NUTRITIONAL EVALUATION OF THREE BROWSE SPECIES COMMONLY FED TO SMALL RUMINANTS BY FARMERS IN THE ACCRA PLAINS OF GHANA

BY

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DEDICATION

This thesis is dedicated to the Almighty Jehovah, my parents, siblings, my lovely wife, Elizabeth Nsoh and to the entire Ayelba's family for their unflinching support towards my education to the highest level.

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DECLARATION

I, Mark Ayelbire Nsoh, declare that, except for references to other peoples work, both published and unpublished, which have been duly acknowledged, the results reported in this thesis is my original research work done in the Department of Animal Science, University of Ghana, Legon, from August 2017 to July 2019. This thesis has not been submitted for any other degree or examination at any other university.

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This work has been submitted for examination with our approval as supervisors:

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Prof. Frederick Yeboah Obese Date

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Dr. Leonard Kofi Adjorlolo Date

(Co-Supervisor)

LIST OF ACRONYMS

ADF	Acid Detergent Fibre
AGD	Average Daily Gain
ADFI	Acid Detergent Fibre Intake
BW	Body Weight
CP	Crude Protein
CPI	Crude Protein Intake
CPM	Cassava Peel Meal
DM	Dry Matter
DMI	Dry Matter Intake
ALM	Acacia Leaf Meal
FLM	Ficus Leaf Meal
FCE	Feed Conversion Efficiency
Hb	Haemoglobin
LIPREC	Livestock and Poultry Research Centre
MCH	Mean Corpuscular Haemoglobin
MCHC	Mean Cell Haemoglobin Concentration
MCV	Mean Cell Volume
NDF	Neural Detergent Fibre
NDFI	Neutral Detergent Fibre Intake
ADRA	Adventist Development and Relief Agency
OM	Organic Matter
PCV	Packed Cell Volume
RBC	Red Blood Cells
SLM	Samanea Leaf Meal
WBC	White Blood Cells
WADs	West African Dwarf sheep
LSD	Least Significant Difference
MS	Mean Square

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

ABSTRACT

Quantitative survey was carried out in five purposely selected districts in the Accra Plains of Ghana using focused group discussions and individual interviews to evaluate and document the existing farming practices, opportunities and constraints among smallholder farmers with particular interest on the probable animal feed resources and cyclical gaps with respect to sheep and goat production in study 1. Also the effect of supplementary feed packages based on *Samanea saman, Acacia auriculiformis* and *Ficus exasperata* browse species and cassava peels on feed intake, digestibility, growth and physiology of the West African Dwarf sheep fed on a basal diet of *Andropogon gayanus* hay were evaluated in study 2. Livestock production constraints affecting the smallholders in study 1 were poor housing, high mortality rates due to diseases and insufficient feed especially in the dry season and theft. Feed resources identified in the study areas suitable for livestock farming were wastes from crops and some by-products like plantain and cassava peels, corn mill wastes, maize bran and rice bran. Also, browse species such as *Samanea saman, Acacia auriculiformis, Ficus exasperata, Gliricidia sepium* and *magnifera indica* among others were fed to small ruminants in the study areas. Feedstuffs were more accessible to ruminants after crop harvest and feed shortage gap was identified during the dry season. In study 2, Samanea leaf meal and cassava peel meal based diets were more acceptable ($p < 0.05$) to the West African Dwarf sheep and improved dry matter intakes than the Acacia and Ficus leaf meal based supplements. Sheep fed the Samanea leaf meal based supplement had the highest dry matter, crude protein and organic matter digestibilities ($p < 0.05$) than those on the Acacia, Ficus and Cassava peel meal based supplements. The three browse species and the cassava peel meal based supplements did not significantly ($p < 0.05$) affect most of

the haematological (Hb, PCV, RBC, WBC) and blood biochemical indices measured (Glucose, Total protein, Albumin, Globulin, Cholesterol, and Urea). The values were within the normal ranges reported for sheep thus indicating no adverse influence on the health and physiology of the sheep. The results suggest feed supplementation packages based on Samanea, Acacia, Ficus and Cassava peels could be fed to sheep by small ruminant farmers in the Accra Plains to improve performance of sheep fed low quality basal diet.

CHAPTER ONE

1.0 INTRODUCTION

1.1 BACKGROUND AND JUSTIFICATION

Ruminant livestock production in sub-Sahara African countries including Ghana is hindered by poor quality and inadequate feed supply (Nurfeta, 2010). High levels of productivity are not achieved since the tropical grasses which are usually fed to these livestock are often deficient in protein, especially in the dry season (Kosgey and Okeyo, 2007). Protein deficiency can hinder the growth of young animals as well as milk production in livestock production systems (Minson, 1990). It has however been reported that, when these tropical grasses are supplemented with concentrates, their intake and digestibility are improved (Nurfeta, 2010). Nevertheless, strategies of this kind are rarely adopted by smallholder livestock farmers because they consider concentrates to be scarce and expensive to use (Nurfeta, 2010) resulting in limited prospects for using cereal grains and by-products as animals feed. In an attempt to alleviate the difficulties linked with the deficiency in the use of conventional protein, supplements that farmers can produce on their own farms at cheaper costs should be sought.

Leguminous forages have the potential to curtail this drawback because of their high protein concentrations compared to non-leguminous browses (Goodchild, 1990). They can therefore, be used in balancing nutrient deficiencies in high fibre low-protein deficient feedstuff (Jayasuriya, 2002). Ruminant livestock production normally require fodder with crude protein values between 100 and 170 g kg^{-1} on dry matter basis and leguminous forages have the potential to supply this (Minson, 1990; Groff and Wu,

2005; Dewhurst *et al.*, 2009). For instance, the crude protein content of some legume forage species were found to be about 170g kg^{-1} DM, far higher than the 115g kg^{-1} DM for grasses (Minson, 1990).

The competition between man and livestock for cereals as a source of feed is another challenge the livestock sector faces. In West Africa, rearing of ruminants is constrained due to the seasonal unavailability of good quality forage (Atuhaire *et al.*, 2014). Gutteridge and Shelton (1993) suggested that crop stovers, some agro industrial by-products and several leguminous plants can be fed to animals as they contain nutrients that can complement deficiencies in the basal feed of animals. Despite the potentials of these feed alternatives, especially with reference to agro-industrial by-products, their utilisation is limited owing to lack of information and resources to enhance the addition of value to these products. Furthermore, inadequate user ability, processing and storage of agro-industrial by-products is a major problem in ruminant livestock production (Ajila *et al.*, 2010).

In tropical Africa including Ghana, smallholder farmers dominate ruminant livestock production and mostly provide low inputs (extensive systems) resulting in low productivity. For instance owing to the low productivity of livestock in Ghana, production does not match the high demand for livestock products. This has led to the importation of meat, milk and milk products from neighbouring countries and overseas to meet the deficit. For example, 80,339 metric tons of frozen meat and dairy products were imported into the country in 2015 (MoFA, 2015). Therefore, considerable

improvement in feeding and management techniques would be required to attain increased productivity to meet increasing demand for livestock production in Ghana.

Small ruminant production is a common feature of Ghana's livestock production system and improving their productivity through improved feeding using feed supplementation packages that meet their productive needs will enhance their productivity and performance. Several fodder shrubs and tree browses maintain their quality during the dry season and can act as sources of protein, vitamins and minerals as well as provide year-round fodder to be used to supplement grazing during lean periods (Smith, 1992).

The West African Dwarf sheep and goat are dominant breeds in Ghana (Koney, 2004). They are an important source of protein in the diet, provide a source of income and play socio-economic roles in Ghana (Baiden and Obese, 2010). They are recognised for their trypanotolerance, prolificacy, hardiness and suitability for year-round breeding (Koney, 2004). However, their productivity is less than optimum characterised by poor growth rates and reproductive performance due to inadequate nutrition. The development of supplementary feed packages which meet their nutrient needs could improved the productivity of these breeds.

Therefore, this study sought to ascertain the feeding strategies of small ruminant farmers in the Accra plains of Ghana and to develop complete feed supplements using some commonly fed browse species and agro- industrial residues.

1.3 Main objective:

To evaluate management practices involved in small ruminant production in the Accra plains and also assess the effects of supplementary feed packages based on Samanea, Acacia and Ficus browse species and cassava peels on intake, metabolism, growth and physiology of the West African Dwarf sheep.

