa differs from 110% to 161% according to Ginisty (1976) and Dettmers and Hill (1999) respectively. Ryder (1999) reported that the WAD sheep is stress and disease resistant breed especially trypanosomiasis. Aside the provision of income and food (meat) for people, the WAD sheep is also used to perform important social functions such as funerals and religious ceremonies in West Africa.

Live animals in terms of value are more valuable than their carcass hence normally given to people as gifts to strengthen relationship, payment of bride prices and a symbol of appreciation. In Ghana, the rearing of sheep is purposely for production of

meat by use of the Sahellian and the Djallonke sheep breeds and also their cross breed (Ockling, 1986; MoFA, 2000). Researches on the Djallonke breed now have been concentrating on the exploitations of linear body dimensions to know the origin of the breed, differentiation and characterization of the breed and the body structure (Birteeb *et al.*, 2012; Sowande and Sobola, 2008; Traoré *et al.*, 2008).

They (WAD sheep) are the most significant local breed of sheep found in the humid regions of Africa where trypanosomiasis and worm diseases impose a major challenge (FAOSTAT, 2005) and play a key economic, social and cultural task in the life of the people (Gbangboche *et al*., 2008). The breed is primarily reared for its meat (Sowande and Sobola, 2008).

2.3 Effects of Feeding on Small Ruminants and Feed Constraints

Small ruminants, precisely goats and sheep play both economic and social significance in the whole world. Data concerning the nutrient requirements and feeding routine of these animals is crucial for controlling their wellbeing and for contributing to the livelihoods of the people depending on them. Sufficient nourishment as well as management is essential for maintaining small ruminants in diverse environments (NRC, 2007).

The most effective converters of poor-quality forage into animal products of high-quality with recognized chemical makeup and organoleptic uniqueness are small ruminants. There exist a variety of goat and sheep farming methods ranging from extremely extensive method depending on natural grasslands to very intensive

methods depending on supplementary feeding and natural grazing (Zervas *et al.*, 2011).

The proportion of goat and sheep meat and milk in micro and macro nutrients rely on some major production features forming the farming method: reproduction, sanitary appearance and genotype, socio-economic environments and agro climatic conditions as well as farming methods like feeding. Feeding emerges as the most significant due to the fact that other factors such as season or the hygienic state of the flocks are uttered due to variations in the quality and quantity of the feed consumed.

The farmer's choice of feeding system to practice is extremely vital and can be rapidly cherished through the nature of products produced by the animal (Zervas *et al.*, 2011). Feeding of dairy sheep and goats is depends on pasture grazing, even though the schemes of production varies from extremely extensive to very intensive. Grasslands, forest ranges and shrub lands all constitute rangelands. Grasslands mostly appear natural, poor quality and are mostly grazed all through the year. Seasonal dietary variations commonly occur with respect to quality and quantity whereas the low-quality grasslands undergo degradation steadily because of overstocking as well as overgrazing according to Zervas (1998).

The grazed forage includes numerous naturally occurring bioactive molecules with anti-inflammatory and antioxidant features such as phytosterols, bioflavonoides, because of multispecies structure and xyrothermic climatic circumstances which are conveyed to milk, meat as well as milk products (Zervas and Tsiplakou, 2011).

Majority fodder trees, herbaceous species and fodder shrubs contain huge sums of polyphenols, several forages forms about 50-80% tanniferous components preferred by goats throughout the year (Silanikove, 2004). Their milk contains high amounts of fatty acids, vitamins and high inphenolic, flavonoids and terpenes compounds, which are required in human nutrition and health with greater oxidative stability, processing effectiveness and value (Silanikove, 2010). Natural pastures in the savannah zone of Ghana becomes insufficient during the dry times of the season because of bush fire out breaksand the little left on the farms also loses their dietary value. This compels the animals drop body weights in these periods and generates a recurring body weight gain and loss in the wet and dry seasons in that order as narrated by Otchere *et al.*(1986). According to Hag *et al.* (2001), the specific challenge concerning animal nutrition in rangeland situations is the climatic changes during the dry hot summer (February to June) causing feed shortage and nutrient deficiencies which are reflected in the seasonality of reproduction, declined conception, increased mortality rate, declined lambing rate and embryonic losses. In order to correct these drawbacks, several feed conservation and storage techniques have been adapted to increase feed availability over a longer period of time. These include ensiling and hay making. Hence drying and ensiling are the main methods of feed conservation in Ghana. A supplementary feeding regime has also been identified as a remedy for rectifying these drawbacks. The use of staple cereal grains however results in competition between humans and animals; this increases the cost of feed supplementation making it unsustainable and unprofitable in livestock production (Karbo *et al.,* 2002).

2.4 Nutrient Requirement of Sheep

Majority of sheep gain their day-to-day nutrients requirement from grown pastures, natural pastures or browse species. Hence flock's dietary management considerably includes managing the quantity and quality of forage resources, since it reacts to regional weather, seasonal climate situations and the type of plant there. Feed in winter may be inadequate whilst in spring, the major phase of pasture development in several grazing schemes, good quality forage mostly gather exceeding the requirements of animals so that in drought, there could be significant amounts to be fed, but this will be of poor quality comparative to the preference of the animal. In comparison with animals that are housed, the dietary resources for the grazing flock is consequently always varying (Dove, 2010). According to Berg and Butterfield (1976), the acclimatization to diets and weather conditions influences the partitioning of nutrients, body structure, animal development, and consequently the protein and energy requirements. Animals' prerequisites of nutrients in tropical and warm are as may vary from those explained in feeding values for temperate areas. Researches on livestock in tropical areas are centered on goats (Mandal *et al.,* 2005), sheep (Paul *et al.,* 2003) as well as cattle according to Paul *et al.* (2004) using local breeds in similar conditions.

2.4.1 Energy Requirement

Energy providing feed ingredients forms the greatest part of the diet and is normally the most limiting nutrient in meeting energy requirements. A deficiency of energy intake normally results in decreased growth rate and even loss of weight in animals

(Carles, 1983). According to McDonald (1991), energy requirement for maintenance is increased by the energy lost in locomotion and muscular activity during grazing. Sheep requires 2.6 kg feed/kg body weight for every kilometer travelled (McDonald, 1991). The deficiency in energy will show itself in growing animals in several means such as weight loss, reduced growth and eventually death while reproducing females show symptoms of reduced conception rates, less multiple births and reduction in milk production (NRC, 2007). The major sources of energy for sheep include pasture, hay, silage, grains and agricultural by-products. According to McDonald *et al.*, (1995), growing lambs of 20 kg body weight and gaining 0-50 g/d require 0.46 kg/d of DM intake, 4.8 MJ/kg of metabolizable energy (ME).

2.4.2 Protein Requirement

Protein is also a very important nutrient and most expensive part of the diet which is important for proper performance of the animal. Since rumen microbes are able to use amino acids to manufacture protein, the amount of protein given to the sheep is very essential compared to the nature of protein in its diet (NRC, 2007). Furthermore, protein need is very high for young growing lambs for building muscle and lactating ewes for the production of milk proteins (NRC, 2007). Ruminants require a minimum of 6 to 7% CP in their diets for effective rumen function (Milford and Haydock, 1965). Growing lambs of 20 kg body weight and gaining 0–50 g/d require 58 g of degradable protein per 8 days (made up of 40 g rumen degradable protein and 18 g of rumen undegradable protein) for optimal growth (McDonald *et*

al., 1995). A minimum of 10 to 12% of protein is recommended for ruminant animals for growth as reported by ARC (1980).

In most feeding circumstances, the protein supply to meet the animal's needs is dominated by the production of microbial CP from the microbial population running to the small intestine (Peter, 1987). This production is a direct function of the fermentable ME intake, given that at least this quantity of rumen-degraded protein is reachable from the efficient degradation of nutritional proteins. The digestible portion of the undegraded nutritional proteins and 0.6 DPLS of the microbial protein forms the total digestible protein leaving the stomach (DPLS) supply (CSIRO, 2007).

The net protein maintenance need of an animal is the total endogenous faecal protein and the endogenous urinary protein, in the case of cattle, the dermal protein loss ARC (1980). The total net protein demand is transformed to truly DPLS by the assumption that DPLS is used with a 0.7 efficiency for all functions with the exception of wool development which the wool protein is assumed to be=0.6 DPLS (CSIRO, 2007).

2.4.3 Mineral Requirement

The 14 minerals that are regarded as vital nutrients ranges from the macro mineral (P) which have a wide variety of essential roles in the body to the micro minerals (I) which has only one. Furthermore, there are seemingly a few unnecessary minerals that may lower efficiency when they are too much. Gross deficiencies of important minerals become obvious from a wide range of clinical symptoms just like if it is too

much. In practice generally the recognition of subclinical deficiencies is the most important problem. These are often temporal and can decrease the production of animals with few explicit symptoms. The acknowledgment of mineral insufficiency might be deferred by the capacity of the animal to use body reserves (like Ca) or stored excesses (like Cu), regularly for a long period usually weeks or months (Freer, 2007). In various cases the concentration of dietary minerals that would be satisfactory is not firmly characterized and impossible to anticipate dependably from the feed analysis. A significant vulnerability in evaluating prerequisite is the accessibility of a mineral to the animal.

The extent of the admission of a mineral that is consumed and metabolized can fluctuate with the age and physiological condition of the animal, with the chemical form and with the presence of different minerals and nutrients in the feed. According to Freer, (2007) Cu sustenance is influenced by Fe, S and Mo; Mg assimilation is influenced by K, Na and by the ruminal ammonia whereas S and I needs are influenced, respectively by the existence of cyanogenic and goitrogenic substances found in the blood. Evaluation of the net maintenance prerequisite for a mineral from the endogenous losses in urine and faeces can be unreliably due to difference in these losses with intake. Due to these reasons, the accompanying dietary mineral concentrations ought to be considered uniquely as a manual for those that are needed. At the point where a scope is given, the values that are higher are for fast developing, lactating or pregnant animals while the lesser esteems are for the ones that have a low degree of production or those at maintenance stage.

Potassium and chlorine concentrations in majority of feeds are usually higher compared to those tabularized and their deficiencies mostly are unlikely (Doty *et al.*, 2017). Requirements of sulfur are best expressed as 0.07 g or 0.08 g for cows and sheep respectively per 6.25 g RDP (thus 1 g N) (Galbraith, 2000). Concentrations per kg feed DM of S surpassing 3 g, Mo surpassing 2 mg, Fe surpassing 500 mg, Zn surpassing 100 mg, or Cd surpassing 5 mg, can have harmful effects on Cu nutrition (Freer, 2007). Cadmium concentration ought to be under 5 mg/kg DM to limit the danger of its accretion in both the liver and kidney to concentrations intolerable in human food. In a similar explanation, lead (Pb) concentrations ought to be considerably lower than 60 mg/kg DM, being roughly the lower frontier for toxicity in farm animals. Concentrations of fluorine happening normally in feed and water consumption need not to be more than the equivalent of 35 mg F/kg DM; intense fluorosis can take place in animals that are grazing on moist pastures with adherent superphosphate considering current usage (Freer, 2007).

Table 3: Mineral requirements of sheep

Mineral	Sheep (g/kg DM)	Mineral	Sheep mg/kg DM
Calcium	1.4–7.0	Cobalt	0.08–0.15
Phosphorus	0.9–3.0	Copper	4–14
Chlorine	0.3–1.0	Iodine	0.5
Magnesium	0.9–1.2	Iron	40
Potassium	5.0	Manganese	20–25
Sodium	0.7–1.0	Selenium	0.05
Sulfur	2.0	Zinc	9–20

Source: CSIRO, 2007

Minerals are required by animals in small quantities and play a significant role in the development and ingestion of nutrients by animals. Lack of some supplements causes severe diseases in farm animals. Table 3 points out some significant minerals and their quantities needed by the animal for effective production.

2.4.4 Vitamin Requirement

Vitamin C is synthesized by ruminants hence does not need a dietary supply. Generally, animals that graze do not need vitamin A supplementation even in the drought period, since a dietary insufficiency is utilized by hepatic stores (Lalman, 2009). One potential exemption is in the case of rams and maybe bulls where it may be needed for reproduction some months after of feeding on dry pastures. Supplementation might be appealing for calves and sheep weaned on time throughout the dry season on to dried forage and grain diets and suggested

allowances in feedlot diets for sheep and cattle. Vitamin D necessities are accomplished by their synthesis in the animal body influenced by solar ultraviolet radiation and by a good number of diets, including both dried and fresh forages (Lalman, 2009). Supplementation of drought rations is therefore pointless. Reactions to vitamin D supplementation are already testified in South-Eastern Australia for lambs grazing on forage oats and there is another study of a reaction in Tasmania by grazing lambs (Freer *et al.,* 2007). Rumen microbial synthesis as well as diets provides vitamin K and its inadequacy is possible with the utilization of vitamin K antagonists like dicoumarol found in some pasture plants (Masters *et al.*, 2001). Suckling calves and lambs and those ones that are given substitutes of milk made predominantly from milk items are probably not going to experience any inadequacy of vitamin B (Freer, 2007). Thiamin might be obliterated by an enzyme called thiaminase I in the rumen from the microbial populace or from a number of plant species. The ensuing problem is cerebrocortical necrosis otherwise called polioencephalomalacia (Rammell and Hill, 1986).

