NAPIER GRASS VARIETIES AS BASAL DIET: EFFECTS OF SUPPLEMENTATION WITH PAPER MULBERRY LEAVES (*BROUSSONETIA PAPYRIFERA*) ON GROWTH PERFORMANCE AND BLOOD PARAMETERS OF WEST AFRICAN DWARF SHEEP (Djallonké)

By

Afriyie Owusu Kyei Kwasi (BSc. Agriculture)

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DECLARATION

I hereby declare that this submission is my own work towards the award of the MSc and that, to the best of my knowledge it contains no material previously published by another person, or material which has been accepted for the award of any other degree in this University or elsewhere, except where acknowledge has been duly cited in the text and in the references.

Afriyie Owusu Kyei Kwasi ………………………….. …………………….
Student (PG 4237810) Signature Date

Certified by
Prof. E.L.K. Osafo …………………………….. ………………………
(Supervisor) Signature Date

Certified by
Mr Worlah Akwetey …………………………….. ……………………….
(Head of Department) Signature Date

DEDICATION

I dedicate this piece of work to my dear parents Mr. Samuel Owusu-Afriyie (late) and Mrs. Victoria Mayfred Owusu-Afriyie and senior brother Prof. Felix A. Asante for their prayers and support.

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ABSTRACT

An experiment was undertaken to assess the effect of dried Paper mulberry (*Broussonetia papyrifera*) leaves as a supplement to West African Dwarf sheep fed a basal diet of Napier grass (*Pennisetum purpureum*) varieties on the growth performance and blood indices. A total of twenty-four West African Dwarf sheep (rams) weighing averagely 17.5 kg were used in a completely randomized design in a 2×3 factorial arrangement of six treatments with four replicates. The main factors were the two varieties of Napier grass; the local variety and the improved variety, supplemented at three levels, thus 0 g/ day (control), 150 g/ day and 300 g/ day with Paper mulberry leaves. Parameters measured included nutrient compositions of the diets, average daily intake, live weight gain, haematological and biochemical indices. The chemical composition of the dry matter, organic matter, crude protein, neutral detergent fibre, acid detergent fibre and cellulose contents for the local variety was 69.05%, 52.97%, 13.21%, 83.00%, 39.00% and 10.41% respectively, and that of the improved variety were 70.02%, 60.53%, 13.87%, 83.50%, 40.00% and 11.79% respectively. The chemical composition of the supplement showed a DM of 89.00 %, CP of 24.06 %, ADF of 21.00 %, NDF of 44.00 %, CF of 12.50 %, EE of 6.50 % and ash content of 14.00 %. Supplementation with Paper mulberry leaves on Napier grass basal diet of sheep resulted in a significant increase (P< 0.05) in the average daily gain of sheep in all the treatments. Total intake improved as the level of supplement increased from 0 g/day to 300 g/day. The amount of feed consumed expressed in terms of kilogram body weight showed a significant increase (P< 0.05) in the basal intake per kilogram body weight as the level of supplement increased. Likewise, there was also a significant increase (P< 0.05) in the basal feed intake per kilogram metabolic size due to supplementation in all the treatments

Effects of the treatments on haematological parameters for Hb, and HCT were found to be within the normal physiological range reported for healthy sheep by other authors. Results for RBC, WBC, MCV, MCH and MCHC were, however, varied; some were above the normal range reported for health sheep while others were below the normal range. Biochemical indices observed were all found to be within the normal physiological range reported for healthy sheep. It was concluded that Paper mulberry can serve as a supplement to Napier grass when fed up to 300 g/day without any adverse effect on the growth performance and blood parameters of the West African Dwarf sheep

TABLE OF CONTENTS

LIST OF TABLES

ABBREVIATIONS

ADF	Acid Detergent Fibre
ADG	Average Daily Gain
ADL	Acid Detergent Lignin
ANF	Anti Nutritional Factors
AOAC	Association of Official Analytical Chemists
ASH	American Society of Haematology
CP	Crude Protein
CRD	Completely Randomised Design
DAGRIS	Domestic Animal Genetic Resources Information System
DM	Dry Matter
EDTA	Ethylene diamine-tetra-acetate
EE	Ether Extract
FAO	Food and Agricultural Organization
FORIG	Forestry Research Institute of Ghana
GHGs	Green House Gases
GLM	General Linear Model
GSS	Ghana Statistical Service

Hb	Haemoglobin
HCC	Hybu Cig Cymru
HCT	Haematocrit
ICSH	International Committee for Standardization in Haematology
ILRI	International Livestock Research Institute
KNUST	Kwame Nkrumah University of Science and Technology
MCH	Mean Cell Haemoglobin
MCHC	Mean Corpuscular Haemoglobin Concentration
MCV	Mean Cell Volume
NCCLS	National Committee for Clinical Laboratory Standards
NDF	Neutral Detergent Fibre
OIE	World Organization for Animal Health
OM	Organic Matter
PCV	Packed Cell Volume
RBC	Red Blood Cell
VFA	Volatile Fatty Acid
WADS	West African Dwarf Sheep
WBC	White Blood Cell

CHAPTER ONE

INTRODUCTION

The importance of sheep production cannot be underestimated since they play significant roles in the domestic and national socio-economic development of many countries, especially, Ghana. It is estimated that out of the 1.541 million livestock keeping households in Ghana, 32.6 % of them keep sheep (GSS, 2000). Sheep serve as a major protein source for many people aside the wool or hair, skins and manure they derive from them. They also serve as a form of investment (Gatenby, 1991).

Tweneboah (2000) noted that features of sheep which recommend them for production include their small sizes suitable for consumption by the farm family, thus obviating storage and refrigeration problems experienced in rural areas, their resistance to trypanosomes pathogenic to cattle, and their ability to get used to the environment where food supply is limited.

Inadequate nutrition has been identified as one of the critical challenges facing livestock development in sub-Saharan Africa. One of the main reasons is due to the fact that most animals depend highly on fibre-based feeds such as stovers and hay, which lack the essential nutrients needed to ensure microbial fermentation (Osuji *et al*., 1993).

The quality and quantity of feed which is a major input in livestock production (Gatenby, 1991) is a big challenge year round in Ghana. According to Baiden and Obese (2010) sheep production in Ghana is normally based on a low-input traditional extensive system where animals are allowed to scavenge for food with no proper feeding and management being in place. Sometimes animals graze on natural pasture and are supplemented with crop residues such as peels of cassava, plantain, yam and kitchen leftovers. Crop residues, according to Garg and Sherasia (2011) have low nitrogen and high fibre and lignin contents which affect feed intake as well as digestibility.

The problem of nutrition (Asante *et al*., 1999) worsens where the supply of feed to ruminants especially in the dry season is often woefully inadequate, forcing animals to walk long distances in search of feed. These feedstuffs are normally not adequate to meet their nutritional requirements and eventually results in reduce growth and productivity. FAO and OIE (2010) maintain that it is necessary to ensure that, the nutritional levels of animals are adequate in order to promote their health, growth and productivity.

Roughages constitute the major component of the diets of ruminants in Ghana. But its energy and protein value may prove inadequate for certain types of production, and the farmer may need to balance the ration with other types of feed (Charray *et al*., 1992). High levels of production as well as maintenance requirements are not achieved, since most tropical grasses usually lack adequate crude protein (Nurfeta, 2010). Part of the problem is that, natural pastures are usually affected by rainfall patterns. During the dry season, especially, in Ghana, most forages drop in crude protein content and digestibility (Ansah *et al*., 2010).

Nsahlai (1991) reported that, adequate amounts of supplements of high protein content such as forage legumes and oil seeds can be used to optimise the utilisation of roughages to increase the productivity of sheep. These supplements provide vital nutrients that are deficient in basal diets, and thereby enhance the rumen environment conducive to optimising the release and utilisation of other nutrients in the roughage.

But feeds high in protein are usually expensive (Pond *et al*., 1995). Oil seed meals such as soy bean meal, peanut meal and cottonseed meal which are mostly used to supplement sheep are expensive. It must be noted, however, that the production of sheep and goats in Ghana are mostly undertaken by small-scale poor rural farmers who cannot afford these expensive supplements. According to Osuji *et al*. (1993) due to the high cost of energy and protein supplements, these smallholder farmers rely solely on the fermentation of fibrous feeds in order to supply energy and protein to their animals. There is therefore the need to find an equally important alternative source of supplement that can easily be accessed and also achieve the desired performance of the animal.

One such source that can be harnessed is the use of leaves of shrubs and trees. Manaye *et al*. (2009) found that supplementation of tree leaves to low-quality Napier grass improved feed intake, feed digestibility and body weight gain of sheep. Among the benefits of supplementing the diets of ruminants with leaves of fodder trees according to Kurup (2011) include reduction on the dependency on expensive concentrate feeds and lowering production costs.

Leaves of trees are known to form an important component of livestock feeding, especially in the supply of protein (Paterson *et al*., 1998). According to Davendra (1990) and Rosales and Gill (1997), the inclusion of fodder tree leaves in the diet of ruminants have been shown to increase palatability hence, increase in feed intake. Tree fodders have high protein and mineral contents and have a high rate of digestibility. Due to the extensive nature of their roots, tree fodders remain productive even in the dry season and are relished by animals. However, some species contain anti-nutritive factors (ANFs) which may pose as nutritional challenge (Paterson *et al*., 1998).

One plant that has been identified but has received less attention is the paper mulberry (*Broussonetia papyrifera*) leaves. In Ghana, paper mulberry was introduced in 1969 by the Forestry Research Institute of Ghana (FORIG). According to Bosu and Apetorgbor (2006) its introduction into the country was to evaluate the tree"s potential for pulp and paper production. But now the tree has become invasive at an alarming rate. Despite various attempts to control its invasiveness, the tree still remains a challenge in farmlands and it is imperative that alternative use of the plant be found and its use harnessed. It is in this respect that leaves of *Broussonetia papyrifera* are being used to supplement Napier grass to feed sheep in an attempt to help in reducing the invasion of farmlands and other forest areas.

1.1 OBJECTIVES

The objectives of the study therefore are to assess:

1. The chemical composition of paper mulberry leaves (DM, Ash, CP, NDF and ADF).
2. The growth performance of sheep supplemented with paper mulberry leaves.
3. The effect of paper mulberry as supplement on blood biochemistry and profile of sheep.

CHAPTER TWO

LITERATURE REVIEW

2.1 Paper Mulberry (*Broussonetia papyrifera*)

Paper mulberry (*Broussonetia papyrifera* L. Vent) is a fast growing, non-leguminous tree belonging to the Moraceae family which is well-known in East and South-east Asia, but native to Japan and Taiwan (Fahrney *et al*., 1997, Whistler and Elevitch, 2006). Other common names of the paper mulberry tree as reported by Whistler and Elevitch (2006) include *Ai masi* (Fiji), *Aute* (Austral, New Zealand), *Hiapo* (Tonga), and *Wauke* (Hawaii). Due to its multipurpose nature, the inner bark of the tree is used in manufacturing paper, the stems used as firewood and the leaves for feeding animals (Hamman, 2001).

Paper mulberry tree can attain a height of about 12 m (40 ft) or higher if it is allowed to grow, and can survive in a wide range of ecological zones. It grows well in both humid tropical and sub-humid tropical as well as temperate climates. The tree is able to withstand several rainfall patterns that ensure that the soil is moist throughout the year and normally grows along river banks. It can also tolerate long dry period of about 3-4 months with less than 40 mm of rainfall (Whistler and Elevitch, 2006).

According to Whistler and Elevitch (2006), paper mulberry prefers light and medium texture soils (sands, sandy loams and sandy clay loams) with free drainage as well as seasonally and continually waterlogged soils. The tree can regenerate very quickly, as it readily forms new stems from the root-stocks after the stems have been harvested. It coppice well, as it is the main means of production of new stem stocks from the root system.

2.1.1 Characteristics of Paper mulberry

Paper mulberry is a deciduous tree with milky sap. The twigs of the tree are hairy reddish brown, with the bark being tan and smooth to moderately furrowed, while the wood is soft and brittle and has conical buds (Swearingen, 2009). The leaves are simple, alternate, blade ovate to three-to-five lobed, 8-20 cm long. The lower surface leaves are densely tomentosed, with the upper surface being scabrous. The margins are serrated and the petioles nearly as long as the blade. The leave margin is sharply toothed, and the leaf base is heart-shaped to round with pointed tips. The leaf surface of the tree has the characteristic feature of being rough and having a sand paper-like surface (Whistler and Elevitch, 2006; Swearingen, 2009).