1.4 Specific objectives of the study:

- To evaluate the management practices for small ruminant production in the Accra plains.
- To determine the acceptability of selected browse species and cassava peel based supplements by West African Dwarf sheep.
- To evaluate the effect of selected browse species and cassava peel based supplements on feed intake and digestibility in West African Dwarf sheep.
- To assess the effect of selected browse species and cassava peel based supplements on growth rate and feed conversion efficiency of the West African Dwarf sheep.
- To determine the effect of selected browse species and cassava peel based supplements on some blood parameters of the West African Dwarf sheep.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Ruminant production in Ghana and constraints

Ruminant livestock are managed under a variety of production systems in Ghana. The systems of production employed in raising ruminants in Ghana are the free range (extensive), semi-intensive and intensive system. The free range system is the common practice with the intensive system being least employed by farmers (Okantah *et al.*, 1999).

In the extensive system the animals are allowed to scavenge for feed merely on range lands with little or no feed supplementation (Okantah *et al.*, 1999). This results in low productivity characterised by slow growth rate, poor body condition, delayed puberty, poor conception rates, extended calving and lambing interval and low birth weight (Clottey *et al.*, 2007).

Major challenges facing livestock production in Ghana is related to shortages in feeding resources particularly pronounced in the dry periods of the year (Larbi *et al.*, 1993). The grasses in Ghana mature faster in the rainy season but turn fibrous during the dry season. The high rate of lignification reduces digestibility and nutritive value.

Livestock productivity is negatively affected by high mortality and annual disease and pest outbreaks (Mahama, 2012), with an estimated annual economic loss of US$50 million in the country (Ministry of Food and Agriculture [MoFA], 2012).

Government budget allocation for livestock development is considerably low (MoFA, 2010; Oppong-Anane, 2010). As a result, Ghana is able to meet only 30% of the country‘s meat and meat products requirements leading to heavy reliance on imports to supplement the animal protein requirements of the population (Asafu-Adjei and Dantankwa, 2001; MoFA, 2007).

Furthermore, crop residues which are used for supplementation tend to have relatively poor feeding value due to high fibre and lignin contents and low contents of important nutrients such as crude protein, minerals, vitamins and easily fermentable carbohydrates (Jayasuriya 2002). These poor quality forages tend to limit feed intake (Owen and Jayasuriya, 1989) and consequently decreases the ability of animals to meet their daily maintenance needs which culminates in liveweight loses (Owen and Jayasuriya, 1989).

For example in the northern parts of Ghana where very dry and hot weather conditions are experienced in the dry season, there is the prevalence of poor feed quality low in nitrogen coupled with inadequate grazing material and lack of drinking water for ruminant livestock on natural pasture (Alhassan *et al.*,1999). Animals lose a considerable amount of their live weight as a result. A study conducted by Peters *et al.* (1997) reports a decline in nutrient content of forage during the dry season where crude protein levels reduced to as low as 3.7% during the dry season. Again, in the urban centres, accessibility to grazing land becomes restricted due to infrastructural and estates development. There is therefore the need for good feed supplementation

packages for ruminants in the dry season to maintain or improve weight gain and reproductive performance.

2.3.1 Supplementation in ruminants nutrition

The main constraints associated with using low quality fodder for ruminant production are low digestibility, low propionate fermentation pattern within the rumen and the low content of both fermentable nitrogen and escape protein (Raghuvansi *et al*., 2007). Bondi (1987) suggested that feeds that contain less than 6% crude protein result in negative nitrogen balance consequently, straw-based feeds require nitrogen supplementation to promote effective cellulolysis in the rumen which may additionally enhance rumen microbial nitrogen supply and retention.

Supplements are feedstuffs which are used to improve the value of basal diets. They are feeds that are fed to ruminants only in small quantities and which supply essential nutrients including energy, protein, minerals and vitamins. Supplements are essential to correct deficiencies and thus increase basal feed intake and consequently enhance animal production. Gatenby (2002), outlined the most common types of supplements as: protein concentrates (for example, soybean meal, cotton seed cake and groundnut cake), energy concentrates (for example molasses, maize bran and rice), non-protein nitrogen (for example, urea), and minerals. Supplements particularly concentrates, are expensive and their cost must be more than repaid by the anticipated increase in productivity to justify their use.

Ruminants due to their rumen physiological adaptation can utilise less expensive supplements to satisfy their dietary requirement for reproduction, maintenance and growth. The microbial organisms in the fore-stomach of ruminants is responsible for the digestion of both the soluble and insoluble fractions of plant material fed on.

Although some of these forages are low in nitrogen, and high in fibre, supplementation with high nitrogen feeds help improve the rumen's ecosystem thereby enhancing the animal's ability to digest fibrous portions of these forages (Preston and Leng, 1984).

The attempt at providing limiting nutrients to the micro-organism in the rumen of livestock to enhance the growth and activities of such microbes and thereby increase the utilisation of fibrous feeds by the host animal has received considerable efforts as an alternative means of improving the digestibility of poor quality forages (Ibrahim *et al*., 1994).

2.3.2 Energy supplementation

Crop residues such as straw, which are commonly fed to ruminants in the tropics are high in mature plant cell wall carbohydrates but low in soluble carbohydrates (Van Soest, 1994). They are therefore, not able to provide all the energy needs of the rumen microbes. Microbes in rumen of ruminants on such low quality diets may thus die out of malnourishment (Van Soest, 1982).

Peels from cassava has proven to be a good means of providing energy in ruminant nutrition. There have been reports on high dry matter degradability of cassava peels with values higher than 70% (Heuzé *et al*., 2012).

Studies show that 60% of the rumen microbial populations die out within two hours due to starvation in the absence of fermentable energy supplementation (Hespel, 1979). For effective utilisation of nitrogen and better growth of rumen microbes, energy supplementation is important (Henning *et al*., 1991). According to Sanson *et al*. (1990), increased supply of readily fermentable carbohydrate decreased ammonia-nitrogen concentrations in the rumen due to improved nitrogen uptake by rumen microbes This is confirmed by other authors such as Pham and Preston (2009), who observed an increased in both intake and nitrogen retention when Tithonia forage was used together with cassava chips compared to when Tithonia forage was fed alone.

Grass silage-based diet was supplemented with sugar and there was an increased in the flow of microbial protein and non-protein nitrogen into the small intestine (Ballard *et al.,* 2001). Work conducted by other researchers observed that heifers on pasture grow slower but on ration supplemented with maize or whole soya hulls grow quicker as compared to their counterparts who did not benefit from a supplementation regime (Anderson *et al*., 1988).

Excessive intakes of readily fermentable carbohydrate causes low rumen pH, resulting in limits on microbial growth in the rumen and inhibiting cellulose digestion (Fahey and Berger, 1988; Demeyer and Fievez, 2004).

2.3.4 Protein supplementation

Protein supplementation in ruminant nutrition may be done with true protein or non-protein nitrogen (NPN) sources. Rumen micro-flora are able to convert non-protein nitrogen into true protein. The non-protein nitrogen can be used as a supplement alone or ensiled with straw. Quarshie (1992) established that when urea is ensiled in addition to straw it adds nitrogen to the straw as well as breaks down lignin in the straw. The improvements in voluntary intake and dry matter digestibility as a result of ammonia and urea treatment have been documented (Quarshie, 1992, Egyir, 1994).

Though rumen microbes are able to synthesize non-protein nitrogen to produce ammonia and amino-acids which can be used by the microbes for synthesis of microbial protein, there is the need to provide an additional by-pass protein to the host animal. By-pass protein or true protein supplement provide amino acids to some rumen microbes and the host animal due to their slow degradability by rumen microbes (Archibeque *et al*., 2001). Supply of amino acids to the microbes in the rumen is important since some classes of organisms generally found in the rumen require peptides or amino acids for development (Mould and Ørskov, 1984).

Low concentration of amino acids in diet may change the rumen ecosystem and may therefore, cause disappearance of some species of microbes in the rumen. Lysine was a potential amino acid limiting growth of rumen bacteria (Atasoglu *et al*., 2004). Addition of amino acids and peptides (dietary protein) will improve growth in cellulolytic and amyolytic bacteria and also increase fibre digestion (Kernick, 1991). Atasoglu *et al.*

(2001) established that cellulolytic bacteria prefer amino acids to nitrogen from ammonia. Marshall *et al.* (2006) therefore concluded that for maximum microbial protein synthesize, some amount of rumen non-degradable protein must be incorporated in ruminant diets.

The rumen environment may not be able to supply sufficient microbial protein to meet the needs of ruminants for maximum production though nutrients may not be a limiting factor in the rumen. Under these circumstances, high scale of production of microbial proteins depends on an added exogenous amino acid supply to the duodenum. Although by-pass protein improved the performance of animals it is often expensive to afford by the poor farmer. Therefore, there is the need to find cheaper ways of providing these escape protein supplements in other to enhance ruminant production. Forages are high in readily degradable nitrogen (NRC, 2000) and some by-pass protein (Archibeque *et al.*, 2001).