2.5 Groundnut Production in Ghana

In Ghana, the most common and extensively grown legume crop according to Wumbei *et al.* (2000) is believed to be groundnut due of its capacity to acclimatize to various weather situations as well as its little field pest cases. Groundnut production in the northern part is exceptionally good and accounts for around 92% of the total groundnut production in Ghana as reported by Wumbei *et al.* (2000). International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) (2001) however

bemoan that yields in Africa have commonly been poor because of components, such as unreliable downpours, little or no technology available to small holder farmers, poor seed varieties, and excessive cultivation on minor land. Also, political volatility and lack of policies supporting small scale farming have negatively affected groundnut production in West Africa. Whereas a portion of these elements are above the control of the farmers, others can be controlled by them. It is essential to know the level to which the latter influences the competence level of the farmers with the goal that particular arrangements might be intended to move forward the production of groundnut in the area (Shamsudeen *et al.*, 2011).

Groundnut production in Ghana almost tripled between 1995 and 2005 (168,200 T in 1995 compared to 420,000 T in the year 2005) basically because of expansions in the area under cultivation which expanded from 180,400ha to 450,000ha from 1995 to 2005,respectively as reported by Asibuo *et al*. (2008). Average yields in spite of this continued to be below 1.0 T/ha which was way below the yield potential of 2.0 to 3.0 T/ha. Groundnut gives a cheap source of high-quality dietary proteins and oil aside the income farmers generate from it (Asibuo *et al*., 2008).

The USDA is also reported to have indicated that close to 24.76 million hectares of farm land was dedicated to the production of groundnut in the 2015/2016 farming season as well as preliminary estimation of around 25.34 million hectares dedicated for the same purpose in the 2016/2017 farming season(USDA, 2018).The worldwide yield of groundnut was as well stated at around 1.63mt/ha in the 2015/2016 farming

season and preliminary estimates of around 1.68mt/ha in the 2016/2017 season as documented by the USDA(2018).

Table 4: Area, Yield and Production Figures of Groundnut in Selected Countries

Rank	Rank Country	Average Area (Million Hectares)	Average Production (millions of mt)	Average Yield (mt/ha)
1	China	4.69	16.72	3.57
2	India	4.93	5.59	1.12
3	Nigeria	2.50	3.00	1.20
4	United States	0.63	2.63	4.19
5	Sudan	1.99	1.64	0.82
6	Myanmar	0.89	1.38	1.55
7	Indonesia	0.61	1.13	1.86
8	Argentina	0.32	1.05	3.26
9	Senegal	1.15	1.00	0.88
10	Cameroon	0.40	0.55	1.38
11	Viet Nam	0.20	0.45	2.31
12	Ghana	0.40	0.44	1.10

Source: USDA (2018)

Table 4 indicates the leading groundnut producing countries in the world. Though China is leading the production of groundnut worldwide, the highest area (4.925

million hectares) used for groundnut production is India. With the yield per unit area, United States and Sudan recorded the maximum (4.19mt/ha) and minimum (0.82mt/ha) output, respectively.

Groundnut is consumed in different ways in Ghana, just like many other countries in West Africa (Atuahene-Amankwah *et al.*, 1998; Awuah, 2000) and is a major aspect of diets (Jolly *et al.*, 2008). Groundnut can be consumed in many ways: roasted, raw and made into candies, cookies and flakes according to McWatters and Cherry (1982). Groundnut is a significant protein source for humans as well as animals and it also supplies good quality cooking oil (Awuah, 2000).

Table 5: Average Yield (Mt/ha) Performance for Groundnut by top 10 Districts

Region	District	2013	2014	2015	3yearr Avg.	Rank
Northern	Savelugu/Nanton	2.32	2.56	2.54	2.47	1
Northern	East Gonja	2.45	2.37	2.35	2.39	2
Northern	Zabzugu/Tatale	2.29	2.43	2.41	2.38	3
Northern	Kpandai	1.92	2.21	2.19	2.11	4
Northern	Nanumba North	1.71	2.00	1.98	1.90	5
Northern	West Gonja	1.65	1.70	1.69	1.68	6
Northern	Tolon/Kumbungu	1.60	1.70	1.69	1.66	7
Upper West	Sissala West	1.57	1.61	1.64	1.61	8
Northern	Karaga	1.55	1.58	1.57	1.57	9
Northern	Nanumba South	1.40	1.65	1.64	1.56	10

Source: MoFA, (2012).

Table 5 represents the various regions and districts where groundnuts are intensively cultivated. With reference to the table, much groundnut haulms will be available in northern region.

2.6 The Use of Agro-Industrial By-products in Feeding animals

Animal rearing in Ghana have contributed enormously in meeting the nutritional requirement of human and the demand for these their products keep increasing at higher pace than their production particularly in urban settlements because of increase in the earnings of consumers (Osei, 2012). Report from the 2010 population census (Ghana) indicated a 51% increase in urbanization according to the African

Development Bank (2014). Urbanization is associated with reduced livestock grazing areas and higher livestock feeds demands to meet the feed requirements of increasing numbers of animals in both urban and peri-urban parts of Northern Ghana as reported by Opong-Anane (2013).

Agricultural by-products like cassava peels, maize cobs, wheat offal and cocoa husks along with others are now fast growing in used as animals feed. The pattern of by-products utilization has been transformed from the circumstance where these by-products were regarded as waste and are presently being enhanced to animal protein for both human and animal consumption. Gone are the days when industrial by-products such as wheat and maize offal from the flour producers, brewers spent grains from the brewing industries, and molasses from the sugar producers were believed to be contaminants and, in this manner, burnt (Iyegbe-Erakpotobor *et al.*, 2002). The materials that are produced after harvesting the crops are referred to as crop residues (Dixon and Egan, 1987). The quality of these crop residues generated is dependent on the quantity and nature of the crops cultivated in a particular zone. The key basal feeds for ruminants in warm climatic developing countries are primarily the residues of crops and low-quality grasses from rangeland gathered manually or grazed at very improved phase of maturity in the dry seasons. Incorporation of livestock and crop residue permits resources to be recycled more efficiently in the livestock production venture. High amounts of crop residues created on government farms as well as private farms in Nigeria are always wasted (John *et al.,* 1992). Some of these residues are left on the farms to decay, which may

increase the fertility of soil at least, but majority of them are burnt on the fields. There is confirmation that indicates livestock fed using crop residues and agro-industrial by-products could attain significant weight gains (O'Donovah, 1979). The bounteous supply of crop residues and agro-industrial by-products at affordable prices could improve production and minimize cost of formulated feeds while not hindering the animals' performance. It has now become increasingly essential that substitute feed ingredients be created to ease the struggle for food between man and animals since there is an increase in population and resulting to high demand and cost for conventional feedstuffs, for instance soybean meal and groundnut cake (Iyegbe-Erakpotobor, *et al.,* 2002). One main restraining factor in using these products is the existence of some anti-nutritional factors that oppose their utilization by animals (Adebgola and Omele, 1973). The drop in accessibility of natural pastures particularly in urban settlements because of an increase in infrastructure has placed additional pressure on farmers in these parts to discover other sources of feed for their livestock and plays a part in the high demand for crop residue. According to reports from the highlands in Ethiopia, approximately 70% of residues from crops are being utilized as feed for animals (Zinash and Seyoum, 1991). The scarcity of feed for the livestock industry in the urban centers has resulted in increased demand for feed in the markets and this has aggravated feed dealers to harvest naturally established browses, residues from crops and collect by-products from agro-industries for sale at rising rate according to Huseini *et al.* (2011) notably to those selling small ruminant to do stall feeding as well as fatten the animals meant for sale. Livestock feed marketing in northern Ghana is promising with the major noticeable

product being the residues of crops to fulfill the ever-increasing need for feed because of growing interest for collected fodder particularly in peri-urban and urban vicinities. These markets can be seen as a significant factor that will play a part in solving the problem of feed scarceness in these urban vicinities. The ILRI (2009) did a report on feed in Ethiopia and it was revealed that there is a rise in feed accessibility for sale to livestock farmers and dealers in urban. These accessible feeds were evaluated and poor-quality fodder selling less than 50% of the high-quality ones in terms of prices due to their accessibility at the market level. Also, those selling these feeds as well as those buying may have divergent observations concerning the quality of fodder being supplied to market centers.

According to the FAO (1999), there has been acknowledgement of increasing policy of the function of non-conventional feed ingredients in the production of livestock. All ruminants depend on two major feed resources. These feed resources play a vital role in the nutrition of ruminants and they include agro- industrial by-products and crop residues (Agarwal and Verma 1983).

Because by-products are obtainable for feeding animals at competitive prices comparative to other products and are turning out to be progressively more significant in the food and fiber scheme (Grasser *et al.,* 1995). By-products are perfect for forage-base diets since these by-products are naturally moderate in protein, low starch content, and most significantly not costly (Poore *et al.,* 2002).Conservative by-products from the agro-industrial companies may well be treated as energy and protein source except that they are very costly for the

smallholder farmer. Supplementation with conventional by-products from distilling and brewery industry is restricted by lack of accessibility and the distribution of processing plants locally. Since conventional feed ingredients are mostly costly, the use of these products may also be economically valuable (Mirzaei-Aghsaghali and Maheri-Sis, 2008). According to Sarwar and Nisa (1999), the naturally low fermentable Nconcentration and carbohydrates of the by-products limits their feeding worth. Furthermore, in a good number of instances, the by-products are produced in moist state making its storage very challenging and very expensive when it comes to transportation and so those by-products normally are underutilized by small scale farmers. Non-conventional agro-industrial by-products like traditional brewery or liquor remains are mostly used in Ethiopia by small scale animal farmers, typically because they are less costly and very accessible in nearly all household localities as reported by Mekasha (2003).

Only a small amount out of the huge quantities of coffee pulps generated in Ethiopia is used as fertilizer whereas the bigger amounts are left unused generating discarding challenges. Low protein digestibility and low intake according to Demeke (1989) are some of the constraints of using the pulps of coffee because of the existence of anti-nutritional factors like tannins, caffeine, and other polyphenols according to Rojas *et al.* (2002). The occurrence of these anti-nutritional factors could lessen satisfactory and deliciousness of coffee pulps by animals. When coffee pulp is added to the feed

of growing lambs, it reduces their growth rate and this is as a result of excess potassium and tannins according to Habte (1992).

On the other hand, the provision of coffee pulps with surplus salt eluded the toxic consequence of the coffee pulps and improved the rates of growth in the sheep which was credited to the complex consequence of the salt and concentrate. The litter of poultry contains great amount of sodium in the ranges of 5-6g/kg DM as indicated by Rossi *et al.* (1999). The best possible inclusion of these substitute resources as feed for animals could be an efficient measure to reduce cost of production of dairy goat farms, hence improving their competitiveness, however it also provides an avenue for the reduction of environmental problems related to products from livestock (e.g. cheese) and organic-waste accretion (Pardo *et al.*, 2016).

2.7 Feed Characteristics and their Digestibility

One of the significant difficulties when it comes to feeding forages of poor quality to ruminant is to improve the intake (Ndlovu, and Hove, 1995). The results of increasing levels of groundnut haulms used to supplement a low-quality basal diet have been explored (Ehoche, 2002; Aregheore, 2009). Alhassan (1985) in a relative investigation of maize residues with other crop residues fed 1-1.5-year-old red Sokoto goats using different legume/cereal residues observed dry matter intake ranging from 0.7% of body weight for maize stover to 2% for sorghum leaves (5.5% CP), whereas leguminous crop residues consumption ranged from 0.8% body weight for cowpea vines (5.9% CP) to 3.4% body weight for the haulms of groundnut (16.7%CP). Adebowale (1988) recognized the advantageous impacts of the

groundnut haulms, to incorporate increment in metabolisable energy and nitrogen consumption, enhanced palatability, expanded accessible vitamins and minerals, improved rumen function and a laxative impact on the alimentary canal. Groundnut haulms and shells are by 18 products which are generally used to fatten animals in northern Nigeria. Adu and Lakpini (1983) fed chopped groundnut haulms solely, to growing Yankasa lambs and recorded live weight gains of 90.2g /day for unchopped haulms. Supplementary feeding of groundnut haulms to cows improved growth rates of suckling calves compared to the non-supplemented control group which was attributed to increased milk consumed by calves arising from the increased milk output when their dams were supplemented (Ehoche *et al.*, 2001). Nicholson (1989) observed that in partial milking system, approximately 60% of the milk produced is consumed by the calf. When maize residues were fed and compared with other cereal or legume crop residues, it was established that live weight gain compared favorably. Maize residues fed recorded higher feed consumption, although it was not significantly higher than sugar cane tops. Nevertheless, the high consumption did not result in better live weight gain, with the exception of sorghum stalks when fed to Red Sokoto goats with groundnut haulms (Alhassan, 1985). Topps (1995) demonstrated that the enhanced intake due to supplementation of groundnut haulms in animals to some extent reduce weight losses. For considerable microbial digestion of plant materials to happen in the rumen, an intimate physical relationship among plant tissues and microbes in charge of the process of digestion is key (Orpin, 1984). According to Cheng *et al.* (1990), reports have revealed that when sheep were fed the supplementary forage in straw-based diet, there was an enhancement in the

digestibility of the basal diet even with moderately small supplementation rates possibly as a result of the colonizing rates and degree of the fibre and also biomass of supporting organisms. As reported by Kreb *et al.* (1989) that bacteria colonization arises from fibre to fibre without passing through the free-floating pool. Then again, fibres are colonized by free- floating pool of rumen bacteria. Leng (1990) clarified that the advantageous impacts of the inclusion of highly digestible forage in an otherwise poor digestible forage diet could be that it applies a vast impact on digestibility by given an extremely colonized fibre source to seed bacteria onto the less digestible fibre. According to Silva and Orskov (1988), supplementing feed with groundnut haulm adds fermentable energy to the rumen in a form of accessible cellulose and hemi-cellulose which arouses the digestion of fibre. Bauchop (1981) opined that it is conceivable that feeding these materials before feeding straw daily may stimulate a more significant level of colonization of basal diet by the bacteria and fungi in the rumen that are involved in fibre breakdown. According to a report by Manyuchi *et al.* (1994), in Sacco degradation of low-quality grass hay was not modified by the groundnut hay. It is possible that any adjustment in the degradation of the basal diet as a consequence of an expansion in microbial activity rely upon the quantity of vacant spots for microbial connection as described by Cheng *et al.* (1990).