According to Swearingen (2009), paper mulberry has a strong growth habit, and grows very quickly in places where the land has been disturbed, thus displacing other plants. On its potential for invasiveness, Whistler and Elevitch (2006) reported that as long as the male clone is used, there is no threat of invasiveness, as no seed is produced. But where fertile trees have been introduced, paper mulberry may become a pest since it fruits and produces seeds.

Whistler and Elevitch (2006) reported that, the tree can attain a height of twelve metres (12 m) or more if allowed to grow. The tree flourishes in wide-ranging environments in the humid tropics, sub-humid tropics and temperate regions (Bosu and Apetorgbor, 2006).

Paper mulberry is highly concentrated in the Pra-Anum and Afram Headwaters Forest Reserves. The two reserves are located within the Moist Semi-Deciduous and Dry Semi-Deciduous Forest zones respectively. The high concentration of paper mulberry in these two reserves and nearby reserves or forests was enhanced by extensive deforestation and bushfires. The plant is spreading from these two centres extensively to other areas up to about 100 km from these points of introduction. Dense stands of paper mulberry can be seen clearly in farms and along roads in and around Pra-Anum and Afram Headwaters Forest Reserves (Bosu and Apetorgbor, 2006).

Agyeman (2000) also reported that the invasive potential of paper mulberry in Ghana and other places has increased significantly due to the introduction of both male and female plants. The tree fruits twice a year and is dispersed over long distances by fruit eating birds.

2.1.2 Uses and Products

The strong and fibrous bark of paper mulberry is of great importance since it is used in the manufacture of the native bark cloth known as „tapa" cloth. The leaves of the plant serve as feed for pigs in Indochina and silkworms in China. According to Dweck (2004), both the flower and young leaves can serve as food for human and animal consumption. The leaves according to Matthews (1996) and Dweck (2004) have been exploited to have medicinal and ornamental properties.

Paper mulberry leaves also have medicinal effect as the infusion of the crushed leaves is used in treating stomach and abdominal pains. The leaf, bark and fruit are used medicinally in Indochina (Whistler and Elevitch, 2006). Inthapanya and Preston (2009) cited that, the leaves of paper mulberry could be a potential feed resource for rabbits, and the bark of the tree used in the handicraft industry to make paper and envelopes. According to traditional Chinese medicine, paper mulberry tonifies the liver and kidney, clears heat and cools the blood, and it is also used to treat diarrhoea (Dweck, 2004).

In places in Ghana where paper mulberry have overgrown and overtaken farmlands, the stems are used for kindling and charcoal making. The bark is used in strips as binding ropes for mud houses and sometimes weaved into mesh in erosion prevention.
The leaves are also fed to livestock (Owusu-Sekyere, 2006).

2.1.3 Chemical Composition

The leaves of paper mulberry on dry matter (DM) basis have been reported to contain 16 % crude protein (Inthapanya and Preston, 2009) and 17 % calcium carbonate (dried leaves). Napasirth *et al*., (2007) also reported a crude protein content of 22.6-28.5 % in the leaves.

Oduro (2009) in a research to assess the feed quality analysis of paper mulberry collected from three ecological zones in Ghana found the crude protein content to range from 16-22 % on dry matter basis for young leaves and 17.8-19.5 % on DM basis for mature leaves. The organic matter (OM) contents range from 87.05- 89.04 % for young leaves and 86.71- 88.03 % for mature leaves. The ash content also ranged from 10.96 % to 12.95% and from 11.97 % to 13.90 % of DM for the young and mature leaves respectively.

A study also conducted by Osman (2011) to determine the effects of supplementation with leaves of paper mulberry on growth performance and blood parameters of West African Dwarf Sheep fed Napier grass based diet found the crude protein content to be 205.0 g/ kgDM, dry matter as 905.0 g/ kgDM, ether extract as 100.0 g/ kgDM, ash as 132.0 g/ kgDM. The acid detergent fibre (ADF) was found to be 340.0 g/ kgDM, neutral detergent fibre (NDF) 430.0 g/ kgDM and hemicelluloses 90.0 g/ kgDM. The chemical composition of the leaves according to Oduro (2009) indicates it can be utilized to provide a nitrogen source in ruminant feeds.

2.2 Napier grass (Pennisetum purpureum)

Napier grass (*Pennisetum purpureum*), otherwise called elephant grass is a warmseason perennial grass, which is extensively grown in tropical and subtropical areas of the world (Wang *et al*., 2005). Its popularity throughout much of the wet tropics is attributed to its prolific growth and usage as forage for ruminants (Rusland *et al*., 1993). Boonman (1993) reported that a yield of 85.4 t/ha without fertilizer application and a record high yield of 130 tons/hectare with 1320 kg/ha of nitrogen fertilizer application have been recorded.

2.2.1 Characteristics of Napier grass

Due to the weak genetic nature of the seeds, Napier grass is propagated vegetatively (Humphreys, 1994). It is a strong perennial grass with an active root system, sometimes stoloniferous with creeping rhizome. It is well adapted to moist grassland, forest margins and along riverbeds. Napier grass can grow to a height of about 4 m and having about 20 nodes upon maturity (Henderson and Preston, 1977). A growth height of 10 m along riverbeds and a harvest yield of 29 t/ha DM have been reported (Boonman, 1997).

2.2.2 Climate and soil requirements

Napier grass requires an adequate and well- distributed rainfall pattern of 1000 mm per annum or more even though it can still do well as it can cope with a fairly dry season of about 3-4 months due to its root system which is deep. Growth is, however, affected by low temperatures at altitudes above 2100 m. Favourable temperature range for growth is 25-40°C with high rainfall. Growth ceases when temperatures fall below 10° C (Bogdan, 1977). Napier grass can be harvested every 6-8 weeks in a year when weather conditions are favourable, since it can withstand frequent defoliation.

According to Bogdan (1977) Napier grass can tolerate different soil types, performing best in fertile and well-drained soils; but cannot grow in flooded and waterlogged areas. Skerman and Riveros (1990) also noted that Napier grass forms well in clay and sandy-loam, but produces better yields in loamy soils.

2.2.3 Significance of Napier grass

The usefulness of Napier grass stems from its nutritional role in livestock production in most tropical and subtropical areas (Rusland *et al*., 1993). In central Kenya for instance, over 70 percent of smallholder farmers are engaged in the production of Napier grass, which provides over 40 percent feed needs of animals (Staal *et al*., 1998). Napier grass yields favourably (Anindo and Potter, 1994) providing yields that exceed that of various grasses found in the tropics (Humphreys, 1994).

Dry matter yields that have been recorded on-farm hovers around 16 t/ha/year (Wouters, 1987) with minimum or no fertilizer application, whereas Schreuder *et al*. (1993) reported on-station yields varying from 10-40 t/ha dry matter depending on soil fertility, climate and management factors. These yields according to Boonman (1993) exceed other grasses such as Rhode grass (*Chloris gayana*), Setaria (*Setaria sphacelata*) and Kikuyu grass (*Pennisetum clandestinum*) which are also well-known plants yielding between 5-15 tonnes of dry matter per year.

High dry matter yields have also been observed for Napier grass in other tropical areas (Ferraris and Sinclair, 1980; Woodard and Prine, 1991). Dry matter yields of up to 85 t/ha has been noted down when high rates of fertilizers were applied (Skerman and Riveros, 1990). Vicente-Chandler (1995) noted that a rainfall amount of about 2000 mm per year where 897 kg of nitrogen were applied per hectare per year and the grass harvested every 90 days, a yield of 84,800 kgDM/ year were obtained. Thus, it is significant to note that the dry matter yield of the grass compliments the dry matter intake of animals.

Even though Napier grass is established as a pure stand, it can be intercropped alongside legumes such as *Pueraria phaseoloides, Centrosema pubescens, Neonotonia wightii, Desmodium uncinatum*, *Desmodium intortum* and *Stylosanthes guianensis*. It can also grow well with fodder legumes such as leucaena (*Leucaena leucocephala*), calliandra (*Calliandra calothysus*), sesbania (*Sesbania sesban*) and gliricidia (*Gliricidia sepium*) as an alley crop. Legumes enhance the nutritive value of Napier grass-based diet as well as maximize the overall yield. Hay and silage can be produced for use during the dry season. It is best when cut young than when it is cut late since it becomes too coarse (Orodho, 2006).

2.2.4 Chemical Composition, Digestibility and Nutritive Value of Napier grass

The chemical composition of forage is of great importance in animal production (Skerman and Riveros, 1990; Minson, 1990). As Napier grass approaches maturity, the nutrient value of the leaf wanes compared to the stem (Kariuki, 1989; Karanja, 1984)**,** thus creating an imbalance in the chemical composition, and at the same time causing a reduction in the feed value of the grass (Minson, 1990). Voluntary intake of feed and animal performance may be affected may be affected by the quality of feed with respect to milk and body weight gain in the animal. The crude protein content in the leaves decreases as the grass nears maturity (Norton, 1981). This is confirmed by Williams and Hanna (1995) in a study to evaluate the performance and nutritive quality of dwarf and semi-dwarf grass genotypes in which they noted that, the level of reduction of crude protein in the stem was faster in the stem than in the leaves.

The cell wall, which is basically made up of structural carbohydrates, cellulose and hemicelluloses is the most critical factor the affects the utilization of forage (Van Soest, 1994). This according to Paterson et al. (1994) makes up the main constituent of forage dry matter and its degree of breakdown by microbes have a marked effect on forage digestibility and intake. The cell wall content of Napier grass according to Minson and Mcleod (1970) slowly increases as the plant ages compared to other grasses such as Kikuyu and Pangola grass which are also found in the tropics. Van Soest (1994) found that the proportion of forage digested by the animal in the rumen is closely linked to the fraction and the degree of lignification.

Minson and Milford (1976) reported that 60-80 g/kg DM of forage is deem as the minimum requirement for ideal rumen microbial activity in the rumen. Results from other works examined by Schreuder *et al*. (1993) showed that the crude protein values normally documented for Napier grass range between 50 and 90 g/kg DM.

Nutritive value, according to Norton and Poppi (1995) is quantity of feed consumed by the animal and the effectiveness with which nutrients are absorbed from the feed. This, according to Minson (1990) is essentially influenced by voluntary feed intake, crude protein and structural carbohydrates, while forage intake is affected by digestible dry matter, crude protein content and the degree of degradation. Cellulose and hemicellulose which basically make up structural polysaccharides are the main limiting determining factors of nutrient intake. Chemical composition and digestible dry matter may not be considered as appropriate indicators of the nutritive value of Napier grass. For that reason, to be able to assess the nutritive value in terms of its practicality, the decisive measure rests on the performance of the animal.

2.2.5 Research work on Napier grass at K.N.U.S.T

Several studies have been carried out at the Department of Animal Science of the Kwame Nkrumah University of Science and Technology to assess the usefulness of Napier grass (*Pennisetum purpureum*) in ruminant production.

One of such works was carried out by Dzimale (2000) to investigate the herbage yield and nutritive value of ten varieties of Napier grass in the Ashanti Region of Ghana. The work involved an assessment of a Local variety and nine other hybrid varieties of Napier grass which were 15743, 16786, 16791, 16798, 16834, 16835, 16837, 16838 and 16840 acquired from the International Livestock Research Institute (ILRI), Ethiopia.

From the results of the experiment, the Local variety was ranked best in persistence and tiller numbers. The leafiness and tiller number was highest in varieties 15743, 16837 and 16838. Crude protein concentration in the leaf, stem and whole plant fractions were consistently higher in variety 15743 while other varieties were similar to the local variety. The neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) concentrations were lower in varieties 15743 and 16838, while the rest were also similar to the local (Dzimale, 2000).