2.3.5 Forage trees as supplement to low quality basal diets

Browse plants, particularly the leguminous ones have a substantial capacity to be used in supplementing the diets of ruminant livestock. For instance Adjorlolo (1999) observed a crude protein level of 25% for *Mucuna* leaves and 16.6% for *Mucuna* whole plant. While there is available information about the value of *Leucaena* and *Gliricidia* as feed supplements, there is dearth of information on the many other browses that have shown considerable potential in augmenting the feed of ruminants.

The nutritive value of the basal feed determines the amount of supplement required. Browse plant leaves, specifically *Leucaena* and *Gliricidia*, are being used as dietary supplements together with a variety of other forages and agricultural by-products. They have been combined into various preparations as replacements in place of conventional protein sources (Norton, 1994). Bamualim *et al*. (1984) supplemented spear grass (*Heteropogon contortus*) with *Leucaena* in goats and sheep and recorded an increase in the amount of feed consumed and a general enhancement in the digestibility when feed supplementation is done.

2.3.6 Palatability of browses

Palatability can be defined simply as the total acceptance and relish, with which an animal consumes any given feedstuff or diet. Palatability is basically the result of summation of many different factors sensed by the animal in the process to locate and consume feed. It depends on texture, odour, taste, appearance, and temperature of the feed and in some cases, acoustic properties of the animal. All these factors are in turn, affected by the physical and chemical nature of the feed. The effect on individual animal may be modified by physiological or psychological differences. Factors that affect palatability vary in time and space are also linked to the animal and the plant (Dicko – Toure, 1980). Animals have feed preferences, which lead them to make greater or less use of a particular layer of vegetation. The nutritional or physiological condition of the animal makes it more or less selective.

On the animal side; the palatability of a feed varies according to its chemical composition, its organoleptic qualities and stage of development. For example increasing the level of neem leaf meal in a concentrate fed to sheep resulted in reduced feed intake due to palatability issues such as the bitter taste of the neem leaf. Some forages are consumed when young and snubbed on reaching older stages while others are palatable when scorched and withered than when green (Le Houerou, 1980).

2.4 Anti -nutritional factors and their effects in browses

They are chemical constituents of feedstuffs which interfere with the normal digestion, metabolism and absorption of nutrients. They also limit optimum utilisation of nutrients and can be toxic when present in high concentrations (Harborne, 1993).

Chemical defence is one of the ways by which plants are protected from herbivores. Such chemical defense encompasses the elaboration and accumulation of organic substances in the plant tissue such that when the plant is eaten, in some way deters feeding. These substances may be toxic, may be associated with very unpleasant odour, sometimes confer a bitter taste on the feed and may even have some anti-nutritive factors (Harborne, 1993).

According to Cooper and Owen- Smith (1985), browse forage intake by ruminants is dependent on their preferences. Tree attributes that stimulates animal's selection and browse preferences were either physical (leaf coarse and spines) or chemical defenses (Woodward and Copper 1995, Thapa *et al.*, 1997). Chemical defence is more

significant because woody plants produce a variety of secondary plant metabolites that are not directly involved in primary plant metabolism (photosynthesis, respiration, catabolism and anabolism). Secondary plant metabolites serve to maintain primary metabolism in situations that is not favourable to growth as in the case of attack by mammalian herbivores, insects or environmental stress.

Woody species seems to rely on diverse chemical array of these metabolites as an evolutionary response to browsing by mammals and attack by fungi and microbes (Bryant *et al*., 1991). Secondary plant compounds affect animals and the nutritive value of forages. Most of the compounds produce more elusive effects only noticed in cases of protracted consumption while some produced acute toxicity (Kuamar and D'Mello, 1995) shortly after ingestion, decrease palatability, affects digestive processes, impede growth or damage essential body organ (Jones *e tal.*, 1994). These metabolites are sometimes referred to as deleterious compounds.

Anti-nutritional factors as observed by Haslam (1993) and Norton (1994) carry out their activity within the animal's digestive system by binding to substrate, such as carbohydrates, lipids, minerals, vitamins and protein. Anti-nutrients may inhibit digestive enzymes or become antimicrobial (Scalbert, 1991, Asfari *et al*., 1993). Anti-nutrients compounds include silica, lignin, polyphenols (tannins), phytohaemoaglutins (lectin), oxalates and phenolic amines. Anti-nutrients of significance are the polyphenols (tannins) of which the flavonoids are of significant classes (Harborne, 1993; Ferreira and Bekker, 1996).

The high concentration of condensed tannins in some legume browse species may cause astringency culminating in reduced feed intake and adversely influence their utilisation as protein supplements to low quality roughages given to ruminants during the dry season in tropical regions (Mueller-Harvey, 2006).

2.4.1 Effects of anti-nutrients on nutrient utilisation in ruminants

Reed (1983) reported that animal performance is a crucial factor in determining the nutritive value of different browses whiles smell and taste function as indicators of the presence of secondary metabolites such as essential oils (strong smell and oiliness), tannins (bitter/ astringent) and alkaloids. Many browses contain high levels of tannins though the presence or absence of tannins may not reliably indicate feed quality (Kuamar and Singh, 1984). Intake and utilisation of tree fodder by livestock is affected by the chemical composition of the plant and the animal's physiological capacity to deal with the different nutrients or compounds (Mehansho *et al*., 1987).

High levels of phenolic compounds as well as strong odours in leaves of some tropical trees (*Cassia siamea, some Acacia and Gliricidia sepium* species) reduces palatability and acceptability of the forage (Simons and Stewart, 1994). Tannins do have a harsh astringent taste and produce rough and dryness feel as well as constriction in the palate (Foo *et al*., 1996) Astringency occurs as a result of precipitation of proteins and micro-polysaccharides in mucus secretions and leads to decrease in voluntary feed intake.

Plants that contained more than 5% proanthecyaninidins were rejected by goats as feed during the wet season in an experiment reported by Cooper and Owen-Smith (1985). Tannins tolerance varies between animal species, with goats being the most tolerant followed by sheep then cattle (Provenza *et al.*, 1990; Longland *et al.*, 1994).

Provenza *et al*. (1990) demonstrated that goats did not select against tanniniferous feeds upon their first exposure but did so with some species thereafter. Work done in Ethiopia (Hulet *et al.*, 1986) showed that goats fed on *Acacia seyal* had lower intakes of the browse at beginning of the trial but by the eighth week, the animals were consuming all feed on offer and their daily gain increase to 45g/day.

2.4.2 Effect of anti-nutrients on nutrient digestion

Substrate deprivation and enzyme inhibition by tannins reduces microbial growth, rate and extent of fibre digestion and consequently a reduction in voluntary feed intake, available metabolisable energy and amino acid absorption (Norton, 1994). Rates of ammonia production and urinary nitrogen loss have been reported to be high in animals feeding on low tannins diets and high nitrogen levels (Waghorn *et al*., 1994).

Rapid proteolysis which is not matched by energy supply tends to result in excessive ammonia production. Condensed tannins bind proteins and hinders its breakdown rate in the rumen. However, species containing high levels of proanthrocyanidins may cause lower digestibility with animals excreting more faecal nitrogen than on low to moderate proanthrocyanidins diets (Butler and Rogler, 1992). Lascano (1995) suggested that high

N losses tend to occur when the ratio of tannins to nitrogen is high which the case with most leguminous species. Low apparent nitrogen digestibility means significant loss of potentially available nitrogen through faeces which can limit availability of protein and energy to the animal (Tanner *et al.*, 1990).

2.5 *Samanea saman* (Rain tree) - general description

The rain tree can attain a high between 10 and 25m. The top is widespread and supported by horizontal branches extensively in a canopy form with plumose leaves that produces, outstanding shade, and wood (Staples and Elevitch 2006). The bark is grayish brown rough with flat streaks.

2.5.1 Ecology, distribution and propagation

The raintree grows very well in a wide range of soils in terms of texture and soil pH. It has also been established that the tree can survive excessive soil moisture for a while but does not do well in cold temperatures. Supplementary water application to the young plant is useful but the fully matured plant can withstand some dry conditions. The tree is common in the Americas and widespread throughout the humid and sub-humid tropical areas (Staples and Elevitch, 2006) and can be established either by the use of seeds or through stem and root cuttings (Selvam, 2007).

2.5.2 Chemical composition of Samanea leaf

The average crude protein value of Samanea saman was reported to be 20 % (García *et al*., 2008). The fibrous fraction of the leaves contained 46.3% neutral detergent fibre (NDF), 33.2% acid detergent fibre (ADF) and 14.8 % lignin. The cell wall of the rain tree increases its lignification level from May to October (Ojeda *et al.*, 2012). This factor is essential in nutritional evaluation due to the strong inverse association between lignin and voluntary intake in ruminants (van Soest *et al.*, 1991). The lipid compounds in the leaves is an indication of high energy value in them.