Residues of food legume crops is reported to contain comparatively great amounts of CP. Tolera (2008) recorded CP value of 11.4% for groundnut haulms compared to CP value of 5.6% for sorghum stover (cereal residues) and can be used for

supplementation according to Yami (2008). Preceding studies made by Mokoboki *et al.* (2000) and Anelea *et al.* (2010) showed that cowpea (*Vignaunguiculata* L.Walp) haulms can also be used as supplementation for livestock in the dry season. Osafo *et al.* (2013) also observed increased intake as well as digestibility of fodder with poor quality after supplementing it with cowpea haulms. Abdou *et al.* (2011) had optimistic live weight gains in sheep that were supplemented with groundnut (*Arachis hypogaea* L.) haulms.

2.8 Substitution Effect of Concentrate Supplement Diet Fed to Ruminants

According to AAFCO (2000), a concentrate is a feed that is used alongside other feeds in order to enhance the nutritional balance of the total and anticipated to be further diluted and blend to produce feed supplement or a whole feed while a supplement feed is one that is used with another feed to increase the nutritive balance or performance of the total and projected to be: (a) fed pure with no dilution as a supplement to other feeds or (b) free alternative offered with other components of the ration accessible independently or (c) advanced dilution and mixing to give a complete feed.

The time required to finish cattle for the market and to enhance profit maximization could be reduced by supplementing with high quantities of energy-rich feeds with a protein source. Cattle consuming forages of low digestibility with protein and energy supplementation showed significant gains in live weight as indicated by several researches (Hennessy *et al.*, 1995; Hennessy and Murrison, 1982; Lee *et al.*, 1987). It was indicated that variation in LW was as a result of digestible organic matter

consumption in steers offered increasing quantities of molasses or cottonseed diet (Hennessy and Murrison, 1982). In central Vietnam, as there is an increase in the quantity of concentrates fed, it is expected that the feeds rich in energy accessible, maize and cassava flour as well as rice bran, will need to be blended with the addition of protein sources in order to optimize their reaction to supplementation. Ba *et al.* (2001) for example indicated that an increasein the quantities of cassava flour and urea supplements increased the LW gain of Laisind cattle, but there were restrictions the quantity of these supplements cattle would utilize, undesirable consequences on NDF digestibility and high substitution rates of cassava flour in place of forage. The flour of cassava has high digestible starch and when fed in large amounts, harmful accompanying consequences on forage digestion can be a possibility with this sort of supplementation (Huhtanen, 1991; Mould *et al.*, 1983).

2.9 Feed Availability and Quality in Ghana

In a study by Konlan *et al.* (2014), it was found out that residues of crops, the peels of cassava and yam and naturally established grasses and legume fodder of grazing lands and *in situ* crop remains like the stovers of millet and maize were used to feed ruminants in northern Ghana. Maize bran, rice bran, waste flour from corn mills and brewers' spent grain of sorghum are all agro-industrial by-products. There was a positive correlation between the feed available annually and the pattern of rainfall and this rose from June-October in the wet season and dropped at the end of the rains (Konlan *et al*., 2014). This is in line with the statement that the accessibility of feed is a function of how the land is used as well as the rainfall pattern of the area as

stated by Jayasuriya (2002) and turns out to be more available to animals subsequent to harvesting of crops by which time animals are permitted to freely graze on those lands (Annor *et al*., 2007). Feedstuffs were available for livestock consumption in some areas due to controlled movement of animals in the rainy/farming season and this was to protect the crops from the dangers of animal. Similar findings have been reported in other studies (Awuma, 2012; MoFA, 2011; Oppong-Anane, 2013). It was further discovered that about 80% of feedstuffs were available to livestock after harvesting crops while feed shortages were experienced during late dry season (Konlan *et al*., 2014).

2.10 Groundnut Plant and its Growth

2.10.1 Groundnut Plant

According to Haile and Keith (2017), groundnut (*Arachis hypogaea L*.) is a significant self-pollinated leguminous crop grown on over 24 million ha of land worldwide for food and for edible oil extraction. The lead producers include China, India, Nigeria, Brazil and United State according to Cheeke (2005). A general feature among all the leguminous crops is that, they partner with certain bacteria types, they are capable of fixing nitrogen from the air and this is a significant nutrient that supports plant growth and development. Distinctively amongst leguminous crops, the pods of groundnut are formed in the soil. Groundnut produces its flowers above ground similarly to other leguminous crops, but after pollination and withering, the stalk of the flower elongates and bends down pushing into the soil the flower that has been pollinated. It then develops into pods in the soil forming

about 1 to 4 seeds in each pod (Haile and Keith, 2017). The extended stalk of the flower, notice on groundnut only, is called the peg. The kernels are mostly high in oil (48 to 50%) as well as in proteins (25 to 28%) and are good source of a number of minerals, biologically active polyphenols, vitamins, isoflavones, flavonoids and antioxidants. Breeders have developed and released superior varieties of groundnuts with high yielding capability for farming worldwide (Janila *et al.*, 2013).

2.10.2 Growth Stages

The stages of growth in groundnut plants have been defined and explained on the bases of visual scrutiny both the vegetative and reproductive growth (Boote, 1982). This extensively accepted method explains the sequence of both reproductive and vegetative stages and all the stages distinctively are events base on population which usually are established through observations in the field (Prasad *et al.*, 2010).

2.10.2.1 Seedling and Vegetative Growth

The seed of groundnut is made up of a radical, two cotyledons, a hypocotyl and an epicotyl. All primitive leaves that the seedling will develop during the first few days subsequent to germination are found in the seed as reported by Rao and Murty (1994). There may be about 4 or 5 primordial leaves found in the seed's embryo; five of them are properly developed into big seeds while four into small ones (Rao and Murty, 1994). Epigeal germination occurs when the cotyledons shortly after emergence turn green. The main axis, cotyledons and the vegetative axes are all constituents of the seedling. The colour of the hypocotyl is white and is differentiated easily during the early stages of its development but turns identical

from roots as the plant reaches maturity (Prasad *et al.,* 2010). According to Prasad *et al*. (2010) the groundnut takes approximately 3-5 days to germinate and emerges from the soil at a temperature of 30°C. It takes around 24 h or even earlier than that for dynamic Spanish type of groundnut and in 36-48 h for the Virginia types radical to emerge (Singh 2003). The major rooting system of the groundnut plant is the tap-root but several lateral roots as well develop after almost 3 days of germination. The roots are concerted within the 5-35 cm zone beneath the soil, but goes through the soil profile to about 135cm in depth. The root of groundnut usually lacks distinctive root hairs but fairly clumps of hair, which are formed in the axils of roots (Prasad *et al.,* 2010). In the first few days, seedlings' development depends on assimilates found in the cotyledons. Depending on the cultivar and conditions of the surrounding environment, the growth of the seedling is autotrophic and is able to absorb minerals through the roots even as the epicotyl is open to light and photosynthesis is possible after 5-10 days. Their stems are mostly angular, pigmented and are solid initially, but the plants become a bit hollow as they grow. The major stem is developed from a terminal bud of the epicotyl and two opposing cotyledonary laterals grows at the soil level. The major stem may be vertical or horizontal and from a length of 12-35 cm or sometimes surpass 1m in some varieties (Prasad *et al*., 2010). The early vegetative growth stage is generally about elongating the main stem and the production of leaves, while later growth is dominated by the development of lateral branches. Within the first 35 days, over 50% of the plants' leaf area is made up of the main stem leaves but accounts for only 10% at 90 days. The accretion of dry matter mostly occurs in the reproductive structures of the plant after flowering as stated by Prasad

et al. (2010). The growth and branch formation patterns vary in botanical form and subspecies. The subspecies hypogaeais made of discontinuous pairs of reproductive and vegetative nodes, where as that of fastigiata has chronological form of reproductive nodes (Prasad *et al*., 2010).

2.10.2.2 Reproductive Growth and Maturity

Caliskan *et al.* (2008) stated that flowering in groundnut cultivars is dependent on the type of cultivar and also the climate conditions of the area and usually takes effect from 20-30 days after planting. The flowering pattern also differs in and among botanically. In the Virginia variety, flowering is late and it contains numerous flowering peaks while there is comparatively early flowering with broader initial flowering peak in the Spanish variety. Also cultivars found within the same subspecies differ in the way they flower (Verheye, 2010). Then again, in theaxils of leaves flowers formed, commonly having three flowers for every inflorescence (Prasad *et al.,* 2010). Normally a bud per inflorescence attains anthesis on a set day, however sometimes more than one bud may open on a particular day. Flower colour differs from say yellow to orange to dark orange and seldom to white. The calyx tube (hypanthium) contains the style. Twenty-four hours before anthesis, the bud is 6-10 mm long and the hypanthium stretches gradually during the day then the bud reaches 10-20 mm in length (Verheye, 2010). The hypanthium elongation is faster in the night. The flower comprises 10 anthers, out of which five are oblong and the others are spherical and small in size. Usually one of the anthers is complex to perceive and

is sterile. At the time of anthesis, the anther reaches a maximum of 5 to 7 mm in length as documented by Verheye (2010).

Immediately the flowers get light early in the morning, they open. The dehiscence of the anther takes place prior to or when the flower opens or much earlier at times. As of 24 h prior to12 h following flower opening, the stigma is sensitive. Usually, groundnuts go through self-pollination hence the flowers open after pollination (Armstrong, 2020).

Sporogenesis and gametogenesis have been observed to happen between 3 to 6 days preceding anthesis when the buds attain a length of 5mm. Anthesis occurs immediately after pollination. Subsequent to pollination, there is a growth rate of 1 cm/h in the pollen tube which leads to fertilization 5-6 hours following pollination. The process may show discrepancies depending on the variety and environmental conditions. The flower later shrivels after fertilization and in so doing triggers the development and extension of the intercalary meristem situated at the bottom of the ovary (Prasad *et al.*, 2010).

The peg (stalk-like structure) turns out to be visible about 4 to 6 days subsequent to fertilization in favorable ecological situations. The elongation of the peg is usually slow initially and uses nearly 5 to 6 days period to infiltrate the bracts. The pegs become certainly geotropic once they attain a length of 3-4 mm and begin to grow in the direction of the soil. The elongation rate of the pegs then quickly increases between day 5 to 10 following fertilization and they can then be long up to 15 cm.

The peg produces the ovary with the ovule that is fertilized at the tip. Characteristically the peg gets to and goes through the surface of the soil within 8 to 14 days subsequent to fertilization (Armstrong, 2020). The tip of the ovary starts to swell up as soon as the peg penetrates through the soil to about 4-5 cm in depth and spin away horizontally from the bottom of the plant and grow into a pod. Usually, it takes 15-20 days from flowering to pod formation stage, after which the pod starts to enlarge quickly until it attains the size typical of the variety. The initial complete pod phase is described as a period or point that about 50% of the plants attain pods that are completely protracted (Armstrong, 2020).

There is gradual increase in the number of flowers that the plant produces per day; it appears the highest numbers normally occur at 14 to 28 days subsequent to flower commencement which afterwards drop to zero in the pod filling phase. Nevertheless, varieties between and within botanical types could differ in the way they flower. After about 60-70 days of planting, the counting and weighing of pods becomes possible. There is a rapid increase in the number of pods per plant to a greatest level at 80 to 120 days based on the botanical type and the cultivar (Prasad *et al.*, 2010).

There is also a very rapid increase in the weight of the fresh pod within the initial 14 days of subterraneous development and the pods reach their highest size 21 days after. Through development stage of the seed, when the seed cotyledon development is noticeable in a minimum of one pod on about 50% of plants, the endocarp diminishes as the ovule develops and by the time seeds are matured will disappeared totally (Verheye, 2010). At this point, the inner part of the shell is darkened as a

result of the deposition of tannin and it turns dark brown when matured. Pods growth rates vary amongst cultivars, and are influenced by temperature of the fruiting region (Prasad *et al.*, 2010).