Ansah *et al*. (2010) also conducted and experiment to evaluate the herbage yield and chemical composition of four varieties of Napier (*Pennisetum purpureum*) harvested at three different days after planting. The varieties (Local, 16798, 16786 and 16840) were obtained from International Livestock Research Institute (ILRI), Ethiopia. The herbage yield of the varieties was measured at 60, 90 and 120 days after planting. It came out that the Local and variety 16798 produced a significantly higher yield among the four varieties and the 120 day harvest also recorded the highest yield among the 3 harvest

days. However, the 60 day harvest had the highest cellulose and lowest lignin content. The balance of quantity versus quality was observed between the Local and variety 16798 with more cellulose but less dry matter yield and varieties
16786 and 16840 with a greater herbage yield as well as greater lignin content. Variety 16798 produced the lowest lignin content among the four varieties. The leaf fraction recorded the highest crude protein compared to the stem fraction; however, the stem fraction produced the highest cellulose content. All the varieties tested recorded a crude protein content above the critical 7 % (70 g/kg) required for voluntary intake in ruminants and therefore recommended their suitability for small ruminant feeding in Ghana.

2.3 The West African Dwarf Sheep

The West African Dwarf Sheep (WADS) is extensively spread out in the humid and sub humid areas, from Senegal to Central Africa (Charray *et al*., 1992). This breed of sheep according to Mason (1951) inhabits the area south of latitude 14°N including the coastal areas of west and central Africa. These areas include Nigeria, Benin, Ghana, Ivory Coast, Guinea, Senegal, Cameroon, Gabon, Congo and Southern Mali.

Several names have been attributed to the West African Dwarf Sheep. In Nigeria it is referred to as the Nigerian dwarf; in Chad, it is known as Kirdi or Lakka, and in Cameroon, known as Fouta Djallon the Djallonké (Mason, 1951). Other names also include Guinea sheep, Koumassi sheep and Mossi sheep. However, two names that have gained more acceptances are the Djallonké among French writers and West African Dwarf Sheep among English writers (Charray *et al*., 1992).

The West African Dwarf sheep, which originated in the forest zone of West Africa, is an indigenous sheep in Ghana. In Ghana, this type of breed is found around human settlements in the forest and derived savannah zones, as well as the savannah zones of the north and south-eastern coastal plains. However, in the Guinea and Sudan savannah zones, a high proportion of sheep are crosses between the West African Dwarf Sheep and West African Long-legged Sheep (Tweneboah, 2000).

2.3.1 Characteristics of the West African Dwarf Sheep (Djallonké)

This breed of sheep is small but genetically not dwarf. True dwarfs, according to Charray *et al*. (1992) are physically weak and poor reproducers, whereas the West African Dwarf sheep have pronounced physical and sexual vigour and strength that makes them able to withstand the harsh conditions such as climatic stress, disease and irregular feeding.

They possess a white body coat with black patches but may be black or brown. The hair is fine and short. The West African Dwarf sheep is characterized by their relatively small size, varying in height from 30-60 cm. The weight of mature animals varies from 15-30 kg, although considerable individual variations occur, depending on the level of husbandry and individual characteristics (Tweneboah, 2000).

They have a rectilinear profile with the forehead being flat and the nose slightly bulging in the rams. Rams are considerably heavier and heavily maned at the neck and chest. The horns of rams are crescent shaped with angular cross sections, while the ewes are hornless or have tiny scars (Tweneboah, 2000; DAGRIS, 2005). According to Charray *et al*. (1992), this breed possesses a slender and short tail, with no fat deposits. They have short ears usually in a horizontal position, only being erected when the animal‟s attention is aroused. The West African Dwarf sheep are well acclimatized to the climatic conditions of West Africa and are regarded as tolerant to trypanosomiasis (Osaer, 1998).

The Djallonké is the main breed of sheep produced in Ghana and they are used for meat. It has an average weight of about 1.89 kg (DAGRIS, 2005). Weaning weights that have been reported at 90 days vary between 7.4 and 11.0 kg (Ambruster *et al*., 1991, Yapi-Gnaore *et al*., 1997, DAGRIS, 2005,), while an estimated average at preweaning daily weight gain is 64.89 g/ day (Senou *et al*., 2009).

The growth rate of the West African Dwarf sheep is fairly slow but ewes tend to mature early, and first lambing may be at 12-14 months (Carles, 1983).

2.4 Fodder Trees

Fodder trees and shrubs, also known as „browse" are utilized as supplements to feed ruminants particularly during the dry season (Lefroy *et al*., 1992, Atta-Krah, 1993). They are known to form an important component feeding, especially in the supply of protein (Paterson *et al*., 1998). Apart from their usage as supplement in ruminant nutrition, they are also utilized to serve as food, drugs, firewood and building poles and nutrient recycling. Over the years, a lot of research studies have been undertaken to seek much information on the potential use of fodder trees and shrubs as a feed source for animals.

In tropical humid areas, fodder legumes such as leucaena, glyricidia and erthyrina have shown to be of very good use (Shelton and Brewbaker, 1994). During the dry season due to the low pasture availability to cater for the maintenance needs of animals, the contribution of leaves from trees and shrubs is very important. Tree leaves are known to contain considerable amounts of crude protein and minerals, and have high rate of digestibility. They are fed easily to livestock and due to their deeproot systems, fodder trees and shrubs still continue to flourish during the dry season.

The presence of anti-nutritional factors (ANFs) in some species poses a problem when fed as a feed supplement (Paterson *et al*., 1998).

2.5 Constraints in Feeding Ruminants in the Tropics

Poor nutrition according to Osuji *et al*. (1995) remains one of the main challenges limiting the enhancement of livestock production in sub-Saharan Africa. High fibrebased diets such as straws and stovers are lacking in essential nutrients such as crude protein, vitamins and minerals, which are needed to ensure efficient microbial fermentation. As a result, there is inadequate nutrient intake and low digestibility when such feeds are fed.

Small ruminants, especially sheep, suffer scarcity of feed supply and pasture quality in humid West Africa, particularly during the dry season when the natural vegetation is of poor quality (Aye, 2007). During the dry season, the native rangelands and crop residues that ruminants depend on after harvesting are normally fibrous and lack the important nutrients needed for maximum rumen fermentation (Osuji *et al*., 1995) thus leading to weight loss, reduced resistance to diseases and poor animal performance (Onwuka *et al*., 1989).

For young animals to grow fast and mature cows to produce high milk yields, extra energy and protein are needed above the daily maintenance requirement. Feed shortage is normally experienced due to dry periods and liquidity problems and as a result low quality feed is used. Due to this phenomenon, animals are not able to obtain enough energy and protein to grow fast or produce milk. Sometimes animals are even fed less than the daily „maintenance requirements‟ and ultimately results in poor body condition (van Tol, 2004).

In Ghana, most livestock producers depend largely on natural pastures and crop residues as a main source of feed. These natural pastures are usually affected by changes in rainfall pattern (Ansah *et al*., 2010), especially during the dry season where most forages drop in quality. The crude protein content of most forages at the beginning of the rainy season as reported by Amaning-Kwarteng (1991) is between 812 % of dry matter (DM), but drops to 2-4 % during the dry season; a situation leading to prolonged periods of animal malnutrition.

Leng (1997) reported that, the growth rate of livestock feeding on tropical grasses or crop residues alone are usually low and their performance is about 10 % of the animal‟s genetic potential. One major cause that accounts for this challenge is the low nutrient composition derived from digestion in such feed material which is normally not supplemented (Baiden and Duncan, 2009). Improving their nutrition therefore could enhance growth and productivity.

2.5.1 Supplementation in Ruminants

Changes in climatic conditions all over the world have lead to increases in feed shortages in most tropical areas for most parts of the year. During these periods, feed quality is low leading to low feed intake and reduced animal performance. Most animals, especially ruminants, perform poorly since they depend on natural pastures (Ondiek *et al*., 2013). These natural pastures are characterised by low digestibility, low protein content and mineral composition (Seyoum and Zinash, 1998), slow rate of breakdown of feed particles that can leave the rumen (Raghuvansi *et al*., 2007). Bondi (1987) reported that forages containing less than 6 % crude protein affect the activities of the rumen microbes in providing microbial Nitrogen and its retention, thereby leading to a negative nitrogen balance. To mitigate the effects of low quality feeds, it is therefore necessary to supplement natural pastures and forages with adequate protein to enhance the activities of rumen microbes. Studies have shown the need for concentrate supplementation to enhance the growth and productivity of ruminants (Kochapakdee *et al*., 1994). These authors found that without supplementation, weight gain and wool production cannot be optimized. Shahjalal (1997) also reported that growth rate of small ruminants is improved when they are supplemented with increased protein supplementation.

The diets of ruminants are mostly fibrous in nature that have low digestibility and are deficit in protein, minerals and vitamins. Such features do not ensure adequate feed intake and productivity. In view of this, the supply of a suitable supplement to ruminants is very crucial in accelerating productivity (Yami, 2008).

Supplements are known to be concentrated feeds made up of one or more nutrients, usually offered in small quantities to animals to improve the nutritional quality of the basal diet. They may include protein supplement, mineral supplement and energy supplement. Supplementing basal diets may be undertaken at different levels and for several reasons such as to ensure survival, to ensure maintenance or to ensure production and reproduction. It can be carried out by supplying a complete feed or by giving specific nutrient. Supplementation enhances adequate feed intake, improve digestibility and overcome nutrient deficiency (Yami, 2008). The most common types of supplements according to Gatenby (2002) are energy concentrates, protein concentrates, molasses, non-protein nitrogen (urea) and minerals. The main purpose of supplementation is to enhance the utilization of the poor quality roughages, and as such, the supplement fails to function as it goes beyond a dry matter level of 30 % of the diet**,** at which it assumes a major role and substitute the basal roughage source
(Yami, 2008).

2.6 Economic Importance of Sheep

The economic value of sheep production in developing nations cannot be over emphasized. Sheep with their small size, high reproductive capacity and rapid growth rate make them suitable for production resource-poor farmers. Ozung *et al*. (2011) reported that sheep can be reared for various reasons such as income generation, religious purpose, household consumption and hobby and security against crop failure. Sheep production provides employment and income to the unemployed and low income rural and urban families. It also serves as supplementary income to the employed as well as the poorly paid. Sheep production contributes to food security for the rural and urban households, especially in the supply of animal protein (AttohKotoku, 2011).

It has been documented that sheep, as well as goats are the principal domesticated ruminants in terms of total numbers and production of food and fibre products (Winrock International, 1983). According to Hirpa and Abebe (2008) the lower feed requirements and smaller body size allows for easy integration of sheep into different farming systems compared to cattle.

Sheep do not compete with man, pigs or poultry for food (Gatenby, 1991) because they can survive on forage and require little grain or concentrates for good production (Terrill, 1983). Winrock International (1992) also reported that sheep are able to use marginal land and crop residues to produce milk and meat in readily usable quantities and can be easily cared for by most members of the family. Sheep meat (mutton) is relished by people all over the world and they compete well with other livestock in quality of meat produced. Meat from sheep is generally tender than even beef from grass-fed cattle, and is more established in marketing systems than goat meat, but both are quite delicious especially under one year of age (Terrill, 1983).

Sheep have a high reproductive rate. In favourable conditions, a ewe can lamb every eight months, and the generational interval is less than two years. A high reproductive rate is also important in unfavourable environment where occasionally the numbers of animals are reduced by natural events, such as drought. After the drought when the environmental conditions are good, the numbers of sheep build up quickly, but the number of large ruminants stays low for several years (Gatenby, 1991). Gatenby (1991) reported that sheep generally need low cost production start-up and can be kept on a limited area of land, and each animal needs only a small amount of feed.

In Ghana, sheep are known to play significant function in the cultural and socioeconomic life of most communities. According to Attoh-Kotoku (2003), keeping sheep and eating mutton are activities which are virtually free from cultural and religious barriers. During religious festivals such as Eid-ul-Adha, the importance of sheep is greatly realized. Sheep also serve as bride price in most communities in the Northern region of Ghana during marriage ceremonies.

2.7 Nutrient Requirements of Sheep

Proper nutrition plays a key role in animal production, in terms of welfare and health of animals. Making feed available to the animal goes beyond its immediate needs, as it influences the animal‟s future productiveness, since insufficient nutrition during critical phases such as embryonic, foetal and postnatal growth affect ensuing performance (HCC, 2006).