2.5.3 Secondary compounds in the rain tree fruits and leaves

Escobar (1972) detailed that seeds and leaf extracts of *Samanea saman* are tremendously toxic due to the presence of 'Pitecolobina', a toxic alkaloid with abortion-inducing properties in the leaves. Obasi *et al*. (2010) found moderate quantities of saponins, steroids, alkaloids, flavonoids, tannins and resins in a phytochemical sieving of Samanea saman pods. Qualitative and quantitative analyses of tannins in the leaves and fruits confirmed the presence of the condensed type with approximate value of 7.9 % (0.979 g) (Ukoha *et al*., 2011).

2.5.4 Palatability of *Samanea saman* fruits and foliage

The fleshy pods of *Samanea saman* are good fattening forage for grazing animals (Durr 2001). For instance, Delgado *et al.* (2016) reported that cattle fed the leaves only when other pasture was rare, while Conklin *et al.* (1991) categorised as high the palatability

of the leaves in Costa Rica. On the other hand, Lowry *et al.* (1992) reported that in Indonesia goats consumed the leaves routinely.

A cafeteria trial was conducted by García *et al.* (2008) in Venezuela on the preference of young cattle for some forage species such as *Samanea saman, Gliricidia sepium, Trichantera gigantea, Leucaena leucocephala, Moringa oleifera and Azadirachta indica*. *Samanea saman* was among the least consumed (58.72 g DM) daily. In another acceptability study of six legume foliages within six hours of supply in the feeding trough, the *Samanea saman* leaves recorded low consumptions in cattle, sheep and goats compared to *Leucaena or Gliricidia* leaves in cattle and small ruminant species (Pedraza *et al.,* 2003). Nonetheless, in other acceptability studies, using cattle and sheep, no correlation between consumption and the presence of polyphenolic metabolites was reported (Sandoval *et al.,* 2005). This indicates that acceptability is mediated by many factors.

2.5.4 Degradability of Samanea leaves and fruits

Crude protein contents and effective degradability of rumen nitrogen in *Albizia, Erythrina, Erythrina, Gliricidia Leucaena* and *Samanea* was studied by Pedraza *et al.* (2003). The CP values obtained ranged between 23.5 and 27.9% indicating the potential these foliages can contribute in ruminant nutrition. The *S.saman* foliage was noted to have low ruminal degradability of DM (44.7 %) and OM (47.4 %). In vitro intestinal digestibility of nitrogen (34.8 %) was found to be lower compared to *Gliricidia* and *Leucaena* which had values of 69.4 and 65.7 %, respectively.

The seedless fruits of *S. saman* and *E. cyclocarpum* recorded the highest effective degradability with a value of 62% and a high soluble fraction of 55.60 and 49.49% respectively in a study conducted by Cecconello *et al.* (2003). Total digestibility of *S. saman* pods using the in vitro technique for ruminal and intestinal digestion established that it could be as high as 74 % (Conklin *et al.*, 1991). When animals are fed whole pods of *S. saman* as it occurs in natural grazing, most of the intact seeds pass through the digestive tract and are expelled with faeces and this represents a potential nutrient loss for the animal (Janzen, 1983). Seedless pods have high nutritive value that can attain in vitro digestibility of 71% (Conklin *et al.*, 1991; Ceconello *et al.*, 2003). However, whole fruit grinding allows a better utilisation of the nutrients contained in the seeds.

2.5.5 Livestock performance on Samanea leaves and pods

Inadequate intake of good quality feed is one of the main bottlenecks in improving livestock production in the developing economies. Supplementation with ground pods or leaves of *S. saman* increases digestible energy consumption without affecting forage intake (Delgado *et al.*, 2016). The same source also indicated that the concentrate for pigs can be replaced up to 22% with ground pods of *S. saman* without impairing live weight gains. Also, the replacement of 20% of supplement for kids by fruit meal of *S. saman* did not affect their growth. However, 30% substitution adversely influenced weight gain. Thole *et al.* (1992) reported that 10 and 20% inclusion of the fruit meal of *S. saman* in the diet of heifers did not affect their development.

There was weight increase of 4.1 to 5.1% when *S. saman* ground or whole fruit 15 or 30% inclusion was added in the diet of dual-purpose cows under grazing. Milk production was also increased between 0.5 to 1.1 L/cow/d. Pregnancy was as well higher with a value of 16.6% (Roncallo *et al.*, 2009). Other studies carried out in buffaloes indicated that the supply of 2 kg of *S. saman* pods as supplement to a basal diet of rice straw was sufficient to maintain their weights during the whole dry season (Seedtakoses *et al*., 1988). The balance between the glucogenic and acetogenic short chain fatty acids in *S. saman* pods and leaf meal augments animal performance (Navas *et al.,* 2001). Rations containing 40% of *Samanea saman* leaf meal increased consumption from 1.9 to 2.6% live weight and feeding performance was improved (Chumpawadee and Pimpa, 2009).

2.6 Eucalyptus species

Eucalyptus camaldulensis also known as the river red gum, is widespread in the Australian continent (Singab *et al.*, 2011). It is a tall non-deciduous tree that also grows in many parts of in Asia, Africa, Europe and the Americas (Sallam *et al*., 2009). Its leaves contain some antioxidants (Singab *et al*., 2011), cytotoxic (Singab *et al.*, 2011; Meshkani *et al.*, 2014), larvicidal (Medhi *et al*., 2010), pesticidal (Batish *et al.*, 2008) and anti-dermatophytes (Falahati *et al.*, 2005) properties.

2.6.1 Chemical composition of *Eucalyptus camaldulensis* leaf

Literature indicated the purification of some chemical ingredients from different parts of *E. camaldulensis* which include eucalyptanoic acid (Begum *et al.,* 2002), flavonoids (Abd-Alla *et al*., 1980), acylated pentacyclic triterpenoids and essential oils (Gakuubi, 2016).

Sallam *et al. (*2010) also reported that *Eucalyptus camaldulensis* fresh leaves had the values 7.64%, 61.62% and 50.4% for crude protein, neuter detergent fibre and acid detergent fibre respectively. Also, in an earlier report by Salem *et al.* (2006) the values obtained for *Eucalyptus camaldulensis* leaf for crude protein, neutral detergent fibre and acid detergent fibre were 15.4% 61.5% and 54.2% with *Eucalyptus* essential oil containing 15.5ml/kg DM. The chemical composition of Eucalyptus depends on the type and nature of the constituents and their individual concentration with different species, season, soil type and age of the leaves (Brooker and Kleinig, 2006).

2.6.2 Secondary plant metabolites in *Eucalyptus camaldulensis* leaf

The major components of *Eucalyptus camaldulensis* include ethanone (13.73%), eucalyptol (25.36%) and caryophyllene (11.55%) (Akin *et al.,* 2010). Eucalyptol (1.8-cineole) is the main active ingredient in Eucalyptus oil (Sallam *et al*., 2009). Lately, the in vitro studies have demonstrated that *Eucalyptus* essential oils or their components have the potential to favourably alter rumen metabolism (Busquet *et al.,* 2006). However, there are few experimental data on effects of *Eucalyptus* on rumen digestion and rumen ecology.

2.6.3 Effect of Eucalyptus leaf meal on feed intake and digestibility

Sallam *et al*. (2010) conducted a study and found that essential oils are the volatile constituents responsible for some of the distinctive aroma of foliage species that may have negative effects on DM intake. Salem *et al.* (2000) on the other hand reported that secondary compounds, mostly phenolics could act by lowering foliage palatability by their sharp bitterness that binds to salivary proteins in the mouth and or adverse effects on gustative receptors. Sallam *et al.* (2009) used Eucalyptus essential oils as a supplement and observed a slight decrease in dry mater and organic matter digestibility at high levels of inclusion, however, they confirmed the decrease was not significantly different compared to the control.

Others also confirmed increase in gas production through *in vitro* incubation for some plant extracts of which Eucalyptus was among such species rich in secondary metabolites (Sallam *et al*., 2010).They attributed the increase in gas production to low or moderate content of secondary metabolites to have positive impacts on rumen fermentation (Salem *et al.*, 2014). The rumen microorganisms may have the ability to utilize the secondary metabolites as an energy source and that led to the increase in gas production (Hart *et al.*, 2008 and Salem *et al.*, 2014).

Reports in some studies indicated that the amylase and lipase present in *Eucalyptus camaldulensis extracts* may be of use to support fibrolytic microbes in the rumen by acting to increase the proximity between substrates and microbes (Morgavi *et al.*,

2000). A favourable rumen environment can stimulate bacterial activity thereby causing faster fermentation rate and substrate degradation (Castillejos *et al*., 2007).