2.11 Harvesting of Groundnut

Since the development of groundnut pods occur underground, there is the need to extract them from the ground before harvesting. Besides, under these circumstances it is occasionally complicated to detect their maturity; during lengthy periods as flowering goes on, the selection of pods for maturity test should be done with care (Ikisan, 2020). Practically, the plants are ready to be harvested when their leaves turn yellow and begin to drop, their pods then turn out to be reticulate, the hull inner colour turns dark then the seed become easily detachable (Prasad *et al.*, 2010).

Harvesting time is extremely important for the groundnut plant, whereas early harvesting reduces the worth and yield of crop, late harvest results in the pods remaining in beneath the ground and become vulnerable to disease attacks which lead to losses during post-harvest activities (Zuza *et al.*, 2017). Harvesting in underdeveloped countries is normally done by pulling out the plant from the ground or through the use of animal-drawn implements or mini machineries to dig the plant. Uprooted groundnuts are mostly dried on the farm or placed on leveled platform. In order to ensure there is faster and uniform pods drying, the plants should be placed upside down with the roots up. Depending on the weather conditions the groundnut is supposed to be dried on the farm for 2 to 3 days. Pods are estranged from the plants after drying by either using threshers or manually by hands (Prasad *et al.*,

2010). Seeds are sometimes separated by use of mechanical shellers after threshing and kept in a dry and well-ventilated space. Inappropriate post-harvest handling of groundnuts as well as storage can lead to aflatoxins (*Aspergillus flavus*) infection. Harvesting is done mechanically in developed countries by using machines which digs out the plants and harvest the pods through striping (Waliyar *et al.*, 2015). The pods are then shelled using machines subsequent to drying and bins used to store the groundnuts (Prasad *et al.*, 2010).

2.12 Nutritional Composition and Utilization of By-products from Groundnut

The nutritional makeup use of by-products from groundnut with market demands has been altered lately. In the past 2 decades, modern scientific studies are centered on the following; First of all, the worth of groundnut by-products is enhanced. Second, proteins of groundnut, groundnut consumable fibre, groundnut phenolic compounds and their possible outcomes in diets are described and rated. Third, consequences of dietary make up of groundnut by-products on human functioning and the value of products in processing food are researched (Zhao *et al*., 2013). The data is important so as to enhance exploitation of by-products from vegetables in food production. The exclusive attention shows the nutritional worth of groundnut could have an effect on the health of humans. But the subject matter still demands more research (Zhao *et al.*, 2013). By-products obtained from harvesting groundnuts and extractions of groundnut oil are commonly referred to as “groundnut by-products”. The various by-products from groundnuts mentioned in this study are outlined below;

2.12.1 Groundnut Meal

Most groundnuts grown worldwide are mainly used to make oil for consumption. An average of 14.09 million Mt of crush groundnut is produced around the world from 2000 to 2010 (Yu *et al.* 2007). Groundnut meals are carefully removed from the kernel subsequent to the extraction of oil. This removal produces a new by-product called groundnut pulp. Extraction of oil as well leads to the formation of water that is waste and this can contribute to environmental pollution.

From 2000 to 2010, the average groundnut meal production worldwide was 5.78 million metric tons (Zhao *et al.*, 2013). According to Sales and Resurrection (2009) the cake subsequent to the extraction of the oil can attain about 50% protein content. Also, it has other useful constituents, like groundnut piceid, lectin and resveratrol (Sales and Resurrection, 2009). The groundnut meal is grouped into dry or fresh meal. Based on a variety of factors like moisture and oil content, various terms may be defined. The diverse procedures for extracting oil, together with causing groundnut by-products all have been reported by Yu *et al.* (2007). It is important to differentiate between the hot and cold groundnut meals crushed using the two and three-phase extraction methods of centrifugation in that order. In comparison to already established oil extraction techniques, the groundnut meal from the cold process consists of greater levels of moisture and less contents of oil. Furthermore, the cold crushing method is more effective and is environmentally very friendly method for extracting groundnut oils. Every 1 ton of groundnut used in the cold

crushing procedure can possibly produce 700 kg of groundnut meal, whereas the hot crushing method gives 500 kg (Zhao *et al.*, 2013).

2.12.2 Groundnut Skin

The groundnut kernels are major raw materials for making groundnut butter, groundnut oil, groundnut confections, and roasted snack groundnuts. It is reported by Sobolev and Cole (2003) that a projected 35 to 45g of groundnut skin is produced per kg of the shelled groundnut kernels. More than 740,000 million metric tons of groundnut skin is generated yearly throughout the world as a by-product from the groundnut processing industries as reported by Sobolev and Cole (2003). Mostly, just a minute quantity of groundnut skins are utilized for the extraction of polyphenolic compounds or to produce cattle feeds, majority of these skins usually are treated as garbage from the groundnut processing industry and thrown away (Sobolev and Cole, 2003). Groundnut skins also offer a very cheap polyphenols source for exploit as an efficient constituent in food or nutritional supplements and create a useful involvement to the wellbeing of the nation according to Yu *et al.* (2006).

2.12.3 Groundnut Hulls

The groundnut hulls acquired after graded groundnuts go through sheller machine to shell producing groundnut hulls and kernels which are sufficient by-products from agriculture worldwide, particularly in China (Wang and Xu, 2008). A kg of groundnut is being projected to produce around 230 to 300 g of groundnut hulls. It is as well projected that Chinese land reserves may be able to produce a minimum of

5million metric tons every year according to Wang and Xu (2008). Groundnut hulls may produce a major waste dumping challenge in and around areas groundnut is cultivated and processed, this will eventually pollute the environment. Hence the hulls of groundnut ought to be discarded very far from human settlements. Another way is to employ devastative methods like incineration (burning). Groundnut hulls are in large quantities, less expensive, and a renewable resource. It is exciting to note that groundnut hulls are very rich in dietary fibre and some biological active constituents, therefore groundnut hulls are gradually attaining status as a functional commodity. But the transportation of these groundnut hulls cannot be economically and effectively done over lengthy distances through to places they can be exploited efficiently (Zhao *et al.,* 2013).

2.12.4 Groundnut Vine

A combination of the stem, leaves, roots, and flowers makes up the groundnut vines. Research have laid emphasis on the significance of useful compounds of the groundnut hulls, kernels and skin though ignoring some useful parts of groundnut leaves, stems, flowers and roots due to a number of objectives. The yield of groundnut vines produced annually worldwide as a by-product from the groundnut industry is much more than the groundnut kernel, hull and skin. The groundnut vines produced as of harvesting groundnut is projected to fall around 60 to 65% of the groundnut production (Du and Fu, 2008). Groundnut vines have high dietary fibre and also compounds of flavonoid (Du and Fu, 2008).

2.13 Nutrients Composition of Groundnut and Groundnut haulms

The most significant product of groundnut is the kernels (seeds), they are high source of nutrients and offers numerous health gains. The kernel is made of 40 to 55% oil, 20 to 35% protein and 10 to 20% carbohydrate, 100 g of the kernels also gives about 567 kcal energy according to Jambunathan (1991). Groundnut oil consist of seven fatty acids out of these, oleic accounts for 40 to 50%, linoleic accounts for 25 to 35% and palmitic accounts for 7 to 12%, together they constitute about 90% of the total fatty acids in the oil. High lines of oleic comprising 80% of the oleic acid are as well accessible. Groundnut seeds are also very high in minerals including calcium, zinc, phosphorus and iron; vitamins such as vitamin E, the B-complex groups of thiamin, foliates, pantothenic acid, niacin and riboflavin; antioxidants including resveratrol and p-coumaric acid and biologically dynamic polyphenols, isoflavones and flavonoids. Groundnut meals acquired subsequent to extracting oil are highly rich in proteins and good for feeding livestock as well as poultry birds. The major components include CP, sugar, fiber, ash, and fat representing 45.6%, 32.50%, 8.3%, 5.0% and2.5%,respectively. Also, it is very rich high in amino acids such as methionine, cysteine, lysine, arginine and threonine and as well rich in minerals like calcium, potassium, sodium and phosphorus. Energy for metabolism in groundnut meal according to Batal *et al.* (2005) is 2664 kcal/kg.

Groundnut haulms are nutritiously a good fodder resource for feeding animals and are made up of about 8 to 15% of proteins, 1 to 3% of lipids, 9 to 17% of minerals, 22 to 38% crude fiber as well as 38-45% carbohydrates (Batal *et al.*2005). The

haulms can be used to feed cattle in dried or fresh state, or by using it to make silage or hay. Groundnut haulm nutrients digestibility is about 53% while CP is around 88% when given to animals (Nagaraj, 1988). Haulms are efficient enough to release close to 2.337 cal/kg energy of DM (Nagaraj, 1988)

2.14 Uses and Importance of Groundnut

Groundnut plays an essential nutritional function in majority of underdeveloped countries, particularly Ghana where it supplies high-quality oil for cooking and is a significant protein source in the diets of both human beings and livestock as indicated by Awuah (2000). Groundnuts can be consumed in numerous ways: roasted, raw, and cooked as well as using it to make candies and flakes as reported by McWatters and Cherry (1982). According to Kirkmeyer and Mattes (2000), groundnuts and its products serve as satiation foods. Research reports have investigated the consequences of both groundnut and its products on health. The habitual consumption of groundnuts enhances the utilization of nutrients related to decreased dangers of cardiovascular diseases and boosts serum magnesium levels (Alper and Mattes, 2003). Kris-Etherton (1999) revealed that groundnuts provide polyunsaturated fatty acid-rich oil that decreases cholesterol levels. In studies carried out by both Awad *et al.* (2000) and Kris-Etherton (1999), they established that groundnuts and its butter have fats that are monounsaturated as well as B-sitosterol that offer defense against some cancers in human. Griel (2004) also stated that groundnuts are a rich source of vitamin E, folate, magnesium and niacin.

2.15 The use of Groundnut haulms as a Feed Resource

The feed for livestock provides essential nutrients needed for the production of animals including protein, amino acid and mainly energy. John and Hall (2009) largely categorized feed into roughages and concentrates, based on the composition of energy and protein in the feed. Groundnut haulms as well as cowpea hay are the main crop residues utilized for the fattening of animal in West Africa. Feeds are usually given ad-hoc and in a free manner in conventional animal fattening, which is wasteful to some extent (Ayatunde *et al.,* 2007). Small ruminants are mostly made to feed on natural pastures but the nutritional value of these pastures reduces in dry seasons. The nutritive value of cereal crop residues equally declines and becomes less palatable according to Singh *et al.* (2011). Supplementing feed using concentrates or high-quality legume forages can increase the feeding or nutritive value of the feed ingredients. Concentrates may however not be readily available to smallholder livestock farmers because they are highly expensive (Tolera *et al.*, 2000).

When the quantity of grasses in pastures is even high and the CP content is high (in short periods during rainy season), the moisture level of those pastures are generally elevated. This characteristic is a discrete inconvenience to animals given that hungers are satisfied without the needed bulk to rich the requirements for both production and maintenance (Musangi and Soneji, 1967). Groundnut haulms as well as cowpea hay are the main crop residues utilized for the fattening of animal in West Africa. Larbi *et al.* (1999) stated that groundnut haulms and cake after harvest and

oil extraction respectively are major sources of nutrients for animals, especially when used as supplementary feed in fattening animals and in lactating cows. Williams *et al*. (1997) also added that the sale of groundnut haulms is one of the main sources of income for the household.

2.16 Feeding Value of Groundnut haulms

Groundnut haulms are more pleasant and high in protein associated to stovers of cereals which have less N, high fibre content, and low digestibility and hereby have low nutritive value and are used as additional feed (Singh *et al.*, 2011). Prasad *et al.* (2010) stated a common daily voluntary feed consumption of higher than 4% of live body weight in male sheep. This stage of voluntary feed consumption is on the high side and is hardly seen in animals on any type of feed except lactating animals (Forbes, 1986). Groundnut haulms are also vital in the poultry industry as substituting 6% of concentrate mixture with groundnut haulms caused 15% rise in live body weight of broilers compared to the controls (Ribadiya *et al.,* 2015). The substantial rise observed was credited to enhance feed intake and high nutrient disposal in groundnut haulms. Crude protein concentration of haulms of many groundnut cultivars varies from 8 to 15% and ether extract from 1 to 3% (Nigam and Blummel, 2010; Ozyigit and Bilgen, 2013). Groundnut haulms contain neutral detergent fibre (NDF) of about 47%, acid detergent fibre (ADF), and lignin content around 36.5% and 6.3%, respectively (Ayantunde *et al.,* 2008). Digestibility of groundnut haulms ranges from 74% to88% in ruminants and support animals'

growth performance even when fed as sole feed (Karbo *et al.,* 1997). Nigam and Blummel (2010) also reported an *in vitro* digestibility between 52% and 61%.

2.17 The Ensiling/Fermentation Process and Microbes Involved

Ensiling refers to forage preservative process depending on natural fermentation of lactic acid in anaerobic situations. The epiphytic LAB ferments the water-soluble carbohydrates (WSC) in the forage to lactic acid and to acetic acid (thus to a lower degree). The pH of the material ensiled lowers hindering the activities of micro-organisms causing spoilage because of the formation of these acids. The process of ensiling can be sorted into four (4) phases as soon as fresh materials are piled and concealed to avoid air entry (Merry *et al.,* 1997; Weinberg and Muck, 1996).