Animals for that matter, sheep need in their feed certain nutrients with which to meet the needs of their physiological functions. These nutrients, according to Tweneboah (2000) are used for energy required to keep all the functions of the animal‟s body, for growth and replacement of bodily structures which have worn out, and for other productive activities such as gestation and lactation. Gatenby (1991) reported that in order to develop new feeding systems for ruminant livestock, it is necessary to understand the nutrient requirements of the animal as well as the ways in which these can be satisfied. These involve combining the available feed ingredients in their right proportions to produce a balanced diet for the animal, as no single feed component contains all the required nutrients in adequate proportions to meet the dietary needs of all animals (Tweneboah, 2000). The major nutrients needed by sheep, according to Gatenby (1991) are energy, protein, minerals, vitamins and water.

2.7.1 Energy

The energy from the feed, according to Gatenby (1991) is used for maintenance; the essential processes which keep the body functioning and for production, which involves growth, lactation and pregnancy. A feed deficient in energy is seen in a decreased rate of production, reproductive failure, increased mortality and susceptibility to diseases and parasites. The major sources of energy for small ruminants are usually pastures and browsers, hay, straw and grains (Gimenez, 1994).

Feeds such as fibre, starch and sugars (HCC, 2006), are mainly broken down into volatile fatty acids (VFAs); mainly acetate, propionate and butyrate. These are absorbed across the walls of the rumen to provide energy for the animal. Gatenby (1991) emphasized the need to supply the sheep with good quality feed with a high energy density as it is not the total energy in a feed that is important, but the amount of energy that can be utilized by the sheep (metabolisable energy).

If the energy intake is below that required for maintenance, the sheep loses weight because it uses its body tissues to keep alive. On the other hand, if the energy density of the diet is above the minimum level for maintenance, the sheep has surplus energy which it uses for reproduction. Thus the growth rate of sheep depends on the energy density of the diet (Gatenby, 1991).

Gatenby (1991) cited the lowest energy density at which the sheep does not lose weight to be between 8 and 10 MJ/ kg DM. This amount of energy is found in reasonable quality grass, or in straw with a small quantity of energy supplement.

2.7.2 Protein

Protein forms the essential structural elements on which all body tissues on which all body tissues such as muscles, nerves are formed. Hence, it is crucial for the development and productivity of animals. The needs of the animal are for the essential amino acids which are the building units of protein. The animal‟s protein requirements are expressed as requirements for crude protein, where Crude protein = % nitrogen × 6.25 (Ibrahim, 1998). Gatenby (1991) observed that much of the crude protein requirement of sheep can be supplied as non-protein nitrogen such as urea, but some must be true protein.

As a guide, Gatenby (1991) reported that the minimum protein level for sheep on maintenance is about 8 % in the dry matter, while the most productive animals such as rapidly growing lambs and lactating ewes require about 11 %. Milton *et al*. (2001) also similarly reported that sheep required about 8 % of crude protein in their feed as a maintenance requirement, while growing sheep on the other hand need between 12 and 15 % crude protein in their feed. The protein levels according to Gatenby (1991) are considerably higher than the average values found in natural pastures; sheep manage to survive and reproduce because they are able to select vegetation with a better than average feeding value.

Low amount of protein in the feed is linked to the low nitrogen that is excreted in the urine. On the other hand, high amounts of protein cause a high concentration of ammonia in the rumen, and as a result, any additional amount goes waste through the urine of the sheep (Milton *et al*., 2001).

It does not harm the sheep to eat more than enough protein, but as high protein feed are expensive, it is unlikely that they will be fed to the sheep in large quantities. Often a deficit of crude protein can be corrected by feeding a small quantity of urea of about 20 g/ day, but this should be done with extreme caution as even moderate amounts can be poisonous (Gatenby, 1991).

Protein rich-feeds include oilseed cakes, certain feedstuffs of animal origin, young forages and leaves of trees. Protein is used to repair body tissues and also to build new ones. Any deficiency of protein will reveal itself by a drop in production followed by severed emaciation which may lead to death if it continues (Charray *et al*., 1992; Gimenez, 1994).

2.7.3 Minerals

Ruminants need in their feed essential minerals to promote tissue growth and the control of several body functions. Macro-minerals are required in comparatively greater quantities. These are calcium, chlorine, magnesium, phosphorous, sulphur and sodium (grams per kilogram). Micro or trace minerals which also include iodine, iron, copper, cobalt, manganese, selenium, molybdenum and zinc are required in lesser quantities (milligrams per kilograms) (Milton *et al*., 2001).

According to Ibrahim (1998), a deficiency in any of these minerals in the feed shows symptomatic signs, while excess of the minerals result in toxicity in the animal.

Gatenby (1991) noted that deficiencies in grass and other vegetation are caused by mineral deficiencies in the soil. Under the extensive livestock system in the tropics, mineral deficiencies are hardly observed (Ibrahim, 1998), but it is only when intensive system of husbandry are developed that mineral deficiencies become a noticeable problem (Gatenby, 1991).

In practice, only chronic symptoms of mineral deficiency are seen rather than acute symptoms as described in many literatures. These chronic symptoms, as reported by Gatenby (1991) include low growth rate, poor fertility, low appetite, loss of hair and diarrhea. They can also be caused by many other problems such as low energy intake, low protein intake and internal parasites, so that it is almost impossible to say that a flock is suffering from mineral deficiency just by looking at the sheep.

2.7.4 Vitamins

Vitamins, according to Charray *et al*., (1992) are substances of widely varying chemical composition that are essential for a wide range of vital functions in animals and are only active in very small quantities. They are divided into two groups depending on the liquid in which they can be dissolved; some of which are soluble in water and others in fat. Vitamins A, D, E and K are classified as the fat-soluble vitamins and the B-group of vitamins, as well as vitamin C are also called the watersoluble vitamins. Most of these vitamins are synthesized in the rumen, notably those of the vitamin B-complex group and vitamin C (Gimenez, 1994; Ibrahim, 1998; Milton *et al*., 2001).

Even though livestock animals do experience vitamin deficiencies in tropical areas, these are not considered as major problems. However, providing vitamin supplements under intensive system is advised (Ibrahim, 1998). Deficiency of vitamin B_1

(Thiamine) is normally brought about by the occurrence of the enzyme, “thiaminase”, which is synthesised by microbes in the rumen. The enzyme destroys the vitamin that is coming into and synthesised in the rumen. Deficiency of vitamin B_1 results in the development of a neurological disease. Switching to a high-grain diet can also trigger vitamin B_1 deficiency, as well as feeding sheep with diets very low in fibre which can promote rumen motility (Milton *et al*., 2001).

Green pastures, according to Milton *et al*., (2001) mostly have considerable amounts of vitamins A, E and K for sheep, with vitamin D being synthesised in the skin when they are exposed to sufficient amounts of sunlight. Vitamin A is found in products of animal origin such as milk, but plants, especially green forage contain provitamin A, which ruminants can convert to vitamin A and store in their liver for periods which in the case of sheep extend to 2-3 months (Charray *et al*., 1992). Vitamin A is a growth vitamin and has a preventive action against infection. This is very crucial for young animals, which obtain the vitamin via colostrums and milk. However, during severe dry season periods, deficiency of vitamin A can happen (Milton *et al*., 2001).

Vitamin E, like selenium, according to Milton *et al*. (2001) plays an important function as an anti-oxidant. Selenium and vitamin E complement each other in their metabolic function in the animal‟s body system.

2.7.5 Water

Water is essential for all livestock in terms of its quality and quantity. According to Herren (1994) water provides the basis for all the fluids of the animal‟s body. In addition, it helps in the utilization of food in the digestive system, the regulation of body temperature, lubricating body joints, transport of waste from the body and in the functioning of vital organs (Gimenez, 1994; Tweneboah, 2000), as well as maintaining the water content of the animal‟s body (Ibrahim, 1998). According to Ibrahim (1998), sheep need water since it influences voluntary feed intake; inadequate supply of water results in reduced amount of dry matter intake.

Water is present in feeds in many varying proportions, depending on the nature of the feed. Green herbage has very high water content (88-90 %), especially when it is young, whereas dry forage and grains contain only small amounts of water (5-55 %) (Charray *et al*., 1992). In a cool environment, a non-lactating sheep needs between 1 and 2 litres of water for each kilogram of dry matter eaten (Gatenby, 1991).

Tweneboah (2000) reported that water in the animal‟s body comes from water drunk as such by the animal, or ingested as a constituent part of its feed, although some water is produced in the cell as a result of the oxidative breakdown of fats, carbohydrates and proteins.

In the extensive system of livestock production, the rate at which water is offered is essential than the quantity of water that is accessible as this has a telling effect on feed intake (Gatenby, 1991). Water may be obtained from sources such as wells and streams during the dry season. This creates a situation whereby animals tend to overgraze around water sources. Livestock farmers are then forced to take their herds on long distances in search of pasture. This poses a big challenge to farmers since the intake of water goes up as the rate at which water is offered also goes down. As a result, feed conversion efficiency is reduced as watering interval goes up (Ibrahim, 1998). Since heat stress is positively related to the water requirement of sheep, Ibrahim (1998) suggested that ruminants be offered drinking water *ad libitum*.

2.8 Blood

Laboratory analysis of blood profile of sheep may be a useful tool in evaluating their nutrition, health and management (Anosa and Isoun, 1978, Oduye, 1976, Olayemi *et al*., 2000). Banerjee (2009) termed blood as a specialized and circulating tissue composed of cells suspended in a fluid intercellular substance which circulates through a closed system of blood vessels (arteries and veins) due to pumping action of the heart. The blood according Eurell and Frappier (2006) is derived from the bone marrow that is suspended in liquid called plasma.

Blood acts as a specialized and circulating tissue (Banerjee, 2009) that helps to regulate the body‟s temperature to maintain a constant concentration of water and electrolyte in the cells to regulate the body hydrogen ion concentration, and to defend against microorganism (Addass *et al*., 2010). The functions of the blood also involve:

- The supply of nutrients such as glucose, amino acids and fatty acids
- Removal of waste substances (CO_2, urea and lactic acid).
- Messenger functions including the transport of hormones and the signaling of tissue damage.
- Immunological functions, including the circulation of white blood cells (WBC).

It has been noted that irrespective of the age, sex and climate, ruminants raised under traditional system have low haematological values compared to those kept under modern husbandry (Coles, 1980; Schalm *et al*., 1975). Low nutrition, stress, parturition and climatic factors also greatly alter the blood values of sheep and goats (Anosa and Isoun, 1979). In an experiment to determine the effect of management systems on the haematology of West African Dwarf (WAD) adult sheep, Olayemi *et al*. (2000) concluded that sheep raised under the intensive system had higher haematological values compared to those managed under the extensive system. This, they attributed to the higher plane of diet given to the former group of animals. The improved grass which was supplemented with maize and salt lick that was given to the sheep under the intensive system was definitely of higher quality than the free range pasture given to the extensively managed sheep which was not supplemented.

2.9 Haematological Parameters

Haemoglobin (Hb) is an iron-containing protein and a respiratory pigment which imparts the characteristic red colour to the red blood cells. Haemoglobin readily associates and dissociates with oxygen and carbon dioxide and is responsible for the red blood cell"s ability to transport these gases. Olayemi *et al*. (2000) reported that animals on high plane of feed have high haemoglobin and packed cell volume (PCV) count than animals on poor diet. The normal physiological range of haemoglobin for healthy sheep is 9.0-15.0 g/ dL (Radostits *et al*., 2000).

Red blood cells (RBC) also known as erythrocytes are known for their bright red colour. They are the most abundant cell in the blood, accounting for about 40-45 % of its volume (ASH, 2011). Red blood cells, according to ASH (2011) contain a special protein called haemoglobin, which helps carry oxygen from the lungs to the rest of the body and then returns carbon dioxide from the body to the lungs so it can be exhaled. Radostits *et al*., (2000) reported that the normal physiological range of RBC for healthy sheep is 8.0 - 18.0 $\times 10^{12}$/ L.