A different trend was conversely observed *in vivo* for cattle that received *Eucalyptus camaldulensis* as supplement to rice straw (Manh *et al*., 2012). The authors indicated that Eucalyptus addition did not affect digestibility coefficient.

According to Patra and Yu (2012), essential oil derived from *Eucalyptus* reduced the methane production *in vitro*. Similar results have been obtained on cows receiving 100 g/day of Eucalyptus leaf meal (Manh *et al.*, 2012) and the conclusion was that Eucalyptus leaf meal can be used to ameliorate methane emission in cattle without adversely affecting nutrients digestibility.

2.7 *Ficus exasperata:* Distribution, description and importance

Ficus exasperata is a member of the family Moraceae, it is ordinarily called sand paper tree. *Ficus exasperata* is a small tree with scabrous, ovate leaves that grows up to about 20m tall and prefers evergreen and secondary forest habitats. The lateral veins ranges 3-5 pairs with a basal pair branched that reaches a margin at or above middle of the lamina. The petiole is about 0.5 to 4cm long while the stipules ranges from 0.2 to 0.5m long. Figs are found either solitary or in pairs in the leaf axils and rarely on older wood.

The sand paper tree bears figs which usually appear in pairs in the leaf axils. The bark of the tree is smooth, grayish cream with brown streats that exudes gummy sap. The

plant usually grows well in evergreen forests and forest margins. However, it also does well in secondary forest and riverine vegetation. It is widespread in tropical Africa, from Mozambique, Zambia, and northern Angola to Senegal and Ethiopia and also in the southern part of the Arabian Peninsula and India. The plant also thrives well in the rain forest regions of West Africa (Gbile and Adesina, 1986).

The leaf extract is reported to have multiple medicinal importance among which include treating hypertensive patients, haemostative, ophthalmia, coughs and haemorrhoids (Buniyamin *et al.*, 2007; Odunbaku *et al*., 2008). The root bark is reported to have been used in the treatment of high blood pressure (Lawal *et al.*, 2009). The leaf is used to scratch skin parts affected by ringworm while the grounded leaves are normally used to treat boils (Okoli *et al.*, 2007). Also, the young leaves are prescribed as a common anti-ulcer remedy (Adebayo *et al.*, 2009). Anti-diabetic, lipid lowering and anti-fungal activities have been reported for *Ficus exasperata* (Sonibare and Effiong, 2008).

Sand paper tree leaves are used to polish wood, stabilises vegetable oils, suppresses foaming, use as supplement and acts as antimicrobials (Odunbaku *et al.*, 2008). The sap is used to stop bleeding in Ghana (Abbiw, 1990). The boiled bark liquid is given to cows to hasten the expulsion of the after birth (Hallan, 1979). In Southern Africa the scraped bark is used to embrocate the body (Burkill, 1997).

2.7.1 *Ficus exasperata* leaves as feed for livestock

Ficus exasperata produces leaves which contain about 14% crude protein (Rothmans *et al*., 2006). They are consumed by elephants, gorillas and other primates (Burkill, 1985; Rothman *et al.,* 2006). In Ghana the leaves are cut and fed to sheep, goats and rabbits.

Baah *et al*. (2011) reported that *Ficus exasperata* leaf meal significantly improved the nutritive value of cassava peels fed to sheep. Ijeh and Ukwemi (2007) reported ant-nutritional factors such as alkaloids, tannins, saponins and cyanogenic glycosides which could potentially have adverse effects on nutrient utilisation by chickens and consequently their performance.

2.8 Acacia species

Acacia auriculiformis is a vigorously growing, deciduous tree that can attain a height of 30m. It belongs to the family Mimosaceae and it is found to be rich in galactose, arabinose, rhamnose methylglucuronic acid and glucuronic acid (Anderson *et al.,* 1978). Reports indicated that *Acacia auriculiformis* contains 91.30% DM, 20.16% CP and 4.50% ash (Devendra and McLeroy, 1982). It has been reported that the tree has central nervous system – depressant, spermicidal and filaricidal activities due to the presence of tannins and triterpenoid saponins (Garai and Mahato, 1997).

2.8.1 Secondary plant metabolites in *Acacia auriculiformis* leaf

The major components of *Acacia auriculiformis* include tannins and triterpenoid saponins. The phenolic compounds are one of the largest and most ubiquitous groups of plant metabolites that possess an aromatic ring bearing one or more hydroxyl constituents (Atoui *et al*., 2005). Current interest in them stems from their antioxidant, anti-inflammatory, antimutagenic and anticarcinogenic activity (Atoui *et al*., 2005). Phenols and polyphenols exert their protective effects through diverse mechanism like preventing the formation of carcinogens from precursor substances by acting as blocking agents or suppressing agents (Lesca, 1983; Tatsuta *et al.*, 1983).

2.8.2 Animal responses to tannins in Acacia species

Not all secondary metabolites are equally effective as defence against browsing because most ruminants have evolved anatomically, physiologically and behaviourally to counter their effects (Palo and Robbins, 1991). These include detoxification of tannins in the oral cavity, the digestive tract and in the post absorptive tissue, particularly the liver, and avoidance (Scalbert, 1991).

Animals avoid tanniniferous browses whenever possible (Provenza *et al.,* 1990). The content of proanthocyanidins in *Acacia nigrescens* foliage increased within a short time of browsing by animals. The animals avoided the high concentrations by reducing browsing time on the particular species (Furstenburg and Van Hoven, 1994). Browsing animals such as goats have praline rich salivary proteins which bind tannins, allowing the animals to feed on tanninferous trees and shrubs (Palo and Robbins, 1991). Praline

binding to salivary proteins reduces the adverse effects of tannin on palatability and feed intake as well as reducing the post ingestive effects (Inhibition of digestive enzymes). *Acacia angustissima* was toxic to sheep when fed without adaptation at levels higher than 50 g per day (Smith *et al.*, 2001).Weaning rats fed a diet supplemented with 7.5% *A. angustissima* had reduced intake and average daily gain (ADG) (4.5 and -0.8 g/d) when compared to rats fed a diet containing 7.5% *Medicago sativa* (6.8 and 2.4 g/d).

2.9 Cassava peels

Cassava peel is an agro-industrial by-product obtained during processing of 'gari'. The peels are important source of energy in ruminant diets. Baiden and Obese (2010) indicated that it contains 88% dry matter, 3.9% crude protein, 12.5% crude fibre 23.9% ADF, 34.3% NDF and 6.5% Ash.

2.9.1 Toxic factors in cassava

Fresh cassava contains high level of cyanogenic glycoside. The normal range of cyanoglucosides content in fresh roots is from 15-400 mg/kg fresh weight. The cyanoglucosides varies with cultivars with some low HCN content of 10 mg/kg or very high HCN content of 2 000 mg/kg. Cassava is classified as "bitter or sweet" taking into consideration the level of cyanide present. However, the bitterness or sweetness cannot exactly be correlated with the level of cyanogenic glycosides (IFAD and FAO, 2004).

The cyanogenic glycosides in cassava (linamarin and lotaustralin) on hydrolysis release hydrocyanic acid (HCN). Safety limit for cyanide in cassava food is 10 mg/kg dry weight and levels below 100 mg/kg dry weight are considered safe in cassava chips for feeding to different classes of livestock (FAO and IFAD, 2004). Sun drying, ensiling and fermentation can reduce the glycosides concentration to levels that can be tolerated by animals (Smith, 1988).

2.9.2 Effect of cassava peels supplementation on voluntary intake and weight gain

The use of cassava peels in feeding small ruminants by famers is popular. Conversely, feeding peels alone as a sole diet has been discouraged due to its low crude protein content and the bulky nature of the peels resulting in low dry matter intake. Baah *et al.* (2011), observed an increase in dry matter intake from 44 to 58g $W^{0.75}$/d in West African Dwarf sheep when cassava peels was supplemented with *Ficus*.

Supplementation has since been documented by several authors as increasing the total dry matter intake. Supplementation can result in substitution of the basal diet depending on the level of the supplement offered. There has been a reduction in intake of the basal diet (grass) as intake of cassava peels increased, however there was an overall increase in total dry matter intake observed in a number of studies with sheep (Pham and Preston, 2009); Lakpini *et al*., 1997; Adegbola *et al.,* 1988).

The increase in dry matter and organic matter intake when cassava peels were given as a supplement was due to the readily fermentable carbohydrates supplied by the peels (Fahey and Berger, 1988). These fermentable carbohydrates help in the utilisation of rumen nitrogen and as a result stimulated microbial activity.