2.18. Phases of Fermentation

2.18.1 Phase 1: Aerobic phase

Normally this phase takes just some few hours and the atmospheric oxygen found between particles of plants is decreased as a result of the respiration of plant materials and aerobic as well as the facultative aerobic micro-organisms like enterobacteria and yeasts. Moreover, plant enzymes like proteases and carbohydrases are efficient in this first phase as long as the pH remain within the accepted range (6.5 to 6.0) for fresh forage juice (Oude Elferink *et al.,* 2019).

2.18.2 Phase 2: Fermentation Phase

The second phase begins once silage turn to be anaerobic and is phase can persist for between a number of days and a number of weeks, subject to the qualities of the

forage crop being ensiled and also the conditions of ensiling (Oude Elferink *et al.*, 2019). In case there is a successful fermentation, LAB develops and turns to the dominant population. The pH decreases to about 3.8- to 5.0 because of the formation of lactic acids and some other acids of importance (Oude Elferink *et al.,* 2019).

2.18.3 Phase 3: Stable Phase

For the duration as air is avoided from flowing into the silo, comparatively dew activities take place at this stage (Oude Elferink *et al.,* 2019). Majority of the organisms from the second phase gradually reduce in population. Some micro-organisms that are tolerant to acid subsist in this phase in practically dormant condition, others including bacilli and clostridia subsist as spores. Just a few acid tolerating carbohydrases and proteases and some particular micro-organisms like *Lactobacillus buchneri* persist to function at an insignificant rate (Oude Elferink *et al.,* 2019).

2.18.4 Phase 4: Feed-out Phase or Aerobic Spoilage Phase

The feed-out phase begins as soon as the silage is open to the atmosphere. This phase is certain, but can be initiated earlier because of damage (usually by rodents, birds and reptiles) of the material covering the silage. The spoilage process is in two (2) stages or phases. The main spoilage phase is the start of relapse because of preservative organic acids degradation by yeasts and, sometimes, acetic acid bacteria (Park and Kim, 2011). This causes an increase in the pH and thus the second phase of spoilage is commenced and is related to rising temperatures and activities of spoilage micro-organisms like bacilli. The other stage includes the work of numerous

aerobic micro-organisms like enterobacteria and moulds (Elferink, *et al.,* 2000). Aerobic damage happens nearly in all the silage opened to the air. Nevertheless, the speed at which spoilage occur depends greatly on the amount and activities of harmful organisms in silage. Losses resulting from spoilage accounts for about 1.5%-4.5% DM loss daily are experienced in areas affected. The range of these losses is the same as those that takes place in silos that are airtight throughout many months in storage according to Honig and Woolford (1980).

It is significant to manage and improve every level of the process in order to prevent failures. In level 1, decent procedures of filling the silo will assist to reduce the oxygen quantity within the particles of the plant in the container or silo (Bolsen *et al.,* 1996). The right techniques of harvesting together with better silo management will decrease WSC losses during aerobic respiration both in the field and silo and will make more WSC accessible for the fermentation of lactic acid in level 2. Throughout levels 2 and 3, producers cannot manage the ensiling process actively. Therefore, optimizing phase 2 and 3depends on the way silage additives are used at ensiling. Level 4 begins immediately oxygen is accessible (Bolsen *et al.,* 1996). A hermetically sealed silo is needed to reduce silage losses in storage and immediately any harm affecting the silo covering. In feed-out, spoilage through air entry can be reduced via a suitable high-rate feed-out. Also, silage preservatives capable of reducing losses can be used at ensiling (Oude Elferink *et al.,* 2019).

2.19 Properties of an Ensiled Material

Generally, improved fermentation can be caused by high amounts of water-soluble carbohydrates in the material for ensiling (Wilkinson, 2005). Usually, it is recommended that at least 25g water-soluble carbohydrates kg^{-1} DM be present in fresh material (Lundén *et al.*, 1990). Considering that fresh materials have about 200 g kg^{-1} DM WSC; 125 g kg^{-1} would be the acceptable concentration on DM basis. The content of water-soluble carbohydrates in forage depends on the species of plant, weather conditions, growth stage, intensity of light, fertilization and diurnal variation according to McDonald *et al.* (1991). In most grasses used for silage, for example; *Lolium perenne* L. water-soluble carbohydrates can attain values above 300 gkg^{-1} DM (McDonald *et al.*, 1991). Under normal circumstances, extreme levels of such water-soluble carbohydrates were not seen in many species of non-leguminous forbs. According to literature reviewed, the maximum level of water-soluble carbohydrates in the initially cut non-leguminous forbs was just more than 150 g kg^{-1} DM. The top most values are present in separate samples of *Ranunculus repens* L., *Ranunculus bulbosus* L., *Plantago lanceolata* L., *Heracleum sphondylium* L., *Taraxacum officinale weber*, and *Anthriscus sylvestris (*L.*) Hoffm* (Lukač *et al.*, 2012). According to Isselstein and Daniel (1996), the values of water-soluble carbohydrates in the subsequent cut of *Achillea millefolium L., Ranunculus repens L., Heracleum sphondylium L.* and *Anthriscus sylvestris (L.) Hoffm.*, were just over 100 g kg^{-1} DM, which the initial cut is significantly higher than. Also in the second cut of *Ranunculus repens L.* (Mainz and Selstein, 1995), *Heracleum sphondylium L., Anthriscus sylvestris (L.) Hoffm.* and *Plantago lanceolata L.* (Wyss and Vogel,

1999), water-soluble carbohydrates values of only around 100 g kg^{-1} DM were recorded (Isselstein and Daniel 1996). The conclusion therefore is that the water-soluble carbohydrates in non-leguminous forbs are commonly higher at spring cut than in the subsequent cuts of the growing season. It is however challenging to make a comparison as only few amounts of similar data exist. Large variety in the concentration of water-soluble carbohydrates in the same groups has been stated, showing clearly that information concerning the properties of ensiling of individual species cannot be universal. It is also necessarily to assume in the mind that plant materials from permanent grasslands are mostly a combination of grasses, legumes and non-leguminous forbs. Hence their ensiling properties do not only depend on characteristics of individual groups but also depend on their ratios in a sward (Lukač *et al.*, 2012).

2.20 Characteristics of Good and Bad Silage

Silage is referred to as nice or poor based on some specific standards such as texture, physical look, color and aroma. Corporeal features such as smell, the texture as well as color are applied, but both the pH and the fermentation acids analysis results in more accurate feedback. It is highly advisable to not taste silage since badly stored feed may contain harmful microbes, yeasts and moulds (Opinya, 2019). The quantity of acid in silage is informed by the pH. Silage that has a pH range of 3.5 to 4.2 specifies exceptionally clean acidic or pleasant silage, 4.2 to 4.5 is seen as good acidic and 4.5 to 5.0 is fair less acidic while over 5.0 is seen as bad pungent/rancid smelly silage. High DM, partial fermentation processes, sampling or opening

prematurely, packing poorly, moulds or manure present in silage usually causes high pH (Opinya, 2019).

Improved quality silage has little acetic acid (1% to 3%), butyric and high in lactic (4% to 7%) and sugar. Most of the decrease in pH of the silage can be attributed to lactic acid, which is necessary even though very high degrees are related to acidosis-type troubles. Conversely, high acetic acid levels and manufacture of butyric acids results in poor fermentation of silage occasionally as a result of poor filling or very moist silage and these results to less consumption (Opinya, 2019).

Bad silage has a soft slippery texture when it is rubbed from the leaf or fibre and has moulds. Extremely dried or fragile silage indicates the ensiled material contained too much dry matter and there was overheating throughout the storage process results in a lot of relapse (Opinya, 2019).

The acceptability of silage by animals and performance in production terms is linked to the ensiled feed material used, its digestibility, nutrient composition, physical make up, fermentation characteristics as well as microbial value (Opinya, 2019). The palatability of poor silage is low, but after eliminating the bad smell or by adding some additives such as molasses or fresh forages through feed formulation, the animals might end up eating. Remember animals needs the nutrients in the feed and not necessarily the feed. An adviser to the farm can also aid in the simple silage quality evaluation (Opinya, 2019).

2.21 Effects of Ensiling on Forage Intake

Regularly, it is presumed reduction in forage consumption and animal performance are affected by ensiling, as in practice animals grazing in the open have a much higher intake compared to those in intensive system receiving silage. This comparison however is not convincing as the animals are generally at diverse phases of their production sequence, grazing animals have the freedom to select their forage, whilst those offered silage are limited to what they are given. Also, other management practices, both feed and animal factors vary as well. Keady and Murphy (1993) reviewed data from 75 and 14 evaluations carried out with sheep and beef cattle revealed a mean decrease in silage dry matter (DM) consumption of 37% and 6% comparative to the parent herbage, respectively. Intake characteristics in silage are distinct for sheep and cattle (Cushnahan *et al.*, 1994). Keady and Murphy (1993) assessed 7 similarities of the outcomes of ensiling on forage consumption of both heifer and sheep and stated that whereas the same forages were offered, ensiling reduced forage consumption by sheep whilst no effects were observed when given to the heifer. Keady *et al.* (1995) and Keady and Murphy (1998) stated that when silage is produced through good ensiling managements then ensiling per se showed no effect on forage consumption however the performance of animals decreased as a result of variations in the nitrogenous constituents and decreased energy value of volatile fatty acids as sources of energy for the rumen micro flora.

2.22 Methods of Hay Preparation

The steps involved in changing fresh green, perishable forage to a feedstuff that can be easily stored and transported safely without any risk of deterioration, while maintaining a minimum nutrients loss can be termed as hay making. It involves decreasing the moisture content of the forage by placing it in the sun or an open place to wilt or dry a little. The green forages are dried without any major alteration to their aroma, flavor and nutritive value and this process is termed curing. It consists of decreasing the moisture content in the fresh green forages, so as to preserve them without any deterioration or additional loss of nutrients (Infonet-Biovision, 2019). According to Abu and Drag (2002) groundnut hay has 9% and 61.7 of crude protein and total digestible nutrients (TDN), respectively.

- The forage to be used is harvested before it matures fully (before seeds development) to keep its nutritive value at a maximum. Though harvesting hay prematurely will result in lower total volume, the higher nutritive value will recompense for moderate yields.

- Forage leaves have higher nutritive value compared to stems so when harvesting forage for hay, it is vital to cut the forage with more leaves and little stems.

- Do not abandon the harvested forage to dry in a humid environment because this might result in mould development. This can pose grave danger particularly to livestock and to people managing it.

- The forage is then spread out in the sun on a thin clean layer and mixed regularly to speed up the drying process.

- The forage should be chopped into small sizes after drying to speed up the process of drying.

- Drying should be done for 2-3 days.

- Do not over dry the forage as it may begin to ferment and may likely turn fire hazard.

- Ideally the dried hay should be preserved in bales the acceptable DM (less than 15%) content is attained. Baling reduces stress in storage and only need less space

2.23 Difference between Silage and Hay

According to Lakna (2018), a major distinction between silage and hay is that silage is the fermented green forage fodder kept in a silo while hay is grass cut, dried and used as fodder for animals. Hay has less than 12% moisture content whilst that of silage ranges from 40%-60%.

Silage and hay are two ways of conserving feed (normally forage) for livestock consumption as it is not easy for them to graze in the field throughout unfavorable weather conditions. The two are all made from grasses and are as well all methods of preserving forage (Lakna, 2018).

2.24 Rice Bran as Ruminant Feed and its Effects

According to Heuzé and Tran (2015), the most significant rice by-product is rice bran. About 14% to 18% oil is contained in the bran fraction. Fatty rice bran is a valuable binder in formulated feeds. The utilization of defatted rice bran is at a greater level compared to the normal rice bran. Usually rice bran is mixed with rice hulls, as it ought to contain about 10% to 15% crude fibre content.