White blood cells (WBC) or leucocytes protect the body from infection. They are much fewer in number than red blood cell, accounting for about 1 percent of the blood. The most common type of WBC is the neutrophil, which is the immediate response cell and account for about 55-70 % of the total WBC count. The other type of the WBC is the lymphocyte; the T lymphocyte and B lymphocyte. T lymphocytes help regulate the function of other immune cells and directly attack various infected cells and tumors. B lymphocytes make antibodies, which are proteins that specifically target bacteria, viruses, and other foreign materials (ASH, 2011). Okah and Ibeawuchi (2011) observed that increase in WBC is normally due to immune response by the animal as a result of the presence of foreign bodies. An increase in WBC count may also be attributed to physiological phenomenon, such as, excitement or strenuous exercise during handling as suggested by Coles (1980). The normal physiological

WBC range for healthy sheep according to Radostits *et al*., (2000) is 4.0-12.0 × 10^9/ L

Haematocrit (HCT) or packed cell volume (PCV) is the measure of the ratio occupied by the red cells to the volume of whole blood in a sample capillary, venous or arterial blood (ICSH, 1982). It is an easily obtained measure for detecting anaemia or polycythemia and can be useful in estimating changes in haemodilution or haemoconcentration. According to NCCLS (2000), HCT or PCV is used, together with the red cell count, in calculating the mean cell volume (MCV) and, together with the haemoglobin content, in calculating the mean corpuscular haemoglobin concentration (MCHC). In a study to determine the effect of management systems on the haematology of the adult WAD sheep, Olayemi *et al*., (2000) reported an HCT value of 24.9 % and 20.1 % for sheep reared under intensive and extensive systems respectively. Addass *et al*. (2010) in an experiment to come up with discrete and direct haematological base line information for the most indigenous sheep breed in

Mubi also reported an HCT value of 25.59 % for the WAD sheep. According to Schalm *et al*. (1975), the normal physiological range of HCT for healthy sheep is 27.0 - 45.0 %.

Mean cell volume (MCV) is the average volume of the red blood cells in a given blood sample (Koepke, 1989). It allows the classification of anaemia as either below normal range (microcytic) or within normal range (normocytic) or above normal range (macrocytic). Radostits *et al*., (2000) reported that the normal range of MCV for healthy sheep is 28.0-40.0 fL.

Mean cell haemoglobin (MCH) is the average mass of haemoglobin per red blood cell in a sample of blood. The normal physiological range of MCH for healthy sheep, according to Greenwood (1977) is 8.0-12.0 pg. Mean corpuscular haemoglobin concentration (MCHC) is the average haemoglobin concentration within the red blood cells. It is expressed as the amount of haemoglobin (in grams) per deciliter of red cells (or per liter of red cells) (Lewis *et al*., 1991). Normal physiological range of values of MCHC for healthy sheep is 31.0 - 34.0 g/ dL (Radostits *et al*., 2000).

2.10 Blood Biochemical Parameters

2.10.1 Total Cholesterol

Cholesterol content in blood plasma has been used to assess the changes in lipid metabolism (Wang *et al*., 2006). Cholesterol is synthesised by the liver and also made available to the body through human and animal feed sources. It forms the structural elements for cell membranes, and forms an important component in the creation of bile (which helps in the breakdown of fats), vitamin D, other steroids and hormones such as progesterone, testosterone, and oestrogen. Cholesterol functions in safeguarding proteins that have to do with signalling, giving access for instance, to neurons to locate each other when establishing synapse, the development of which is an essential aspect of learning as well as the establishment of memories (Adamu *et al*., 2008).

Two types of cholesterol exist; high density lipoprotein cholesterol (HDL-c) and low density lipoprotein cholesterol (HDL-c). HDL-cholesterol, according to Adamu *et al*. (2008), is the major cholesterol carrier in the blood and is responsible for transporting cholesterol from the liver to organs and tissues of the body. LDL-cholesterol, on the other hand is responsible for carrying cholesterol from various organs and tissues to the liver for recycling or degradation Adamu *et al*., (2008). According to Radostits *et al*., (2000), the normal cholesterol range for healthy sheep is 1.05-1.50 mmol/ L.

2.10.2 Total Protein

Total protein, also called plasma total protein, is a biochemical test for measuring the total amount of protein in blood plasma or serum (WebMed, 2010). According to Hagawane *et al*. (2009) total protein in the blood is usually used as an appraisal of nutritive status of an animal reflecting feed intake and metabolism. Plasma proteins normally participate in the maintenance of body immune status and haemodynamic balance directing fluid movement across vascular and interstitial compartments (Nicholas and Oluwole, 2013). According to them, derangement in fluid movement could result in oedema fluid accumulating in interstitial spaces or body cavities.
Normal physiological range of total protein values for sheep according to Kaneko (1980) is 60-79 g/ l.

Albumin is synthesised exclusively in the liver, which functions importantly in controlling the movement of water between the plasma and tissue fluid by its influence on colloid osmotic pressure (Orhue *et al*., 2005). Robert *et al*. (2000) reported that a low albumin level suggests poor clotting ability of blood, hence poor prevention of haemorrhage. A drop in serum albumin level according to Cheesbrough (1998) is normally attributed to the drop in the production of protein by the liver or a rise in protein loss through the kidneys. The normal half-life of albumin is an average of 21 days, and therefore a decrease in serum albumin is usually not apparent early in the course of liver diseases. Kaneo (1980) recorded a normal physiological range of 24-30 g/l for albumin content of sheep blood.

Globulin is made up of different proteins such as alpha, beta and gamma. Some globulins are made in the liver while others are made by the immune system (WebMD, 2009). Rastogi (2008) found that globulins in the blood carry the lipid fraction of proteins and contain antibodies for generating immune response. Certain types of globulins bind with haemoglobin and transport metals such as iron in the blood and help fight infection (WebMD, 2009). Milne and Scott (2006) reported a normal physiological of 30-48 g/l for healthy sheep.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Location and Duration of Experiment

The study was conducted at the Livestock Section of the Department of Animal Science of the Kwame Nkrumah University of Science and Technology (KNUST), Kumasi. The site is located within the Moist Semi-deciduous Forest belt of Ghana with a bimodal rainfall pattern (Osafo, 1976) and lies within latitude 06° 43‟N and longitude 01° 36‟W (Jollans, 1960). The study covered a period of 12 weeks from 19th May, 2012 to 11th August, 2012.

3.2 Experimental Animals and Management

The sheep pen unit at the Department of Animal Science was used to house the animals. A total of twenty-four pens were cleaned and disinfected with Izal disinfectant. Feeding and watering troughs were washed clean prior to the arrival of the animals.

A total of twenty-four ear-tagged Djallonké male sheep less than a year old with an average weight of 17.5 kg were acquired from the Ejura Sheep Breeding Station at Ejura in the Ejura-Sekyedumasi District in the Ashanti Region. Prior to the start of the experiment, animals were quarantined for 2 weeks in order to monitor their health and also to get them acclimatised to their new environment. During this period, animals were fed with the supplementary leaves (paper mulberry) on a daily basis as a way of getting them adapted to the leaves. All the animals were dipped in an acaricide solution as a measure to control ecto-parasites. Each animal also received 3 ml of Abendazole[11] 10 % to control endo-parasites.

3.3 Source and Processing of Feed

[1] Albendazole 10% Pyvet Holland. Contains 100 mg Albendazole/1 ml

The basal diet used in the experiment were two varieties of Napier grass (*Pennisetum purpurem*); the local and improved varieties. They were obtained from the Department of Animal Science, KNUST, Kumasi. The grasses were harvested at about 90 days, chopped into pieces of about 3-5 cm and fed fresh.

The supplement, paper mulberry (*Broussonetia papyrifera*) were also acquired from the plant site at the Afram Headwater Forest Reserve and Opro River Forest Reserve, both located at Offinso-Abofour in the Ashanti Region. The fresh leaves were harvested and shade-dried for 4-8 days. Upon drying, the leaves were then bagged and stored for later use.

3.4 Feeding and Watering

The local and improved varieties of Napier grass were harvested every morning, chopped into short lengths of about 4-10 cm with cutlass. They were weighed and fed to each animal at a rate of 50 g/kg live weight. Each of the grass variety was supplemented with the paper mulberry at three levels of 0 g/day (control), 150 g/day and 300 g/day. Each animal was provided with a weighed amount of salt lick[2]. The difference between the amount given and the amount left after the experiment was determined to know the amount of salt lick[2] consumed. Fresh clean water was provided *ad libitum* every morning. Medications were administered when the need arose. [2]

3.5 Experimental Design

Twenty-four Djallonké male rams weighing between 15.5-26 kg were randomly assigned to six treatments with four replicates per treatment. The experimental designed

[2] Mineral Salt Lick, Frankatson Ltd, Kumasi. Contains per 10 kg: Sodium 38.00 %, Calcium 1.00%, Magnesium 0.50 %, Zinc 290 mg/kg, Manganese 180 mg/kg, Iodine 40 mg/kg, Iron 40 mg/kg, Cobalt 28 mg/kg and Selenium 6 mg/kg.

used was a 2×3 factorial arrangement in a Completely Randomized Design (CRD). The main factors were the two varieties of Napier grass; local variety and the improved variety and supplemented at three levels, thus: 0 g/day (control), 150 g/day and 300 g/day with the paper mulberry leaves.

3.6 Statistical Analysis

The data collected were analysed as a 2×3 factorial arrangement in a Completely Randomised Design (CRD) using the PROC general used linear model (GLM) of SAS (2002) statistical package.

3.7 Chemical Analysis

3.7.1 Sample Preparation

Dried samples of both varieties and that of the supplement (which had been previously air-dried) were dried at 60°C for 48 hours and ground using a laboratory mill (Wiley mill) to pass through 1mm sieve screens for laboratory analyses. Chemical analysis to determine the dry matter (DM), crude protein (CP), neutral detergent fibre (NDF), acid detergent fibre (ADF) and cellulose of the grass as well as the (CP), ether extract, ash, neutral detergent fibre (NDF) and acid detergent fibre (ADF) of *Broussonetia papyrifera* were performed. The Proximate analysis (DM, CP, ash, ether extract and crude fibre) were performed according to the Association of Official Analytical Chemists (A.O.A.C., 1990). The NDF and the ADF fractions were determined following the technique described by Goering and Van Soest (1970).

3.7.2 Dry matter (DM)

Moisture content is normally established by the weight loss observed in a feed sample when dried at a given temperature to a constant weight. Moisture can or crucibles were weighed. Two (2) g of granular samples were also weighed and made to dry overnight in an air oven at 110°C for 24 hours. Crucibles together with samples were cooled in a desiccator and weighed again to determine the dry matter.

3.7.3 Ash

Ash, the inorganic residue, was acquired by burning a sample at 500°C - 600°C. Ashing of a feed sample burns off all organic constituents, leaving behind the nonvolatile mineral elements. Ash crucible was removed from oven, placed in desiccator, cooled and weighed. Then 2.0 g of sample was weighed into porcelain crucible in duplicate and put into furnace for 2 hours at 600°C. Furnace was allowed to cool below 200°C and maintained for 20 minutes. Crucibles were placed in dessicators with stop cork, and then weighed to determine the ash content.

3.7.4 Crude Protein

Two grams (2g) of the sample was weighed and transferred to a 500ml digestion flask. A spoonful of $CuSO_4$-$NaSO_4$ mixture (to act as catalyst) and 15ml of concentrated H_2SO_4 were added to the digestion flask. Boiling chips were added and the sample digested till the solution became colourless. The digest was cooled, diluted with a small quantity of distilled ammonia-free water and transferred to the distillation apparatus. The Kjeldahl flask was rinsed with successive small quantities of water. A 100 ml conical flask containing 25 ml of boric acid solution with a few drops of mixed indicator was placed and 50ml of 40% sodium hydroxide solution added to the test solution in the apparatus. The ammonia on boric acid was distilled and collected. The solution was titrated against the standard acid until the first appearance of pink colour, i.e. the end-point. A reagent blank was ran with equal volume of distilled water and the titration volume subtracted from that of sample titration volume to determine the nitrogen content and subsequently the crude protein as:

% Crude Protein (CP) = Total Nitrogen (NT) x 6.25(Protein factor)

3.7.5 Ether extract

A piece of filter paper was folded in such a way to hold the sample. It was wrapped around a 2nd filter, left open at the top like a thimble. A piece of cotton wool was placed at the top to evenly distribute the solvent as it dropped on the sample during extraction. The sample packet was placed in the butt tubes of the Soxhlet extraction apparatus. The extraction flask was placed in an oven for about 5mins at 110°C then cooled and weighed. The sample was extracted with petroleum ether for 2-3 hours without interruption by gentle heating. It was allowed to cool and the extraction flask dismantled. The ether was evaporated on a steam until no odour of ether remained and then cooled at room temperature. The extraction flask and its extract were re-weighed and recorded to determine the ether extract.