Ifut (1987), concluded that the increase in intake as a result of using cassava peels as a supplement is reflected in the overall weight gain of animals. This is supported by the work of Adegbola (1988) when he fed sheep with diets consisting of 100% *Gliricidia*, 20% *Gliricidia*, and 80% dried cassava peels and observed that animals on the dried cassava peels based diet plus *Gliricidia* had high weight gain compared to those on the sole Gliricidia diet. Grazing cross-bred cattle were fed with supplement made up of molasses and dried cassava peels at 0.7% of body weight, for about six months. Weight gains recorded were 0.07 kg/day for control (cattle grazed with no supplement), 0.29 kg/day for diet supplemented with dried cassava peels (Larsen and Amaning-Kwarteng (1976). Weight gain as a result of supplementation with cassava peels depends on the

level of supplementation. The higher the level of intake the higher the weight gains (Fomunyam and Maffeja, 1987).

2.9.3 Effect of cassava peels supplementation on nutrient digestibility

There was an increase in dry matter and crude protein digestibility when cassava peels was used to supplement elephant grass in the diets for sheep with cotton seed as the main source of nitrogen (Fomunyam and Maffeja, 1987). Supplementing Gliricidia with cassava peels led to higher organic matter and dry matter digestibility compared to feeding Gliricidia as a lone diet (Ifut, 1987). Though Gliricidia as a sole diet guaranteed a high crude protein digestibility and increased nitrogen intake, but when it was supplemented with cassava peels in a ratio of 70% Gliricidia to 30% cassava peels there was increase in nitrogen retention and neutral detergent fibre digestibility (NDF). This difference might be attributed to the readily available carbohydrate supply by the cassava peels to the rumen microbes to provide energy to enhance digestibility. Activated rumen microbes led better degradability of fibre hence the high NDF digestibility observed in the study.

2.10 Haematology

Haematology involves the study of blood cells namely erythrocytes, leukocytes and thrombocytes (Manual of Basic Techniques for a healthy Laboratory, 2003). Haematological studies are good indicators of the nutritional and physiological status of livestock and are also essential in diagnosing diseases (Onyeyili *et al*., 1992; Khan

and Zafar, 2005; Togum *et al*., 2007). Breed, age, sex, and environment are important factors that affect haematological parameters (Etim *et al*., 2014).

2.10.1 Haemoglobin

Haemoglobin is a large complex, biomolecule made up of four polypeptide chains. An iron-containing porphyrin termed haem is bound to each polypeptide chain which is responsible for the transport of oxygen (Baker *e tal.,* 1971). Haemoglobin is the pigment found in the erythrocytes and it responsible for carrying oxygen from the lungs to the body tissues and cells (Frandson, 1986). The normal physiological values of haemoglobin in sheep ranged from 9 to 15 x 10g/L (The Merck Veterinary Manual, 2010). Low concentration of haemoglobin below normal is indication of anaemia (Frandson, 1986).

2.10.2 Packed cell volume (PCV) or haematocrit value

Packed cell volume (PCV) is a measure of a given unit of blood constituted by cells. It is related to levels of erythrocytes counts (Frandson, 1986). The normal PCV values in sheep ranged from 27 to 45% (The Merck Veterinary Manual, 2010). When the PCV value is too high then it is an indication of haemoconcentration (that is the ratio of red cells to fluid is above normal). Excess loss of water due to diarrhea or low intake of water may lead to haemoconcentration as postulated by Frandson (1986).

Packed cell volume and haemoglobin levels are positively correlated (Quinto *et al.*, 2006 as cited by Turkson and Ganyo, 2015) and factors such as season, sex, breed, and physiological state which affect haemoglobin have also been observed to affect PCV levels. Packed cell volume values are correlated with high red blood cell count (Frandson, 1986) which in turn is associated with more oxygen being carried to the

tissues for oxidation to supply energy (Frandson, 1986). Changes in the concentrations of blood components of ruminants have been used both as an index of metabolic disturbance, toxicity and as a criterion of nutrient status and nutrient value of feeds (Church and Gilbert, 1984; Puoli *et al.*, 1992).

2.10.3 Total erythrocytes (Red blood cells) count

The RBCs are round/oval biconcave cells that contain haemoglobin. They do not contain nuclei. Erythrocytes carry haemoglobin which carries oxygen from the lungs to the tissues during respiration (Etim *et al.*, 2014). Carbon dioxide from the tissues are carried backed to the lungs through the erythrocytes thus, removing the major end-products of organic substances (The Merck Veterinary Manual, 2010). Reduced red blood cell count may imply a reduction in oxygen level that would be carried to the tissues as well as carbon dioxide level returned to the lungs (Ugwuene, 2011).The normal physiological range of red blood cells for sheep is 10.63 to 11.94 x 10^{12}/L (The Merck Veterinary Manual, 2010).

2.10.4 Mean cell volume (MCV)

The MCV is a measure of the average red blood cell size stated as part of standard complete blood count. It permits the classification of anaemia as either normocytic anaemia (MCV within normal range) or macrocytic anaemia (MCV above normal range) or microcytic anaemia (MCV below normal range). The normal physiological range is 28 to 40 fl for sheep (The Merck Veterinary Manual, 2010).

2.10.5 Mean cell haemoglobin (MCH)

The MCH is the average mass of haemoglobin per red blood cell in a sample of blood. Normal physiological MCH for healthy sheep is 8 to 12 pg (The Merck Veterinary Manual, 2010).

2.10.6 Mean cell haemoglobin concentration (MCHC)

The MCHC is a measure of the concentration of haemoglobin in a given volume of packed red blood cells. It is calculated by dividing the haemoglobin by the haematocrit. Normal physiological range of values of MCHC for sheep is 31 to 34 g/dL (The Merck Veterinary Manual, 2010).

2.10.7 Total leucocyte count

Leucocytes are nucleated cells in the blood which act as a defense mechanism. Leucocytes are of two main types namely:

- Granulocytes which consist of neutrophils, eosinophils and basophils
- Agranulocytes that comprise monocytes and lymphocytes

The neutrophils are phagocytic and can engulf bacteria or any foreign matter. The eosinophils detoxifies toxins produced by bacteria and parasites foreign proteins as well as foreign proteins introduced into the body through the lungs or the lower gut (gastro intestinal tract). Basophils encompass heparin (anti-coagulant) that is released in an inflammatory areas to prevent clotting and stasis of blood and lymph (Schalm *et al.*, 1975). The monocytes are also phagocytic that engulf bacteria and other foreign matter.

The lymphocytes on the other hand form antibodies in the blood in response to antigen thus protecting the body against foreign matter (Coles, 1967) and Frandson (1986).

2.11 Blood biochemistry

Blood chemistry encompasses the study of the chemical components in the blood. This chemical constituents include proteins, triglycerides, cholesterol, glucose, urea and enzymes (such as alkaline phosphatase, glutamic oxaloacetic transaminase) and minerals including sodium, potassium among others.

Blood biochemical values provide information and realistic evaluation of management practice, nutritional and physiological status of an animal as well as the diagnosis of health condition (Osman and Al-Busadant, 2003). Factors such as age, breed, sex, seasonal variation, nutrition and physiological status influence blood biochemical parameters (Cjodova' *et al.*, 2016).

2.11.1 Serum proteins

Plasma proteins include albumen, globulin and fibrinogen (Coles, 1967). Plasma proteins have nutritive functions such that nitrogenous requirement of a fasted animal can adequately be supplied by intravenous administration of plasma proteins (Breazile, 1971).

Blood protein concentration have been observed to assist in regulating cellular activities, functions and transports hormones, lipids, enzymes vitamins and metals

(Quintavalla *et al*., 2005). Blood total protein including albumin is primarily responsible for maintaining the pressure of plasma and is used to transport many substances including macromolecules and the maintenance of normal water distribution between tissue and the blood (Rastogi, 2008). High serum total protein value is an indicative of high quality protein present in the animal's body (Tewe, 1985). The normal physiological range of total protein values for sheep is 59 to 78 g/L (The Merck Veterinary Manual, 2010).

Albumin aids in keeping the blood from leaking out of the blood vessels and its concentrations below 2g/100ml, are associated with oedema (Rastogi, 2008). A normal physiological range of 23 – 40g/L is reported by the Merck Veterinary Manual (2010) in sheep. Some globulins are secreted by the liver while other globulins are developed by the immune system of the animal. Some of these globulins have the capacity to form a complex with haemoglobin in order to carry metals such as iron in the blood stream and help ward of impending infections (Rastogi, 2008).

Globulins are known to transport the lipid portion of proteins and this contains some antibodies that are responsible for generating immune response (Rastogi, 2008). The normal globulin level in sheep is reported to be 32 to 50 g/L (The Merck Veterinary Manual, 2010).