Studies on animal performance revealed that cattle who received supplementary rice bran are likely not to perform like those that were supplemented with corn or soybean hulls. In a demonstration utilizing rice bran in place of corn for cattle fed an 80% concentration finishing diet, Snell *et al.* (1945) noticed a 25% decrease in ADG and 23% increase in feed to gain. Increasing rice bran from 0% to 21% of the ration by replacing grain sorghum did not appear to affect ADG (Wayne, 1965). The researchers noted a simultaneous increase in diarrhea when rice bran levels were increased, and diarrhoea was stated as a problem in some works where the rates of inclusion were 40% and 50% of the diet. In a study by Forster *et al.* (1993), there was a comparison in the performance of steers supplemented with grazing tall fescue (*Festuca arundinacea*), clover (*Trifoliumpratense* and *repens*), and Bermuda grass hay alongside either low or high concentrations of corn or rice bran. The corn and rice bran were fed at levels expected to supply similar amounts of DE. Average daily gain was highest for calves fed corn at 0.6% BW (0.97 kg/d gain) and lowest for calves fed rice bran at 0.76% BW (0.76 kg/d gain). Calves fed lower levels of corn (0.3% BW) and rice bran (0.38% BW) performed similarly (0.76 kg/d gain). In a

second study by Forster *et al.* (1994), weight gain of steers fed corn at 0.62% BW (1.14 kg/d gain) did not differ from those fed rice bran at 0.8% BW (1.18 kg/d). The rate of gain for calves supplemented with rice bran was however significantly higher than non-supplemented (1.06 kg/d), whereas the gains for the calves supplemented corn was significantly not different from the control calves. Sanson and Coombs (2003) supplemented gestating heifers fed Bahiagrass (*Paspalumnotatum*) hay with 1.4 kg/d per head of corn, rice bran, or soybean hulls. Heifers fed the corn and soybean hulls gained significantly more (9 kg) than heifers fed rice bran. Till *et al*. (1991) compared the performance of grazing heifers fed iso-caloric supplements of rice bran, molasses plus urea, or molasses plus urea and rice bran. Supplemented calves had a significantly greater rate of gain compared with non-supplemented controls. Heifers fed rice bran and molasses plus urea performed similarly; however, heifers fed a combination of molasses plus urea and rice bran gained at a faster rate than heifers fed rice bran or molasses plus urea. White and Hembry (1985) observed similarities between the calves on diets with 20% and 30% inclusion levels of rice bran, but their performance decreased when 40% and 50% of the rice bran was fed. De Fries *et al.* (1998) compared the reproductive responses of postpartum cows fed isocaloric and isonitrogenous diets with and without rice bran. Rice bran partially replaced corn and soybean meal. The rice bran diet contained 5.2% fat, and the control diet contained 3.7% fat. There was more body condition gain for cows on the rice bran diet than the cows on the control diet. There was increasing numbers of medium, large, and total follicles in cows that were on the rice bran diet. Fat supplementation did not affect postpartum interval. However, there was a higher rate

of pregnancy (94.1%) in the cows on the rice bran feed comparative to that of the control feed (71.4%) (NRC, 1984).

2.25 Corn and Its By-products as Feed Source

By-products account for 30-40% of the total product yield, but 20-25% of the kernel is processed without added value, even though maize germ oil and maize gluten meal have a higher value than starch in the US market (Rausch and Eckhoff, 2015). At the point when cereal grains are refined for human consumption, some parts of the grains are removed and then turn into by-product and is generally used in feeding animals. Mostly, these by-products contain greater amounts of proteins, fats, and fiber than the grain itself. Some of these by-products have greater amounts of some particular vitamins in them. This large amount of the vitamins, proteins, and fats content in these by-products contribute to their significance. Their greater fiber content restricts their utilization in feeding poultry and swine (Ellis and Bird, 1951).

At the point when corn is refined to produce degerminated corn meal or hominy for food, hominy feed is the by-product. It contains some proportions of starch, besides the germs and bran of the corn which includes the tip caps and outer layers of the kernels. After corn is wet milled to produce glucose and starch, the by-products are the gluten feed (consisting of both the gluten and bran), the gluten meal (usually gluten), and the germ (which is typically divided into meal and oil), (Ellis and Bird, 1951). The gluten meal and to an insignificant extent, the oil meal and the gluten feed may be considered as protein supplements. The gluten meal can be compared to the oilseed meals in protein content. However, the nature of the protein is mostly

inadequate from the nutritional perspective when compared oilseed meals. The hominy feed, gluten feed and the gluten meal produced using yellow corn consist of carotenoid pigments, therefore contain a bit of vitamin A activity. This is not factual of white corn by-products (Ellis and Bird, 1951). Hominy feed, corn-gluten feed and corn-gluten meal are largely used for feeding livestock, particularly for the dairy cows. The gluten feed is also used in beef cattle and sheep fattening as a protein supplement. It is not comprehensively utilized in the rations of swine, though small quantities may be added with different supplements which have proteins of great values biologically. Gluten meal is usually fed under much similar circumstances as gluten feed and is mainly regarded to some extent more useful in keeping with its greater protein content. Generally, hominy feeds are used as substitute to part or the whole corn in livestock rations. In poultry rations, it can also be an alternative to grains (Ellis and Bird, 1951).

In the poultry industry, yellow corn-gluten meal is a significant ingredient of the growers' diet owing to its protein content as well as the carotenoid pigments. This pigment gives the chicken vitamin A and is responsible for the yellow color of chickens shanks and skin (Ellis and Bird, 1951). Chaffs are generally low in protein (~2.5%), though mostly supplemented with plant proteins and used as feeds for ruminants as well as poultry and other livestock (Iyayi and Aderolu, 2004)

CHAPTER THREE

3.0. Materials and Methods

3.1. Study Area

The animal experimentation was carried out at the Livestock Unit of the Department of Animal Science, Faculty of Agriculture, Food and Consumer Sciences (FoAFCS) of the University for Development Studies (UDS), located in Nyankpala. The chemical analyses were done at the Spanish and Forage Evaluation Laboratories of UDS, Nyankpala Campus. Nyankpala is located on longitude 0˚ 58'47.57" W and latitude 9˚ 23'45.53" N and at an altitude of 168m above sea level in the Guinea Savannah ecological zone of Ghana (SARI, 2015). The rainfall pattern of the area is unimodal starting from late April and reaches its peak in July-September; there is a sharp decline and absolutely no rain in November (SARI, 2004). The study was conducted in the dry season from 10th November, 2016 - 20th May, 2017. The average annual rainfall is 1200mm (SARI, 2004). Generally, there is temperature fluctuation of between 19^{o}C and 42^{o}C (minimum and maximum respectively) with an average yearly temperature of 28.5^{o}C (SARI, 2015). The average annual day time relative humidity and sunshine are 27% to 40% and 80% to 87%,respectively. The area goes through dry cold Harmattan winds and a period of warm dry conditions from November-February and from March -Mid-April, respectively. Information on environmental situation during the period was sourced from the weather records of Savanna Agricultural Research Institute (SARI, 2004; SARI, 2015) sited 1.8km (22 minutes) walk from the location of the experiment.

Plate 1: Sheep and Goats Unit of the Animal Science Department, UDS.

3.2. Experiment I: Fermentation Characteristics of Groundnut haulms

3.2.1. Collection and Ensiling of Groundnut haulms

Fresh groundnut haulms were obtained from the agronomic trial fields of Savannah Agricultural Research Institute (SARI) located within Nyankpala and were transported to the ruminant unit of the UDS, Nyankpala campus for storage. They were wilted to approximately 20%-25% DM. The haulms were divided into two portions. One portion was chopped to about 3cm - 4cm in length using cutlasses and later ensiled in a 500kg capacity flexible intermediate bulk containers (120× 90 × 90 cm; Shandong Anthente New Materials Technology Co., Ltd; Shandong, China) lined with 0.1mm thick polyethylene. The packing was done by manually trampling on the fodder and kept at room temperature to allow for anaerobic fermentation for

90 days. The second batch was shade dried (90.4% DM) and stored in polyethylene bags until used.

Plate 2: Transportation of Groundnuts Haulms from agronomic field to the Sheep and Goats unit of UDS

Plate 3: Chopping of GH into theoretical length (3-4cm)

Plate 4: Compacting the GH in the silo bag

Plate 5: Silo bag containing groundnut haulms

Plate 6: After 90d of anaerobic fermentation

3.3. Experiment II: Growth performance

3.3.1. Experimental Animals and their Management Practices

A total of 20 healthy West African Dwarf (Djallonké) growing rams with average initial live weight of 14.65 ± 3.17kg were purchased from Katinga market in Tolon District of the Northern region and transported to the experimental site in Nyankpala. Animals were given 14 days adaptation period to both the feed and experimental environment. Prophylactic treatment was given to the animal using Oxykel 20 L.A. (KELA, Belgium) against infections and administered by deep I.M. Dosage was 1ml per 10kg body weight while ivermectin 1% (Hovione, Portugal) was administered for controlling internal and external parasites by subcutaneous injection: 1ml per 50kg body weight. Animals were assigned to twenty wooden made pens (2.44m × 0.87m)randomly floored with concrete, each of the pen contained a ram, at the Ruminant unit of the UDS, Tamale, Ghana.

Plate 7: Experimental animals ready to be transported from market site.

Plate 8: Experimental animal housed to adapt to the environment of the unit

Plate 9: Experimental animal assigned to individual pen and treatment

3.3.2 Formulating the diet

The diets were formulated at the ruminant unit of the Animal Science Department of the UDS for both ensiled and dried groundnut haulms with ingredients including cracked corn, maize bran, rice bran, grower concentrate and vitamin/mineral supplement each at specified quantity. The formulated diet contained 30, 40, 15, 7, 7, and 1 of groundnut haulms, maize bran, cracked corn, rice bran, grower concentrate and vitamin/mineral supplement respectively to get a 100 kg of feed. The following steps were employed in formulating the diets. 7kg of the rice bran was weighed onto a large polythene bag. 1kg of vitamin/mineral supplement was added to the rice bran thoroughly mixed to assume an even mixture. Then 7kg of grower concentrate was weighed into the mixture and thoroughly mixed. After this, 40kg of the maize bran was also added and mixed uniformly. 15kg of the cracked corn was also weighed into mixture and rigorously mixed. Finally, 30kg of the groundnut haulms (either ensiled or dried) was included into the mixture and uniformly mixed to assume an even distribution of the mixture. The final mixture was scooped into a large sack and indicated either ensiled groundnut haulms (EGH) or dried groundnut haulms (DGH).

Plate 10: Mixing of different feedstuff thoroughly

Plate 11: A mixture of the various feedstuffs excluding the forage

Table 6: Formulation of feed during the experimental period (% as fed basis)

	% inclusion levels of feed formulated
Feed ingredients	100kg
DGH or EGH	30.00
Maize bran	40.00
Cracked corn	15.00
Grower concentrate	7.00
Rice bran	7.00
vitamin/mineral supplement	1.00

Table 6 shows the various feed ingredients and their inclusion levels in the ration formulated.

3.3.3. Experimental Design and Treatments

The 20 growing rams with average initial weight of (14.65 ± 3.17kg) were assigned randomly to individual pens labelled from P_1 to $P_{20.}$ The 20 growing rams were each tagged with a number, ranging from 1 to 20 and assigned randomly to the pens by the use of simple random sampling using ballot papers which had numbers corresponding to the tag number on each ram. Again, with the help of simple random sampling using ballot papers, the experimental units were assigned to treatments (either EGH or DGH) diet. The sheep were allocated such that each received one and only one treatment throughout the entire experiment till the end.

Sheep were weighed with a digital scale (Avery Weigh-Tronix; Minnesota, United States) for two days consecutively at the start of the experiment and weighing was done every two weeks until the end of the feeding experiment. The average values of the successive weights at the start of the study and at the end were respectively used as the initial weight and final weight. The animals were weighed biweekly and feed and leftovers were collected every 14 days until the experiment which lasted for 70 days ended. Collected feed and leftover samples were used to determine DM and the daily DM intake. The biweekly weights of animals were used to estimate average daily weight gain. Weights of feed supply and leftovers were taken and used to determine DM intake. Daily DM intake was estimated per pen as DM offered minus DM left.

The experimental animals were fed each morning (07:00 am GMT) and evening (05:00pm GMT). The amount of the feed given per day were regulated to meet the animals' taste and to ensure less feed leftovers without limiting intake. Clean water was provided *ad libitum* daily per pen.

After the formulation, the feeds were administered to the sheep for the EGH or DGH diet equally as follows. All the rams were offered 0.5kg of the diet in the morning and 0.5kg in the evening according to their apportionments. The leftovers were weighed early in the morning of the next day before feeding the animals. When any is seen to have completely consumed the feed, feed quantity was increased until there is some leftover.