3.7.6 Neutral Detergent Fibre (NDF)

Neutral detergent solution was added to a 2.4 g sample placed in a refluxing beaker and refluxed for 60 minutes. The resultant solution was filtered and the residue washed with hot water. This was repeated three times and was followed by washing with acetone to remove any remaining plant pigments. The residue was transferred to a pre-weighed crucible and dried in an oven at 105°C over night. The residue was then weighed after cooling to determine the NDF content.

3.7.7 Acid Detergent Fibre (ADF)

Acid detergent fibre was determined by placing 2.4 g of sample in a refluxing beaker and refluxed with acid detergent solution for 60 minutes. The refluxed samples were filtered and thoroughly washed with hot water followed by acetone to remove any remaining plant pigments. The residue was dried in a pre-weighed crucible in an oven at 105˚C overnight. The residue was weighed after cooling to determine the ADF content.

3.8 Parameters Measured

Parameters measured during the trial included initial live weight, weekly weight gain which was used to derive the average daily gain, intake of supplement and intake of the grass basal diet. Feed intake was determined by subtracting feed refusals (which were weighed back every morning) from feed offered. The feed refused were weighed back the following morning for each animal, and the difference between the quantity offered and the quantity refused was calculated as the amount of feed consumed. Samples of feed offered and the refusals were taken, dried in an oven to determine the dry matter content which was used in calculating the amount of feed given to each animal. Blood haematological and biochemical parameters were also measured as described below.

3.9 Blood

Blood samples were taken with hypodermic needles from the jugular vein of all the animals at the end of the feeding trial into vacutainer tubes containing Ethylene diamine-tetra-acetate (EDTA) to keep the samples from clotting. The plasma samples were stored in a freezer prior to analysis. The samples were allowed to thaw, after which they were shaken thoroughly. Capillary tubes were filled with the samples, sealed and then centrifuged at 3000 revolutions per minute (rpm) for 5 minutes using a micro-haematocrit centrifuge. The capillary tubes were removed after 4 to 5 minutes, for the determination of the packed cell volume (PCV) using the haematocrit counter. The haemoglobin (Hb) was determined spectrophotometrically, the red blood cell (RBC) and white blood cell (WBC) subsequently calculated as described by Doxey (1977), Greenwood (1977) and Potter (1986). The mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH) and mean corpuscular haemoglobin concentration (MCHC) were calculated as described by Jain (1986).

Total Protein was determined using the Biurets method as described by Singh (2003) while the albumen was also determined using the Bromocresol Green method (BCG) as described by Grant (1982). The globulin contents were calculated as the difference between the contents of total protein and albumen. Total cholesterol was determined using the Liebermann Burchard (LB) method as described by Ellefson (1982).

CHAPTER 4

RESULTS

4.1 Overview

All rams used in the experiment remained healthy throughout the feeding trial. Animals put on the supplementary feed consumed the entire paper mulberry supplement. No mortality was recorded during the experiment. Only the means of the chemical components of the grass and supplement are presented.

4.2 Feed Characteristics

The chemical composition of the two varieties of Napier grass is presented in Table 4.1. The dry matter (DM) values obtained for the two varieties of Napier grass were 69.05 % and 70.02 % for the local and improved varieties respectively. The organic matter (OM) content for the local variety was lower (52.97 %) than the improved variety (60.53 %). Analysis of the local variety recorded lower values for the crude protein (CP) content 13.21 %, neutral detergent fibre (NDF) 83.00 %, acid detergent fibre (ADF) 39.00 % and cellulose 10.41 % than the improved variety which recorded a CP value of 13.87 %, NDF 83.50 %, ADF 40.00 % and cellulose 11.79 %.

Table 4.1 Chemical Composition of Napier Grass (*Pennisetum purpureum*)

	Variety	
Composition Chemical	Local	Improved
Dry Matter (%)	69.05	70.02
Organic Matter (%)	52.97	60.53
Crude Protein (%)	13.21	13.87
Neutral Detergent Fibre (%)	83.00	83.50
Acid Detergent Fibre (%)	39.00	40.00
Cellulose (%)	10.41	11.79

Table 4.2 shows the chemical composition of the paper mulberry used as the supplement. Chemical analysis of the paper mulberry showed a dry matter content of 89.00 %. The crude protein content recorded a value of 24.06 %. The neutral detergent fibre and acid detergent fibre were 65.00 % and 19.50 % respectively. The ether extract (EE) and ash contents were also found to be 6.50 % and 14.00 % respectively.

Table 4.2 Chemical Composition of Paper Mulberry *(Broussonetia papyrifera*).

Chemical Composition	Value (%)
Dry Matter	89.00
Ether Extract	6.50
Ash	14.00
Crude Protein	24.06
Neutral Detergent Fibre	65.00
Acid Detergent Fibre	19.50

4.3 Live Body Weight Changes and Feed Intake

The initial live weights of rams were 22.3 kg, 21.6 kg, 21.8 kg, 22.4 kg, 23.1 kg and 22.8 kg for Lo0, Lo150, Lo300, Imp0, Imp150 and Imp300 respectively. There were no significant differences (P> 0.05) in the final body weight due to supplementation (Table 4.3). There was also no significant difference (P> 0.05) on the final live body weight of the rams.

The average daily gain (ADG) of rams was significantly affected by supplementation (P< 0.05). The results showed increasing levels of the supplement resulted in increases in ADG. These were 0.02 kg, 0.03 kg and 0.04 kg for supplement levels of 0, 150 and 300 g/ day respectively.

Variety of grass consumed did not significantly affect (P> 0.05) the average daily gain of the rams (0.03 kg versus 0.03 kg).

The results showed that there was no difference (P> 0.05) in feed intake which could be attributed to variety. However, intake was significantly affected (P< 0.05) by supplementation. Total intake improved as the level of supplement increased from 0 g/day to 300 g/ day. The intake of supplement was significant (P< 0.05) and increased as the level of supplementation increased from 0 g/ day to 300 g/ day for both varieties of grass used.

The amount of feed consumed expressed in terms of kilogram body weight showed a significant difference (P< 0.05) in the basal intake per kilogram body weight. However, there was a decrease in basal intake as the level of supplement increased. Supplement intake showed a significant effect (P< 0.05) as the level of supplementation increased from 0 g/ day to 300 g/ day. Total intake per kilogram body weight showed a significant increase (P< 0.05) as the level of supplementation increased.

There was a significant difference (P< 0.05) in basal intake per kilogram body weight when expressed in terms of metabolic size due to supplementation. However, intake decreased as the level of supplementation increased from 0 g/ day to 300 g/ day.

There was a significant effect due to the supplement on supplement intake (P< 0.05).

Table 4.3 Effect of the level of Supplementation on Feed Intake.

	Variety							
	Local			Improved				
Suppl. Level	**Lo0**	**Lo150**	**Lo300**	**Im0**	**Im150**	**Im300**	**S.E**	**Sig**
Live weight								
Initial Wt/kg	22.3	21.6	21.8	22.4	23.1	22.8	1.23	NS
Final Wt/kg	24.3	23.5	24.8	24.0	25.1	25.3	1.39	NS
Weight gain	2.0^{b}	1.9^{b}	3.0^{a}	1.6^{b}	2.0^{ab}	2.5^{a}	0.49	* /kg
ADG (kg)	0.02^{b}	0.02^{b}	0.04^{a}	0.02^{a}	0.03^{a}	0.03^{a}	0.01	*
Intake								
Grass (g/d)	1204.89^{b}	1077.96^{a}	1091.61^{a}	1171.54^{a}	1160.96^{ab}	1096.20^{b}	68.21	* Offered
Suppl. (g/d)	0.00^{a}	133.50^{b}	267.00^{c}	0.00^{a}	133.50^{b}	267.00^{c}	0.00	* offered
Basal Intake	1008.9^{a}	891.3^{b}	910.2^{b}	975.5^{a}	949.1^{a}	902.9^{a}	84.09	** (g/d)
Suppl. Intake (g/d)	0.0^{a}	133.5^{b}	267.0^{c}	0.0^{a}	133.5^{b}	267.0^{c}	0.00	*
Total Intake	1008.9^{a}	1024.8^{a}	1177.2^{b}	975.5^{a}	1082.6^{b}	1169.9^{c}	84.09	** (g/d)
Basal Intake /kgBW	41.6^{a}	37.7^{b}	36.4^{b}	40.7^{a}	37.7^{b}	35.2^{c}	1.81	**
Suppl. Intake /kgBW	0.0^{a}	5.7^{b}	11.0^{c}	0.0^{a}	5.3^{b}	10.7^{c}	0.46	*
Total Intake /kgBW	41.6^{a}	43.4^{b}	47.4^{c}	40.7^{a}	43.00^{b}	45.9^{c}	2.27	*
Basal Intake /kgMBW$^{0.75}$	92.3^{a}	82.9^{b}	81.3^{b}	89.9^{a}	84.3^{b}	79.6^{b}	4.74	*
Suppl. Intake /kgMBW$^{0.75}$	0.00^{a}	12.7^{b}	24.3^{c}	0.00^{a}	12.0^{b}	23.9^{c}	0.77	*
Total Intake /kgMBW0.75	92.3^{a}	95.6^{a}	105.6^{b}	89.9^{a}	96.3^{b}	103.5^{c}	5.51	*

Total intake in terms of metabolic size showed a significant increase (P< 0.05) due to the grass fed. Total intake per kilogram metabolic weight showed a linear increase as the level of supplementation increased from 0 g/ day to 300 g/ day.

4.4 Blood Parameters

4.4.1 Haematological results

The blood profile of experimental animals is presented in Table 4.4. Haemoglobin (Hb) content in the blood showed significant differences (P< 0.05) due to treatment effect. For the local variety, there was no significant (P> 0.05) increase in Hb content in the blood as the level of supplementation increased. The opposite can be said of the improved variety where there was a significant decrease (P< 0.05) in Hb content at 300 g/day of supplementation. Significant differences (P< 0.05) were observed in the red blood cell (RBC) content of the blood which could be attributed to treatment effects. On the local variety, RBC content increased significantly (P< 0.05) as the level of supplement increased from 0 g/ day to 300 g/ day. Similarly, the RBC content in the blood of animals put on the improved variety also showed a significant increased (P< 0.05) as the level of supplement increase to 150 g/ day but a drop with supplementation of 300 g/ day.

There were significant differences (P< 0.05) in the white blood cell (WBC) content in the blood due to treatment effects. With the local variety, there was a significant increase (P< 0.05) in WBC content as the level of supplementation increased to 300 g/ day from 150 g/ day. Similarly with the improved variety, supplementation also led to a significant increase in WBC content from 150 g/day to 300 g/ day.

Table 4.4 Haematological indices of sheep fed Napier grass supplemented with Paper mulberry leaves.

	Variety							
	Local			Improved				
Supplement Level	Lo0	Lo150	Lo300	Im0	Im150	Im300	S.E	Sig.
Parameters								
Hb (g/dL)	11.23^{a}	11.20^{a}	11.43^{a}	11.38^{a}	12.08^{b}	11.45^{a}	0.25	*
RBC ($\times 10^{12}$/L)	7.23^{a}	7.98^{b}	8.35^{c}	7.38^{a}	8.80^{c}	7.38^{a}	0.52	*
WBC ($\times 10^{9}$ *l*)	16.15^{c}	14.33^{a}	15.05^{b}	15.60^{b}	13.95^{a}	15.15^{b}	0.64	*
HCT (%)	34.58^{a}	33.63^{b}	34.55^{a}	35.05^{a}	35.38^{a}	34.23^{b}	0.69	*
MCV (f*l*)	45.25^{b}	42.75^{a}	42.00^{a}	41.50^{a}	42.23^{a}	41.83^{a}	0.95	*
MCH (pg)	14.53^{c}	14.25^{c}	13.53^{b}	14.25^{c}	14.50^{a}	14.60^{a}	0.28	*
MCHC (g/ d*l*)	27.28^{a}	28.83^{b}	29.75^{c}	29.50^{a}	30.48^{b}	29.63^{a}	0.71	*

Within rows, means with the same letter (a, b, c) are not significantly different (P> 0.05)

*P< 0.05; ** P< 0.01 Where Hb-Haemoglobin, RBC-Red Blood Cell, WBC-White Blood Cell, HCTHaematocrit or (PCV-Packed Cell Volume), MCV-Mean Cell Volume, MCH-Mean Cell Haemoglobin, MCHC-Mean Cell Haemoglobin Concentration.