2.11.2 Cholesterol

Cholesterol is a waxy steroid of fats (Sadava *et al.*, 2011). It is an important component of the mammalian cell membrane and is required to establish proper membrane permeability and fluidity. It is similarly an essential element for the manufacture of steroid hormones, vitamin D and bile acid. Cholesterol is synthesised predominantly in the liver. Cholesterol exists in the blood as a free sterol in an esterified form. Knowledge of the plasma levels of lipids (triglycerides and cholesterol) together with lipoproteins of low and high density aid in the detection of many conditions associated with metabolic disorders of high risk. Lewington *et al.* (2000), termed abnormally low cholesterol levels as hypocholesterolemia. Normal range of total levels of cholesterol stated for healthy sheep is 1.1 to 2.3mmol/L (The Merck Veterinary Manual, 2010).

2.11.3 Blood urea

Urea is the primary end product of catabolism of proteins. High blood urea concentration is associated with impairment of renal functions such as uremia (Coles, 1967; McDonald *et al.*, 1993). Normal blood urea value for a clinically healthy sheep ranges from 3.7 to 9.3mmol/L (The Merck Veterinary Manual, 2010).

2.12 Challenges for small ruminant production in the Accra Plains

Small ruminant production is popular in the Accra Plains of Ghana. The animals provide meat as protein source, help in the generation of income and play socio-economic roles (Baiden and Obese, 2010). Their production however is hampered by

scarcity of quality feed resources especially in the dry season which results in loss in body weight and condition, poor growth rates, poor reproductive performance and health issues. Also poor management practices and housing conditions contribute to this poor performance.

There is therefore the need to ascertain the various feeding and management practices in the Accra Plains to enable the development of feed supplementation and management strategies to improve the performance of small ruminants in the Coastal Savvana Zone in Ghana. This led to the conception of the following studies:

1. To assess practices involved in small ruminant production in the Accra Plains and
2. To select some commonly fed browse plants available to farmers and develop supplementary feed packages to improve productivity of sheep.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study one: Survey on small ruminant production in the Accra Plains

3.1.1 Study area

The survey was conducted in Ga East, Ga West, Ga Central, Shai Osu-Doku and Ada West Districts (Figure 3.1) of the Greater Accra Region. All of these districts lie within the Accra plains in the Coastal Savannah zone of Ghana. The districts were purposively selected based on prevalence of small ruminant farmers and this was made possible by an earlier information from interaction with Extension Agents of the Ministry of Food and Agriculture.

3.1.2 Enumeration Procedure

Quantitative survey was carried out using the Feed Assessment Tool (FEAST) of the International Livestock Research Institute (ILRI) (Duncan *et al.,* 2012). The Feed Assessment Tool was chosen because it makes room for extensive analysis of livestock management systems and helps in identifying peculiar production constraints and prospects. This tool comprises participatory rural appraisal (PRA) and a semi-structured questionnaire for individual and small group interviews to capture information on small ruminant production. The interviews involved issues on socio-economics, crop and livestock husbandry practices, available and alternative feed resources, production constraints/opportunities and training in livestock production. The participating farmers were purposively selected based on earlier information from interaction with key community informants (Ministry of Food and Agriculture Extension Agents) through which livestock farmers were identified. In each district, 20

farmers were selected for the PRA, giving a total of 100 farmers in all the five districts. The questionnaire used is indicated in appendix 27.

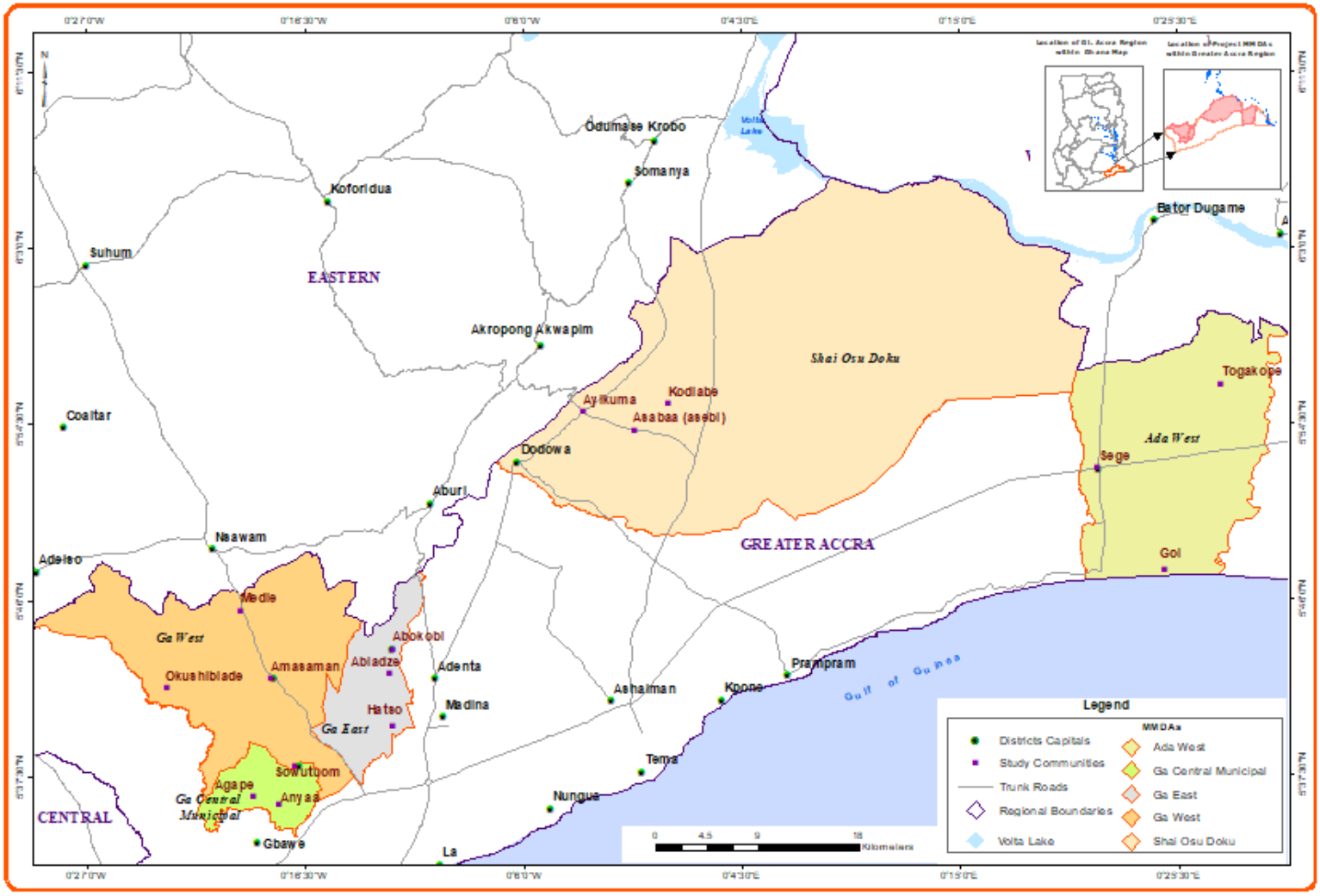

Figure 3.1: Map showing the study areas

3.2 Study 2: Intake, digestibility and growth response of sheep fed Andropogon grass hay and Samanea, Acacia and Ficus leaf meal supplements

3.2.1 Study area

This study was conducted at the Livestock and Poultry Research Centre (LIPREC) of the School of Agriculture, College of Basic and Applied Sciences, University of Ghana, Legon, from February, 2019 to May, 2019.

LIPREC is located within the Coastal Savannah zone on latitude 05040'N and longitude 00016'W. The mean monthly temperature is 26^0C. The area is covered by natural grassland of medium tussock growth with scattered fire resistant trees and shrubs (Osei-Amponsah, 2010; GSS, 2014).

3.2.2 Experimental animals and their management

Eight West African Dwarf sheep with a mean liveweight of 14.9 ± 1.5kg, were used for the studies. The animals were housed in individual well-ventilated and properly illuminated pens which had cemented floors. The housing unit had roofs made of corrugated iron sheets. The pens were 3m x 1.5m in dimension. The pens were thoroughly cleaned and disinfected prior to the introduction of the animals. Feed and water troughs were washed and disinfected. Each pen had one wooden feeding trough for the basal diet designed to minimise spillage and two plastic troughs, one for the supplement and the other for water. All the animals were treated against external

parasites with pour-on acaricide and dewormed with Albendazole (10%), a broad-spectrum anthelmintic.

3.2.3 Preparation of experimental diets

Leaves of three browse plants (*Samanea saman, Acacia auriculiformis* and *Ficus exasperata*) which were identified (Table 4.1.1c) to be commonly fed by farmers to small ruminants in the five districts surveyed were harvested from trees around LIPREC. Apart from these three browses cassava peels were also commonly fed. The browse species and cassava peels were selected based on the frequencyof usage by respondents. They were shade dried for 4 to 6 days and the leaves were separated from their twigs. All the leaves were ground in a hammer mill (1-m screen) to form the browse plant leaf meals. Cassava peels were bought from cassava processors, sun-dried and ground in a hammer mill (1-mm screen) to form cassava peel meal. The peels were intentionally chosen to serve as energy source and as a control to the leaf meal diets. The dried cassava peel meal and the leaf meals were mixed with conventional feed ingredients and micro-nutrients to form four concentrate supplements (Table 3.2.1). The experimental diets were made isonitrogenous and pelleted.