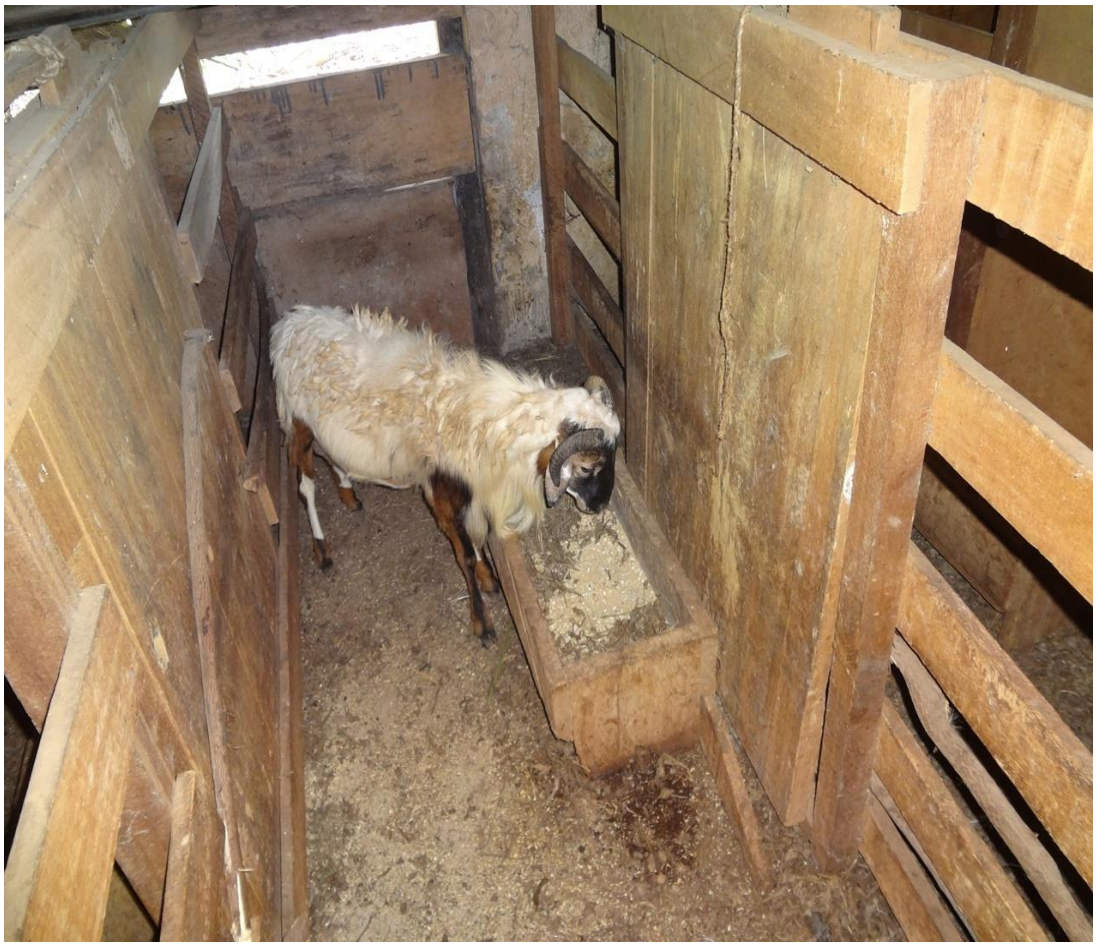

Plate 12: Experimental animals in their separate pens with the experimental diets

3.3.4. Growth Performance

The rams were weighed with a scale (Avery digital scale; Avery Weigh-Tronix, Minnesota, USA) at the start of the feeding experiment and also weighed every two weeks until day 70. The initial live weight (kg) per animal was deducted from its final live weight (kg) at the end of the feeding trial. It was then divided by the number of days (70) the feeding lasted to get the average daily weight gain.

Plate 13: Weighing of individual rams

3.4. Laboratory Analyses

3.4.1 Measurement of pH

pH of replicate samples of the dried groundnut haulms and those acquired from groundnut haulms ensiled for 90 days in a 500kg capacity flexible intermediate bulk containers (120× 90 × 90 cm; Shandong Anthente New Materials Technology Co., Ltd; Shandong, China) lined with 0.1mm thick polyethylene in experiment I was measured. The representative samples were taken from 2 parts of the silage in the flexible containers (surface layer and the core of the silage) and independently processed for analysis. Samples were mixed thoroughly and sub-sampled.

About 15 g of the sample was weighed (Sartorius Gottingen, Germany) and placed in a clean beaker. Roughly 135 mL of distilled water was included and blended (Moulinex Uno) for 45 sec. The blended sample was then discharged into another clean beaker and a pre-calibrated pH meter (Crison pH meter) used to determine the pH of the blended sample.

3.4.2 Microbial Analysis

After ensiling for 90 days, both the ensiling and dried groundnut haulms were each sub-sampled from each bulk container for recording of LAB using the lactobacilli MRS agar and yeasts and moulds using the Sabouraud's Dextrose Agar (SDA).

For LAB detailing, 62g of MRS agar was weighed into a clean flask and 1L distilled water added and dissolved through boiling by the use of a magnetic stirrer and then autoc1aved (Micro clave, J.P. Selecta, Spain) for 15 min at 121^{o}C and it was left to

cool at 50°C in a water bath. The agar was then poured and spread unto sterilized petri dishes to about half-full and placed on a laminar flow hood (Envair, Haslingden, UK) under acceptable conditions. The dishes were left to cool and set to room temperature. An analogous protocol was applied for enumerating yeasts and moulds just that 65g of the SDA was included in 1L distilled water. A sub-sampled dried or ensiled groundnut haulm (about 10 g) was weighed into 90 ml of distilled water in a medium size sealable polyethylene bag and vigorously mixed up to separate the microbes from the samples. Serial dilutions (-2 to -5) were done and 1mL of every dilution was used in inoculating all prepared MRS and SDA agar plates. After inoculation, MRS plates were together in batches held using a clinch film and lay up turned in an incubator (Incubator-Coy J.P. Selecta, S.A., Barcelona, Spain) at a temperature of 32°C. Bacteria or fungal colony forming units were counted after 24 h and 48 h for MRS and SDA plates, respectively by the use of a digital colony counter (J.P. Selecta, S.A., Barcelona, Spain).

Plate 14: Inoculation of plates

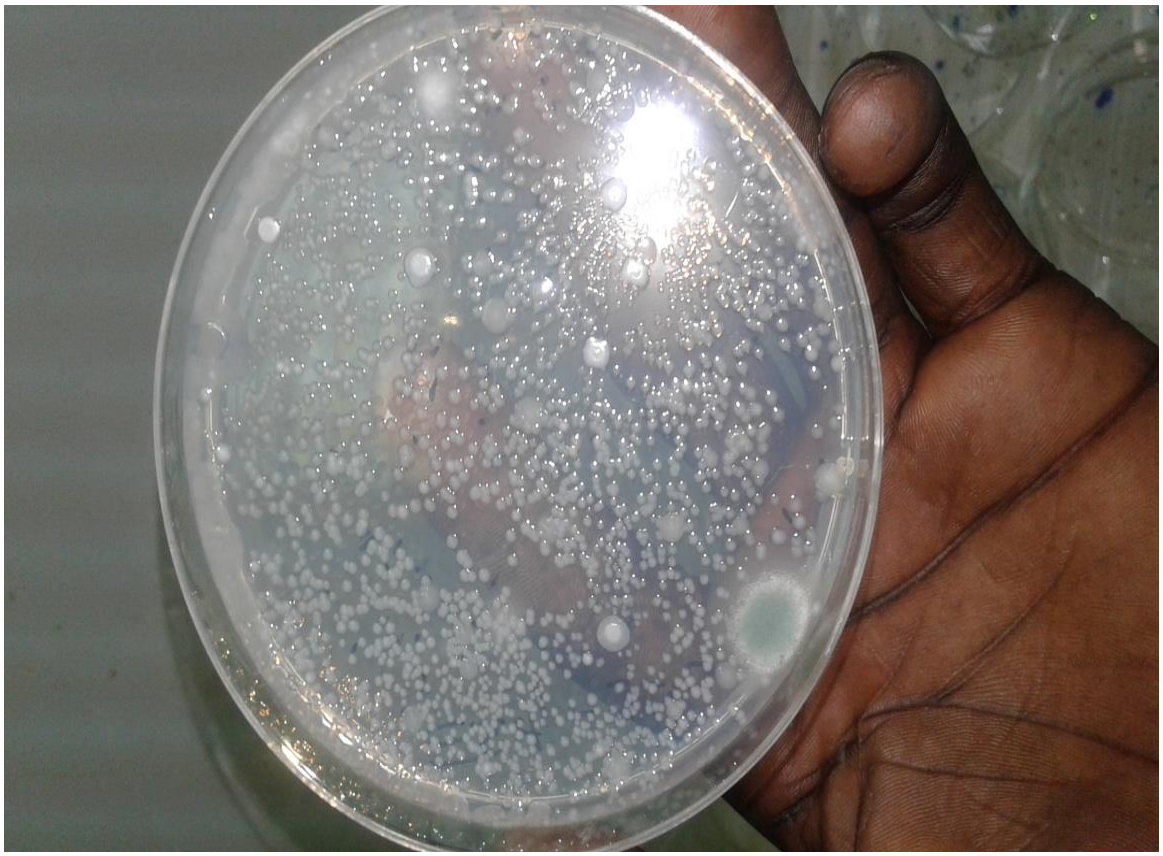

Plate 15: Bacterial growth on plate

3.4.3. Determination of Ammonia Nitrogen (NH_3-N)

Samples of the dried or ensiled groundnut haulms attained subsequent to 90 days of ensiling in flexible containers was blended and filtered using 2 layers of cheesecloth and the filtrate centrifuged afterwards for 15 mins at 10,000 x g (4°C). The analysis of NH_3-N was done using the supernatant. 0.15 mL of 65%trichloroacetic acid (wt/vol) was combined with the supernatant (1.6 mL) and the analysis done using the method of phenol-hypochlorite as outlined by Broderick and Kang (1980). Calibration of the colorimeter was done using a standard solution prepared by adding 0.25 mL of stock solution to 4.75 mL distilled water. The standard preparation was

done by dissolving 25g phenol in 95% NH_3-N.Quantification was then done using a spectrophotometer (Spectrotroquant Pharo 300, J.P. Selecta, Spain) by reading the absorbance of the standards and unknown samples at a wavelength of 630 nm at a sample concentration scope of 0.00 to 3.00 mg/L

3.4.4. Proximate and Fibre Analysis

Every week (7 days) feed samples were collected and combined together to make a biweekly (14 days) sample for the 70 days of the animal experimentation. At the end of the experiment, preserved sample from each treatment were bulked together and sub-samples were taken for laboratory analysis. The proximate analysis of both diets and ingredients was done according to the procedures of the Association of Official Analytical Chemists (AOAC, 2000). Duplication was done on all analyses.

3.4.5. Dry Matter

About 25g of the groundnut haulms samples (silage) were dried in an oven (J.R. Selecta) for 48 h at a temperature of 60^0C. For feed samples, the air oven was regulated to 80^0C. Using aluminum dishes, 2g sample were approximately weighed into each dish. The dishes were placed in the oven as quickly as possible and samples were dried overnight. The dishes were transferred into the desiccator to cool. The dishes were weighed and loss in weight as moisture was calculated. After being oven dried, the weights were recorded and used in estimating the DM % of every feed sample.

3.4.6. Crude Protein

2 g of ground feed sample was weighed into Kjeldahl digestion tubes and blank determination carried out through digesting filter paper in all the sets of digestion. Approximately 15 mL of concentrated Sulphuric Acid (H_2S0_4) and two (2) Kjeldahl tablets were added to the content of every digestion tube. The Kjeldahl tablet contains Potassium Sulphate (K_2S0_4) as well as Copper Sulphate ($CuS0_4$) which respectively increases the boiling point and serves as a catalyst. The digestion tubes were set up on Kjeldahl digestion block (J.P. Selecta, RAT 2) and heated progressively to 420°C and retained for 3 h. The tubes were then taken off and left to cool down to room temperature. Subsequently, distillation was done by adding 50 ml of distilled water using an automatic Kjeldahl distillation device (J.P. Selecta, s.a., Pro-Nitro II). About50 mL of earlier prepared sodium hydroxide (35% NaOH) and 25 ml of Boric acid (4% H_3B0_3) were then drawn into a 25 ml Erlenmeyer flask to collect the NH_3 that were being released in the distillation process which lasted 9 min for each sample. The collected distillate was titrated against a 0.1 M hydrochloric acid. The percentage CP (%CP) and Nitrogen (%N) were calculated with the help of the recorded average titre values using the formulae:

% Crude Protein = %Nitrogen × 6.25

%Nitrogen = (T-B) × N ×1.4/sample weight (g)

Where:

T=Titre value of sample; B= Blank titre value; N = Hydrochloric acid(HCL) concentration.

3.4.7. Ether Extract

The Soxhlet equipment was used for the determination of ether extract. About 150mLof anhydrous diethyl ether (petroleum ether) at a boiling point of 40^{o}C - 60^{o}C was put into a flask. About 2 to 5 grams of the sample was weighed into a thimble and plugged with cotton wool on top of the mixture. The thimble and its content were placed into an extractor. The ether in the flask was at this point heated. The ether soluble substances were dissolved and were carried into solution through a siphon tube back into the flask. The process of extraction was continued and lasted not less than 4 h. The thimble was then taken off and the solvent distilled into the extractor from the flask. The flask was detached and then placed in an oven for 4 h at 65°C, cooled in desiccator and the weight recorded.

3.4.8. Ash

Two (2) grams of feed samples were weighed into porcelain crucible and place in temperature-controlled furnace initially heated to 600^{0}C. Then it was held for 2 h at this temperature. The porcelain crucible was then transferred directly into the desiccator, cooled, and immediately weighed and %ash reported to two decimal places.

3.4.9. Neutral Detergent Fibre (NDF) and Acid Detergent Fibre (ADF)

Sub-samples of the diets were stored at a temperature -20°C until being dried and ground through a 1 mm screen for NDF and ADF analyses through the procedures by Van Soest *et al.* (1991) using an Ankom^{200} fibre analyzer (Ankom Technology Corp., Fairport, NY). Each treatment was replicated twice for both the NDF and

ADF samples. About0.5 g of each sample was directly weighed into the filter bags (Ankom F57) and well labeled. The filter bags were then sealed within 4 mm of the top with an electronic heat sealer. One blank filter bag was added in each run to establish blank bag correction. The bags containing the samples were then placed on the bag suspender and inserted into the Ankomfibre analyzer vessel with a bag suspender weight on top to keep it immersed. NDF solution was prepared by dissolving 30g Sodium dodecyl sulfate, USP; 18.61g Ethylenediaminetetraacetic disodium salt, dehydrate; 6.81g Sodium borate; 4.56g Sodium phosphate dibasic, anhydrous; and 10 ml Triethylene glycol, in 1L distilled water. The ADF solution was prepared by dissolving 20g Cetyltrimethyl ammonium bromide (CTAB) into 1L 1.00N H_2SO_4.