Significant differences (P< 0.05) were observed in the haematocrit (HCT) or packed cell volume (PCV) content of the blood which could be attributed to treatment effects. In the local variety, there was a significant increase (P< 0.05) as the level of supplement was increased from 150 g/day to 300 g/day, whereas in the improved variety there was a significant decrease as the level of supplement was increased from 150 g/ day to 300 g/ day.

Significant differences (P< 0.05) in mean cell volume (MCV) content were observed among the treatments. Supplementation in the local variety led to a linear significant decrease from 0 g/ day to 300 g/ day (P< 0.05) in MCV content. The improved variety on the other hand saw no significant change (P> 0.05) in MCV content upon supplementation. However, there was a significant effect ($P < 0.05$) on MCV due to the variety of grass consumed (43.33 vrs 41.85).

Mean cell haemoglobin (MCH) content for the treatments was significant as a result of treatment effects. Supplementation led to a significant increase ($P < 0.05$) in MCH content. In the local variety, MCH content decreased significantly ($P < 0.05$) as the level of supplement was to 300 g/ day from 150 g/ day whereas in the improved variety there was a significant increase ($P < 0.05$) as the level of supplement increased from 0 g/day to 300 g/ day.

There were significant differences ($P < 0.05$) in the mean cell haemoglobin concentration (MCHC) in the blood which could be due to treatment effects. There was an interaction between variety of grass consumed and level of supplement. The MCHC content increased significantly ($P < 0.05$) in the local variety as the level of supplement was increased to 300 g/ day from 0 g/ day. The improved variety on the other hand saw a significant decrease in MCHC content as the level of supplement was increased to 300 g/ day from an initial increase at 150 g/ day.

4.4.2 Blood Biochemistry

The biochemical results obtained from the blood analysis of rams are presented in Table 4.5. Total cholesterol in the blood recorded significant differences ($P < 0.05$) which could be due to treatment effects. Total cholesterol in the blood of sheep fed the local varieties of Napier grass increased significantly ($P < 0.05$) as the level of supplement increased to 300 g/day from supplement level of 150 g/day. With the improved variety, there was a significant increase ($P < 0.05$) in total cholesterol as the level of supplement increased to 300 g/day. Varietal differences of the grass did not have any significant effect ($P > 0.05$) on total cholesterol.

There were significant differences (P< 0.05) in the total protein in the blood which could be attributed to treatment effects. Total protein deceased significantly (P< 0.05) in rams fed the local variety up to 300 g/day. The improved variety on the other hand saw a significant increase (P< 0.05) in the total protein as the level of supplement was increased from 150 g/day to 300 g/day.

Table 4.5 Biochemical results carried out on blood samples of rams.

	Variety							
	Local			Improved				
Supplement Level	**Lo0**	**Lo150**	**Lo300**	**Im0**	**Im150**	**Im300**	**S.E**	**Sig.**
Parameters								
Total Cholesterol (mmol/L)	1.4^a	1.3^c	1.4^a	1.3^a	1.3^a	1.5^b	0.08	*
Total Protein (g/L)	73.3^a	72.8^a	69.8^b	73.8^a	70.5^b	74.0^a	2.28	*
Albumin (g/L)	26.8^a	27.0^a	27.0^a	27.5^a	27.0^a	27.5^a	0.75	NS
Globulin (g/L)	46.5^a	45.8^a	42.8^b	46.3^a	43.5^b	46.5^a	2.39	*

Within rows, means with the same letter (a, b, c) are not significantly differently (P> 0.05). Lo= Local, Imp= Improved

Albumin content in the blood recorded no significant changes among the various treatments. Varietal and level of supplementation did not influence (P> 0.05) the values obtained for the albumin content in the blood.

Treatment effect was significant for globulin content in the blood. This could be attributed to treatment effects. Supplementation in the local variety up to 300 g/day led to a significant decrease (P< 0.05) in the globulin content in the blood. The improved variety on the other hand recorded a significant increase (P< 0.05) in globulin with supplementation up to 300 g/day. Varietal differences of grass did not produce any significant effect (P> 0.05) on the globulin content in the blood (45.00 g/*l* vrs 45.42 g/*l*).

CHAPTER 5

DISCUSSION

5.1 Characteristics of feed offered

5.1.1 Chemical composition of Napier grass (*Pennisetum purpureum*)

The dry matter of the grasses used were 69.1 % and 70.2 % for the local and improved varieties respectively. They were found to be higher than the values reported by Ansah *et al*. (2010), Kanitta (2010) and Osman (2011) (48.38 % and 48.26%, 22.72% and 48.38% and 48.26% respectively. The DM content recorded for the present study was, however, found within the range (60-80 %) considered to be the minimum requirement for rumen microbial activity as reported by Minson and Milford (1976). The low moisture found in the grasses is bound to decrease the rate of deterioration when properly stored (Minson and Milford (1976).

All the varieties, both local and improved recorded a CP level higher than those reported by Ansah *et al*. (2010) but comparable to the value reported by Bayble *et al*. (2007) when Napier grass was harvested after 60 days of planting. The crude protein content for the local and improved varieties 13.21 % and 13.87 % respectively were higher than the minimum level of 7 % required for optimum rumen function (Van Soest, 1994) and therefore could effectively support microbial fermentation.

The neutral detergent fibre (NDF) content was higher compared to the findings of Bayble *et al*. (2007) and Ansah *et al*. (2010). The contents of ADF and cellulose also recorded values lower than those recorded by the same authors. The NDF indicates the structural components of the plant, especially the cell wall content. Singh and

Oosting (1992) reported that roughage diets with NDF content 45-65 % and below 45 % were generally considered as medium and high quality feeds respectively. The rather high NDF content observed in this study suggests that the grass varieties used were of poor quality.

Feeds with high ADF content could lower the availability of nutrients since there is a negative relationship between ADF and digestibility of feeds (McDonald *et al*., 2002), therefore the higher the ADF, the lower the digestibility of the feed. The low values recorded in this study compared to those recorded by Bayble *et al*. (2007) and Osman (2011) indicate that the varieties of grass used were high in digestibility.

5.1.2 Chemical Composition of Paper mulberry (*Broussonetia papyrifera*)

The dry matter (DM) content (89.00 %) recorded in the present study is comparable to the value (90.50 %) reported by Osman (2011). The neutral detergent fibre (NDF) content found in the present study (44.00 %) was slightly higher than the value reported by Osman (2011). The acid detergent fibre (ADF) was, however, lower (21.00 %) than the value reported by the same author. The difference in the NDF and ADF could be attributed to the time of harvesting of the leaves. The ash content investigated in this study was higher (14.00 %) than the values 10.96-12.95 % and 13.20 % reported by Oduro (2009) and Osman (2011) respectively. This indicates the Paper mulberry leaves used in the study had high mineral content.

The chemical composition showed *Broussonetia papyrifera* has a high level of CP. The CP content for Paper mulberry (24.00 %) in the present study compares favourably with the values (22.60-28.50 %) obtained by Napasirth *et al*. (2007), but was found to be higher than the values 16.00-22.00 % and 20.50 % reported by Oduro (2009) and Osman (2011) respectively. This indicates that Paper mulberry has the potential as a protein feed supplement in ruminant diets. As stated by Preston and Leng (1987), protein is the nutrient most often deficient, and this deficiency can affect livestock productivity in the tropics.

5.2 Effects of supplement and variety on animal performance

On the initial weights of rams, no significance differences were observed in all the treatments. The final weights on the other hand recorded no significant difference. Supplementation with paper mulberry leaves had no significant effect on the final weights in spite of the increase in total protein intake. The nitrogen supplementation provided by the paper mulberry leaves (24.06 %) influenced weight gain of animals as the level of supplement increased in all the treatments. A study conducted by Nurfeta (2011) showed that supplementation of sheep fed a basal diet of grass hay with supplementation of moringa leaves (*Moringa oleifera*) increased body weight with increasing levels of the supplement.

The average daily gain (ADG) of animals witnessed a significant increase (P<0.05) with supplement level of 300 g/day in the local variety. In the improved variety, however, no significant effect was observed. This observation may be due to inadequate level of supplementation. Osman (2011) observed a similar situation in ADG of animals, where there was no significant effect when animals were supplemented at 100 g/day and 200 g/day for the local variety and improved variety respectively using Napier grass. Varietal differences did not influence ADG significantly even though treatment Loc300 performed better than the Imp300. The margin of improvement was not significant. This may be attributed to low appetite experienced by animals fed the improved variety even though the CP intake was

slightly better than that of the local variety.

Supplement intake and total intake was significantly affected (P<0.05) by treatment effects. Total intake was influenced by supplementation of paper mulberry leaves. Total intake increased with increasing level of supplement from 0 g/day to 300 g/day in both varieties of the grass consumed.

The increase in intake of feed is in agreement with Van Soest (1994) who noted that improvement in dietary protein supplementation is due to an increase in nitrogen supply to the rumen microorganisms. This leads to an increase in microbial population and efficiency, thereby enhancing the rate of breakdown of the digesta which eventually leads to feed intake.

Basal intake expressed in terms of kilogramme body weight (KgBW) decreased significantly ($P<0.05$) as the level of supplement increased. Supplementation of paper mulberry leaves led to a linear decrease in the basal intake per KgBW of animals. Since animals consume feed to satisfy their protein requirement, it could be that the amount of protein in the feed of animals with no supplementation had to eat more feed to satisfy their protein needs, thus the highest intake of feed. Supplementation in the subsequent treatments ensured that the protein intake of animals was good.

Total intake per KgBW was significantly affected by treatment effects. Increase in supplementation saw an increase in the total intake per kilogramme body weight of animals. This follows the same trend observed in the total intake. Supplementation may have influenced such increases. This is consistent with the findings of Tessema and Baars (2004) who reported that to improve the efficient utilisation of Napier grass, a supplement of high CP is required.

Basal intake also expressed in terms of metabolic weight recorded a significant decrease with increasing levels of the supplement. This is similar to the trend observed in the basal intake per kilogramme body weight of animals. Both intake of supplement and total intake expressed in terms of metabolic weight increased significantly with increasing levels of supplementation. Osman (2011) on the other hand observed a similar fashion in the supplement intake and total intake expressed in terms of metabolic weight where increase in supplement level from 0 g/day to 200 g/day saw a linear increase. This could be due to the high acceptability of the supplement.

5.3 Effect of treatments on blood parameters

The significance of determining the haematological and biochemical indices of animals may give some insight as to the performance of animals (Orheruata and Akhuomobhogbe, 2006). These indices according to Opara *et al*. (2010) could help in the realistic evaluation of the management practices, nutrition and diagnosis of the health condition of the animal. Haematological and biochemical parameters carried out to determine the effect the feed had on them are as follows.

5.3.1 Haematological assessment

All the parameters measured were statistically significant ($P<0.05$). Treatment effect was evident in the improved variety for Hb content, but absent in the local variety. Values obtained in the local variety were not significantly different ($P>0.05$), although treatment Loc300 recorded the highest Hb concentration in the blood. The improved variety on the other hand saw a significant increase in Hb level for treatment Imp150 with a total increase crude protein intake of 167.78 g DM/day but a decline in Hb content for treatment Imp300 with a total crude protein intake of 197.42 g DM/day. Improved variety of grass consumed and the level of supplement had an effect on Hb content. However, the values recorded were all within the normal physiological range of haemoglobin for healthy sheep (9.0-15.0 g/dL) reported by Radostits *et al*. (2000). The Hb values recorded in this study for Djallonké rams were higher than the values reported by Osman (2011) (10.33-11.53 g/l). The high Hb values as shown in this experiment reveal that all the diets were suitable for the rams. This is in support of

Olayemi *et al*. (2000) who observed that animals on high plane of feed have higher haemoglobin and packed cell volume count than animals on poor diet.

The red blood cells (RBC) values obtained were comparable to the findings of Osman (2011), although treatment Loc300 and Imp150 recorded higher values. The values obtained were also comparable to the range of results (7.87-11.29×10^{12}/L) obtained by Fadiyimu *et al*. (2010). Compared to the reference value range of 8.0-18.0×10^{12}/L reported by Radostits *et al*. (2000), treatments Loc0, Loc150, Imp0 and Imp300 were found to be lower than the normal range. According to Ikhimioya and Imausen (2007) RBC counts aids in the characterization of anaemia. The low RBC values recorded for treatments Loc0, Loc150, Imp0 and Imp300 could be an indication of anaemia-related disease by the rams within those treatments.