For the NDF, 2L NDF solution was added to every 24 sample bags in the fibre analyzer vessel. About 20 g (0.5g/50ml) of sodium sulfite and 4.0 mL of alpha-amylase was added to the solution in the vessel. The fibre analyzer was then left to run for about 75 minutes. After 75 minutes, the solution in the vessel was finished and the content rinsed using 2L of hot water (70-90 °C). The rinsing was repeated three times for 5 min and 4.0 mL of alpha-amylase added to the first two rinses. The samples were then placed in acetone after rinsing for 3 to 5 minutes subsequent to which they were oven dried at 102°C for 2 h and their weights recorded. The same procedure was repeated for ADF as for NDF except that for ADF, the fibre analyzer was left to run for 60 min. Also, sodium sulfite and alpha-amylase were not included.

% NDF /ADF =100 × (W3 –- (WI × C 1)/W2

Where: WI = weight of bag the tare, W2=weight of sample, W3=dried weight of the bag containing fibre subsequent to the extraction processes.

C 1 = blank bag correction (running an average of final oven-dried weight divided by the original weight of the blank bag).

3.5. Statistical Analysis

The PROC MIXED procedure (SAS Inst. Inc., Cary, NC) was used to analyze all the data. Data on microbial populations were modified to $\log_{10}$ colony-forming units preceding statistical analysis. The bulk storage container was used as the experimental unit for both dried and ensiled groundnut haulms. DMI and growth performance data on the sheep (body weight gain and ADG) were analyzed for the effects of ensiling as a completely randomized design considering the initial body weight as a covariate in the model and pens used as experimental units. Differences in least squares means of all fixed effects were separated at $P \leq 0.05$

CHAPTER FOUR

4.0RESULTS

4.1. Effects of Ensiling on Fermentation Characteristics

With reference to Table 1 below, there is no significant difference (p>0.05) between DGH and EGH on pH and microbial count.

Table 7: Microbial counts of dried and ensiled (90days) groundnut haulms.

Item	DGH	EGH	SEM	P-Value
Ph	6.31	5.97	0.18	0.26
Microbial population (Log_{10} CFU/g DM)				
LAB	5.47	5.08	0.33	0.41
Yeasts	6.39	6.27	0.29	0.75
Moulds	6.63	6.88	0.38	0.62

LAB = Lactic Acid Bacteria; SEM = Standard Error of Mean; P-Value= probability; Means are not significantly different (P > 0.05); CFU/g DM = colony forming units per gram of dry matter.

4. 2. Nutrient Intake and Growth Performance of Animal

Table 8: Intake and growth performance of West African Dwarf (Djallonké) growing rams fed DGH or EGH.

Parameter	DGH	EGH	SEM	P Value
Nutrient intake (DM basis)				
DMI (kg/d)	0.57	0.67	0.03	0.01
Initial weight (kg)	13.99	15.31	1.00	0.37
Final weight (kg)	16.13	17.21	0.33	0.04
Weight gain (kg)	2.14	1.90	1.41	0.88
ADG (kg)	0.03	0.05	0.01	0.04
FCE (ADG/DMI)	0.05	0.08	0.01	0.12

DMI= dry matter intake; ADG=average daily weight gain; FCE= feed conversion Efficiency; OM= organic matter.

There was significant difference (p=0.01) between DGH and EGH in DMI. EGH recorded the highest intake of 0.67 kg\d whiles DGH recorded the lowest of 0.57 kg/d. Final weight gain differed (p=0.04) among the treatments. EGH and DGH had values of 17.21 and 16.13 kg, respectively. Also, average daily gain was significant among the treatments. It was observed that EGH had the highest of 0.05 kg and DGH had 0.03 kg which is the lowest. Initial weight, weight gain and feed conversion efficiency were not significant (p>0.05) among the treatments.

4.3. Chemical Composition of the Various Diets

The CP content and ADF are relatively higher in the EGH compared to the DGH whereas DGH has higher ether extract and NDF than the EGH (Table 3). However, the DM and the ash are comparable. The ammonia content of the feed was higher (1.43±0.02) in the DGH diet than that of the EGH diet.

Table 9: Chemical composition (mean ± SEM) of dried-groundnut haulms and ensiled-groundnut haulms diets

Item (% DM)	DGH	EGH
DM	89.35±0.31	89.12±0.50
CP	4.14 ±0.80	6.56±0.19
Ether extract	5.25 ±0.96	4.75±0.87
Ash	5.50 ±0.73	5.36±0.24
NDF	38.88±4.16	35.56±1.59
ADF	37.86±12.52	39.76±9.73
NH_3-N(mg/kg DM)	1.43±0.02	0.60±0.02

DM=dry matter; DGH=dried groundnut haulm; EGH=ensiled groundnuts haulm; CP=crude protein; NDF=neutral detergent fiber; ADF=acid detergent fibre.

CHAPTER FIVE

5.0. DISCUSSION

5.1. Experiment I: Fermentation Characteristics

5.1.1. pH and Microbial Counts

The pH of EGH is fairly comparable to the 5.2 reported by Weseh *et al.* (2017) in ensiled groundnut haulms but much higher than 4.60 reported by Foster *et al.* (2011) in perennial peanut haylages. The pH of legume silage ranges from 4.60 to 5.20 when the DM content is higher than 350g/kg (Heinrichs and Ishler, 2000). The pH exceeded 4.50 which is known to favour clostridial fermentation with the production of butyric acid (McDonald *et al.,* 1991). Also, the EGH had a pH that surpasses the cutoff point (4.0) for reducing proteolysis and clostridial activities (Muck, 1988), and maybe attributed to high buffering capacity of leguminous plants (Adesogan *et al.*, 2004). Meneses *et al.* (2007) reported a pH of 3.5-5.5 as suitable for good silage produced using crop by-products. At such a lower pH, growth of sacchrolytic spoilage organism is inhibited resulting in light-brown silage with a pleasant odour. The high pH in the silage may be attributed to the silage being exposed to oxygen, causing yeast to use the lactic acid for growth (Addah *et al.*, 2014). The increase of silage pH may also dispose it to degradation by some spoilage organisms as reported by McAllister *et al.* (1995). Higher number of moulds recorded in this work contradicts the works of Dolci *et al.* (2011) and Duniere *et al*. (2017) who recorded (1.74 Log_{10} CFU/g) and no moulds in ensiled forages respectively. According to Kung and Randy (2001), the presence of high pH and clostridial is an indication of poor fermentation. This may have accounted for higher moulds in this study. A

population threshold of 5 log CFU/g DM has been instituted for silage to go through deterioration (Woolford, 1990).

The EGH was expected to have a higher Lactic Acid-producing Bacteria (LAB) counts so as to cause rapid decline of pH in silage. Interestingly, this study recorded a lower LAB counts with fairly lower pH as compared to DGH which is inconsistent. Lactic Acid-forming Bacteria, accelerates the decline of pH in silage as a result of an upsurge in the formation of lactic acid. The rapid decline in pH inhibits the development of spoilage bacteria, yeasts and moulds as well as averts respiration by plant cells, thereby conserving the plant sugars in silage (Addah *et* al., 2014). McAllister and Hristov (2000) reported that a pH < 3.8 inhibits growth of all microorganisms including LAB. The numbers and quality of natural microorganisms on forage is mostly inconsistent and at times can be extremely low to facilitate a successful fermentation (Merry and Davis 1999).

5.2. Chemical Composition of Ensiled and Dried Forages

The chemical composition though was not statistically analyzed but calculated, some parameters such as NH_3-N, EE and NDF were higher in DGH diet whiles CP and ADF were higher in EGH diet.

The higher NH_3-N in dried though might be confusing, the severe rise in the NH_3-N concentration in the dried diet could be as a result of the proteolytic actions of both yeasts and moulds during the storage of DGH diet at the time of feeding.

The NH_3-N value recorded in this study was lower than the 12.4% N in peanut silage reported by Yang (2005) and 11.3% N reported by Fairbaire *et al*. (1988) in alfalfa. The NH_3-N concentration was lower than the acceptable concentration of 10% N (Church, 1991).

Therefore, EGH had NH_3-N concentration below the threshold of 100g of total N/kg of DM, which implies very little proteolysis (Seglar, 2003).

The CP concentration was greater in EGH (6.56±0.19) compared to DGH (4.14 ±0.80). This may be because ensiling increased the CP content. Oboh (2002) reported that the surge in growth and buildup of the fungi or bacterial complex during fermentation could result in an increase in the CP content. It could also be that the ensiled groundnut haulms contained less hydrolysable protein, hence did not record losses in CP. The CP concentration reported in the current study is lower than 14.4±0.3 against 14.2±0.2 reported by An (1998) in ensiled peanut haulm and dried peanut haulm, respectively. However, the findings contradict findings by Petit and Tremblay (1992), who reported that forages will generally have less CP concentrations after ensiling on account that proteolysis occurs during wilting and ensiling due to enzymatic activities and microbial fermentation. However, the CP concentration estimated in EGH (6.56±0.19) meets the recommended (7%) minimum requirements for ruminants (NRC, 2007). The EGH can supply adequate rumen nitrogen for microbial activities (Van Soest, 1982).

The lower NDF in the ensiled diet could be due to the fact that ensiling or fermentation was able to convert the enzyme-resistant lingo-cellulose material into a more digestible substrate (Muck, 1989; Ubalua, 2007). The lower EE in EGH with a corresponding high DMI agrees with Palmquist (1994) that high EE (above 70 g/kg) in ruminant diets can cause decrease in DM intake as well as decrease in the rate of fibre degradation.

The daily DM intake differed significantly (p=0.01) in DGH and EGH diets (Table 3). The DM intake increased by 0.10 kg/d with the EGH (0.67 kg/d) diet recording the highest compared to DGH (0.57 kg/d). Rogosic *et al.* (2006) reported that DM intake is to a large extent influenced by dietary CP content and the current study supports this assertion because EGH recorded the highest CP content (Table 2).

However, the daily DM intake in EGH and DGH was lower than the 1,383g/d reported by Khan *et al.* (2013).

The highest ADG was recorded in Djallonké rams fed EGH (0.05kg) with the least for Djallonké rams fed DGH (0.03kg).The average daily live weight gain (ADG) recorded in the current study however, falls within the 10.7g – 52.7g range reported by Ansah *et al.* (2017) and lower than the 66.07g documented by Nyako (2015) in groundnut haulms as a single diet.

5.3 Implication of the Study for Small-holder Sheep Farmers

In rural Ghana, small ruminant production is seen as an important component of the farming system and contributes tremendously to the local economy through the sale of live animals. Aside this, farmers also get good supply of manure for fertilizing their lands to increase crop productivity. The crop residues from the crops including ground nut haulms are feed to the animals. Therefore, there is the cyclical use of resources in this mixed farming system. Occasional feed shortage in quantity and quality is one of the challenges posing a challenge to the industry in the rural setting. The natural growing grasses, left over crop residue and forages which the animals depend on usually rapidly decline both in availability and quantity during the dry season while some are completely lost through bushfires. This leads to a cyclic body weight gain during the wet season and weight loss during the dry season referred to as season weight loss. Preserving the accessible residues and agro-industrial by-products of crop will contribute to resolving the problem of feed shortage and reduction in nutritional quality and by extension seasonal feed loss. Groundnut vines produced from harvested groundnuts is approximated to be 60 to 65% of the groundnut production (Du and Fu, 2008). The haulms of groundnut are more appetizing and higher in proteins compared to the stovers of cereals which contain low nitrogen, high fibre content, and have poor digestibility and hence contain low nutritive value and are utilized as supplementary feed according to Singh *et al.* (2011). Lack of knowledge on how to preserve groundnut haulms makes farmers resort to only drying as a way of preserving them to use for feeding their livestock. This drying method even though popular and economical, it comes with some

shortcomings. This study therefore compared ensiling to drying methods to determine which of the two methods is more beneficial. We found that weight gain was better in the group fed the ensiled haulms compared to the dried haulms. Since weight gain is the priority of the rural farmer, because that translates to more money when the animal is sold, the small-holder farmers need to be educated on the benefits of ensiling groundnut haulms compared to drying.

CHAPTER SIX

6.0 CONCLUSION

Ensiling groundnut haulms increased the CP content (4.1 % against 6.6%) and decreased the NDF (37.9% against 35.0%) compared to drying. The nutrient composition of the ensiled diet was better than the dried groundnut haulm as ensiling increased ADG (0.03-0.05 kg/d) compared to drying.

6.1 RECOMMENDATION

It is recommended that another study should be carried out where the blood samples of the animals should be analyzed to see the effects of the combination of these diets on the health of the animals. It is also recommended that a different study be conducted where the animals should be allowed to graze with these diets used as supplementary feed to see its effects on growth. Also, another study should be conducted where the forage will be grown and harvested early to meet the recommended time for harvesting forage meant for silage.

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