White blood cell (WBC) values obtained were above the normal range of 4.012.0×10^{9}/L reported by Radostits *et al*. (2000). Treatment effects as a result of grass consumed and the level of supplementation had significant effect ($P<0.05$) on WBC content of the blood. The WBCs values recorded in this study were higher than the values reported by Osman (2011) (6.00-9.08×10^{9}/L). The high values of WBCs are indicative of the fact that the immune responses of the animals are capable of generating antibodies to fight infections or foreign bodies (Oka and Ibeawuchi, 2011).

Haematocrit (HCT) values obtained were not significant for treatments Loc0, Loc300, Imp0 and Imp150. However, significant differences were recorded for treatment Loc150 and Imp300. It was clear that supplementation and increase in total crude protein intake in Loc150 led to a significant decrease in HCT content but an increase in HCT content for treatment Loc300. The improved variety on the other hand saw a significant decrease in HCT content upon supplementation and total crude protein intake. The HCT or PCV values observed in this study were lower than the values reported by Osman (2011) (31.58-78.18 %). However, values recorded were all within the normal physiological range of 27.0-45.0 % reported for healthy sheep by Schalm *et al*. (1975). The difference in the PCV values may be attributed to nutritional factors.

The mean cell volume (MCV) values recorded were only significant for treatment Loc0 (without supplementation). Virtually no significant effect (P>0.05) was realised upon supplementation and consumption of grass variety on MCV content in the blood. Values obtained for MCV were all found to be above the normal range of 28.040.0 fL reported by Radostits *et al*. (2000). The MCV values reported in this study for Djallonké rams were lower compared to the values reported by Osman (2011) (37.3099.03 fL). MCV values according to Koepke (1989) allows for classification of anaemia as either below, within and above normal range. The results obtained suggest that the rams were not anaemic as the values recorded were above the normal range.

Treatment effects were evident for the contents of the mean cell haemoglobin (MCH). In the local variety, the MCH content decreased as the level of supplementation increased. However, the improved variety on the other hand saw an opposite trend. Supplementation and increase in total crude protein intake led to a significant increase (P<0.05) in MCH content. Both the variety of grass and the level of supplementation influenced the MCH content in the blood. The values obtained were all found to be out of range of the normal values of 8.0-12.0 pg reported by Greenwood (1977). The MCH values observed in this study were lower than the values reported by Osman (2011) (13.68-18.08 pg). MCH values give indication of the state of blood level as being anaemic or not anaemic (Aster, 2004). The results obtained imply that rams were not anaemic as the values recorded were above the normal range for sheep.

Mean cell haemoglobin concentration (MCHC) values depicted significant differences ($P<0.05$) across the treatments. Values obtained were all found to be below the normal physiological range of values reported for sheep (31.0-34.0 g/dL) by Radostits *et al*. (2000). MCHC increased linearly as the level of supplement increased as in the local variety. The improved variety saw an increase only at a supplement level of 150 g/day. Compared to the values obtained by Osman (2011) (16.35-34.40 g/dl), the values observed in this study were found to be lower. The values recorded may be attributed to the low level of haemoglobin concentration in the red blood cells.

5.3.2 Biochemical assessment

The total cholesterol in the blood showed significant difference ($P<0.05$) across the treatments. The ranges of 1.28-1.43 mmol/L and 1.30-1.53 mmol/L for the local and improved varieties respectively were all within the normal physiological range of 1.05-1.50 mmol/L reported by Radostits *et al*. (2000) for healthy sheep. This result is an indication of the fact that treatment differences as a result of grass consumed and levels of supplement had an effect on the total cholesterol in the blood. For the total cholesterol content in the blood, increase in the level of supplementation from 150 g/day to 300 g/day saw an increase for both varieties of grass consumed.

Total protein contents in the blood of rams were statistically different ($P<0.05$) across treatments evidence of treatment effects. Supplementation in the local variety led to a decrease in the total protein in the blood, while in the improved variety supplementation led to an increase in the total protein in the blood of rams. The values were, however, within the normal physiological range of 60-79 g/L reported by Kaneko (1980). The values observed in the total protein content in the blood supports the assertions of Hagawane *et al*. (2009) that the total protein in the blood is an appraisal of the nutritive status of an animal reflecting feed intake and metabolism.

The albumin content in the blood showed no significant effect (P>0.05) across the treatments. All the values obtained were found within the normal range of 24-30 g/L for healthy sheep according to Radostits *et al*. (2000). Although treatment effects were evident, supplementation and consumption of grass varieties had no significant influence on the values.

Globulin contents were statistically significant (P>0.05) by the treatment effects. Globulin content was significantly lower in the treatment that received the highest level of supplement (Loc300) in the local variety, while in the improved variety treatment Imp150 recorded the least globulin content. An increase in the total crude protein intake as a result of supplementation led to a decrease in globulin content in the local variety, while in the improved variety supplementation due to increase in total crude protein intake saw a significant increase (P<0.05) in treatment Imp300. The values obtained for globulin were within the normal range of 30-48 g/L reported by Milne and Scott (2006) for healthy sheep.

All the biochemical parameters evaluated were all found to be within the normal physiological ranges reported for sheep by several authors. These indicate that the feed fed to animals had influence on these biochemical indices.

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

From the results of the experimental work, the following conclusions were drawn:

The crude protein content of the grass varieties used was higher than the 7 % level required for voluntary intake in ruminants. Napier grass, despite its suitability for feeding ruminants in terms of its crude protein content, supplementation with Paper mulberry would enhance and improve the utilization of Napier grass to growth and productivity in sheep.

Paper mulberry has also proved to be a useful feed resource in supplementing Napier grass basal diet, since its nutritive value compares well with other leaf supplement such as Moringa. They were readily consumed by animals in this experiment.

Total intake of feed improved considerably when Paper mulberry leaves was supplemented with Napier grass basal diet. Supplementation beyond 200 g/ day as carried out by Osman (2011). He observed no substitution effect and therefore concluded that Paper mulberry can be supplemented beyond 200 g/ day. Supplementation beyond 300 g/ day also showed no substitution effect. Weight gains were recorded with supplementation of 300 g/ day recording the highest weight gain which reflected in the average daily gain of animals.

Increasing the supplement level from 150 g/ day to 300 g/ day of Paper mulberry in the Napier grass basal diet of rams had no deleterious effect on the haematological as well as biochemical indices of animals.

6.2 Recommendations

Based on the results obtained in the experiment, Paper mulberry leaves is recommended to be fed to sheep as supplement at 300 g/ day. Further research is necessary to determine the level that is suitable for supplementing Paper mulberry with Napier grass fed to rams so as to assess their growth and productivity. Carcass analysis of sheep fed

Napier grass, supplemented with Paper mulberry should be carried out to determine their effect on carcass parameters.

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APPENDIX 1: ANALYSIS OF VARIANCE (ANOVA) TABLES

Appendix 1.1 ANOVA tables for feeding trial

Dependent Variable: DMOff

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	1211023.434	242204.687	14.92	<.0001
Error	18	292223.868	16234.659		
Corrected Total	23	1503247.302			

R-Square	Coeff Var	Root MSE	DMOff Mean
0.805605	16.02720	127.4153	794.9942

Dependent Variable: DMRef

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	17677.36897	3535.47379	5.45	0.0032
Error	18	11684.54953	649.14164		
Corrected Total	23	29361.91850			

R-Square	Coeff Var	Root MSE	DMRef Mean
0.602051	31.83572	25.47826	80.03042

Dependent Variable: Basal Intake

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	937745.207	187549.041	9.13	0.0002

Error	18	369858.427	20547.690		
Corrected Total	23	1307603.634			

R-Square	Coeff Var	Root MSE	Basal Intake Mean
0.717148	20.04929	143.3447	714.9613

ANOVA tables for feeding trial (Cont‟d)

Dependent Variable: Suppl Intake

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	0	0	-	-
Error	18	0	0		
Corrected Total	23	0			

R-Square	Coeff Var	Root MSE	SUPPINT Mean
0.000000	0	0	20.93000

Dependent Variable: Total Intake

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	937745.207	187549.041	9.13	0.0002
Error	18	369858.427	20547.690		
Corrected Total	23	1307603.634			

R-Square	Coeff Var	Root MSE	Total Intake Mean
0.717148	19.47905	143.3447	735.89.13

Dependent Variable: Weight gain

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	5.45833333	1.09166667	1.16	0.3643
Error	18	16.87500000	0.93750000		
Corrected Total	23	22.33333333			

R-Square	Coeff Var	Root MSE	Weight gain Mean
0.244403	44.68827	0.968246	2.166667

Appendix 1.2 ANOVA tables for blood haematological parameters

Dependent Variable: Hb

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	4.89833333	0.97966667	0.93	0.4836
Error	18	18.92000000	1.05111111		
Corrected Total	23	23.81833333			

R-Square	Coeff Var	Root MSE	Hb Mean
0.205654	9.725569	1.025237	10.54167

Dependent Variable: HCT

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	26.9787500	5.3957500	0.49	0.7822
Error	18	199.7875000	11.0993056		
Corrected Total	23	226.7662500			

R-Square	Coeff Var	Root MSE	HCT Mean
0.118972	10.34245	3.331562	32.21250

Dependent Variable: RBC

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	5.66833333	1.13366667	0.61	0.6954
Error	18	33.60500000	1.86694444		
Corrected Total	23	39.27333333			

R-Square	Coeff Var	Root MSE	RBC Mean
0.144330	16.39634	1.366362	8.333333

ANOVA tables for blood haematological parameters (Cont‟d)

Dependent Variable: WBC

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F

Model	5	24.7437500	4.9487500	0.79	0.5681
Error	18	112.2225000	6.2345833		
Corrected Total	23	136.9662500			

R-Square	Coeff Var	Root MSE	WBC Mean
0.180656	16.52218	2.496915	15.11250

Dependent Variable: MCV

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	12.54708333	2.50941667	0.79	0.5718
Error	18	57.32250000	3.18458333		
Corrected Total	23	69.86958333			

R-Square	Coeff Var	Root MSE	MCV Mean
0.179579	4.405819	1.784540	40.50417

Dependent Variable: MCH

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	16.13000000	3.22600000	2.70	0.0547
Error	18	21.53500000	1.19638889		
Corrected Total	23	37.66500000			

R-Square	Coeff Var	Root MSE	MCH Mean
0.428249	8.462635	1.093796	12.92500

ANOVA tables for blood haematological parameters (Cont‟d)

Dependent Variable: MCHC

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	115.3037500	23.0607500	2.20	0.0997
Error	18	188.8225000	10.4901389		
Corrected Total	23	304.1262500			

R-Square	Coeff Var	Root MSE	MCHC Mean
0.379131	11.29010	3.238848	28.68750

Appendix 1.3 ANOVA tables for blood biochemistry parameters

Dependent Variable: Total Cholesterol

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	0.02875000	0.00575000	0.45	0.8043
Error	18	0.22750000	0.01263889		
Corrected Total	23	0.25625000			

R-Square Coeff Var Root MSE Total Cholesterol Mean

0.112195 9.883324 0.112423 1.137500

Dependent Variable: Total Protein

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	44.2083333	8.8416667	0.86	0.5255
Error	18	184.7500000	10.2638889		
Corrected Total	23	228.9583333			

R-Square Coeff Var Root MSE Total Protein Mean

0.193085 4.875684 3.203730 65.70833

Dependent Variable: Albumin

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	21.3333333	4.2666667	0.87	0.5186
Error	18	88.0000000	4.8888889		
Corrected Total	23	109.3333333			

R-Square Coeff Var Root MSE Albumin Mean

0.195122 8.089329 2.211083 27.33333 ANOVA tables for blood biochemistry parameters (Cont"d)

Dependent Variable: Globulin

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	68.3750000	13.6750000	1.20	0.3489
Error	18	205.2500000	11.4027778		
Corrected Total	23	273.6250000			

R-Square Coeff Var Root MSE Globulin Mean

0.249886	8.799479	3.376800	38.37500