Table 3.2.1: Ingredient composition of supplements used in the acceptability study

	Supplements			
Ingredients: (g/kg)	1	2	3	4
Maize	159	124	165	0
Wheat bran	120	135	108	650
Mineral salt	5	5	5	5
Dicalcium phosphate	5	5	5	5
Sulphate of ammonia	5	5	5	5
Urea	6	26	12	15
Cassava peels	0	0	0	320
Samanea saman	700	0	0	0
Acacia auriculiformis	0	700	0	0
Ficus exasperata	0	0	700	0
Total (kg)	**1000**	**1000**	**1000**	**1000**
CP	160.6	160.1	160.7	160.7

1 = Samanea leaf meal concentrate; 2 = Acacia leaf meal concentrate

3 = Ficus leaf meal concentrate; 4 = Cassava peel meal concentrate

Each treatment has Andropogon hay basal diet

3.2.4 Acceptability study

Four female West African Dwarf (WAD) sheep with an average live weight of 13.7 ± 1.5kg were used for this trial. Each animal was penned individually and given free access to fresh water. Each sheep was offered the four supplements at the same time in a refectory style at 08:00 hours each day and were allowed one hour to select. After the

one hour, the refusal was deducted from the feed offered to determine the amount of each supplement consumed. The *Andropogon gayanus* hay which acted as the basal diet was then offered *ad libitum.* The adjustment period was 14 days followed by a data collection period of seven days. The ingredient composition of supplements used in the acceptability study is detailed in Table 3.2.1.

3.2.5 Voluntary feed intake and growth studies

Eight female WAD sheep with an average initial body weight of 14.9 ± 1.5kg were randomly allotted to four experimental diets in a replicated 4 x 4 Latin square design. This means at the end of the study eight sheep were assigned to each of the four test diets. They were offered grass hay as basal diet and either of the four supplements (pelleted concentrate) as shown in Table 3.2.1.

Treatment 1 (T_1) = Grass hay + Samanea leaf meal concentrate

Treatment 2 (T_2) = Grass hay + Acacia leaf meal concentrate

Treatment 3 (T_3) = Grass hay + Ficus leaf meal concentrate

Treatment 4 (T_4) = Grass hay + Cassava peel meal concentrate

Each sheep was housed individually with unrestricted access to clean drinking water. A daily supplement allowance of approximately 25% of voluntary intake was offered as single meal at 08:00 hour followed by the grass hay offered *ad libitum* in a replicated 4 x 4 Latin square design after ensuring that the sheep have consumed all the supplements. The grass hay was weighed before and after feeding to ascertain daily

feed intake. The animals were allowed 14 days to adjust to the diet and was followed by 74 days of actual data collection. Feed intake was determined daily and body weights were recorded fortnightly throughout the study.

Feed intake was calculated as: Weight offered – Weight of residue.

Average daily gain was calculated as: $\frac{\text{Final weight of sheep} - \text{Initial weight of sheep}}{\text{Number of days of study}}$

Feed conversion efficiency was calculated: $\frac{\text{Feed intake (g)}}{\text{Weight gained (g)}}$

3.2.6 Digestibility study

Rectal faecal samples were taken from each of the eight sheep used in the feed intake study and bulked for each sheep for six days. The faecal samples were stored in a refrigerator. The faecal samples were then oven dried at 55℃ for ten days to a constant weight for dry matter (DM) determination. The dried faeces were ground using a laboratory mill through 1mm sieve and labelled respectively for subsequent analysis.

Apparent digestibility (AD %) of dry matter, crude protein, neutral detergent fibre, acid detergent fibre, and organic matter were calculated as:

$$100 - (100 * (\frac{Lignin\ in\ feed}{Faecal\ lignin}) \times (\frac{Faecal\ lignin}{Total\ dry\ matter\ intake})) \text{ (de Oliveira } et\ al.\text{, 2012)}$$

Lignin was used as internal marker.

3.2.7 Chemical analysis of feed and faeces

Dry matter, crude protein, and ash for the feed and faeces were determined using the method of AOAC (2004). Neutral detergent fibre (NDF), acid detergent fibre (ADF), lignin, cellulose, hemicellulose and silica were determined using the method of Van Soest *et al.* (1991). Organic matter was determined as dry matter minus total ash (AOAC, 2004). Hemicelluloses were calculated as the difference between NDF and ADF.

3.2.8 Blood sampling

Blood samples were collected every two weeks (week 1, 3, 5, 7 and 9) from the jugular vein of each sheep (used in the intake and digestibility study) using a vacutainer needle between 07:30 and 08:00 hours. A total of 10 ml of blood sample was collected with 4 ml being transferred into a glass vacutainer tube containing the anticoagulant tripotassiumethelyne diamine tetra acetic acid (K3.EDTA).The tubes were placed in a cold box containing ice packs and transported immediately to the Laboratory for haematological parameters such as Hb, PVC, total RBC, WBC and their differentials. The remaining 6 ml was transferred into glass vacutainer tubes containing clot (Gel) activator. This was placed on ice pack and also transported to the Laboratory where it was centrifuged at 3000 rpm for 10 minutes at 4 ^{0}C using the Centaur 2 centrifuge. The sera obtained were gently harvested into Eppendorf tubes and stored at -20 ^{0}C until the analysed for biochemical indices such as glucose, total protein, albumin, globulin, total cholesterol and urea.

3.3. Haematological analysis

3.3.1 PCV (Haematocrit) determination

The PCV was determined by the Microhaematocrit method (Samour, 2006) using the Hawksley Micro-haematocrit Reader (Hawksley, London). The blood sample from each sheep after proper mixing was sucked into plain micro-capillary tube to about three-quarters full. One end of each filled tube was sealed with plasticine. The filled micro-capillary tubes were subsequently arranged in the numbered grooves of the microhaematocrit rotor with the sealed ends facing the rim gasket (Plate 3.1). The microhaematocrit tubes were spun at 12,000g for 5 minutes using the micro-capillary centrifuge.

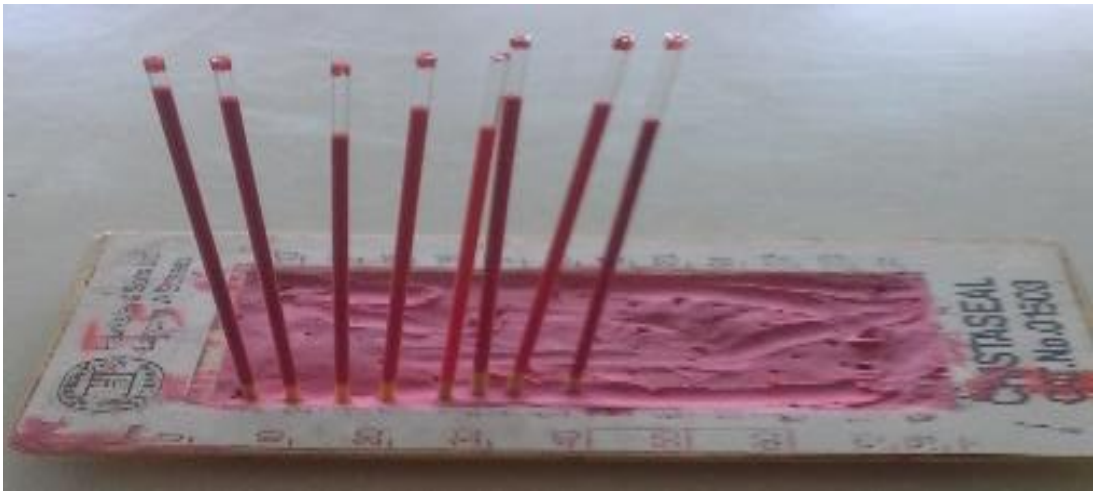

Plate 3.1: Whole blood in microhaematocrit tubes before spinning

After spinning, three distinct layers were observed in the tubes; the plasma layer, the buffy coat and the red cell column (Plate 3.2). Each tube was carefully positioned in the slider slot such that the demarcation between the sealant and the red column was on the zero mark (base line). The tube holder was slid until the mark on top the plasma

column was in line with the top line (100 marks). The knob was adjusted until the middle line passed through the top of the RBC column. The PCV was read on the scales on the right corresponding to the middle line on the Hawksley Micro-haematocrit reader (Hawksley, London).

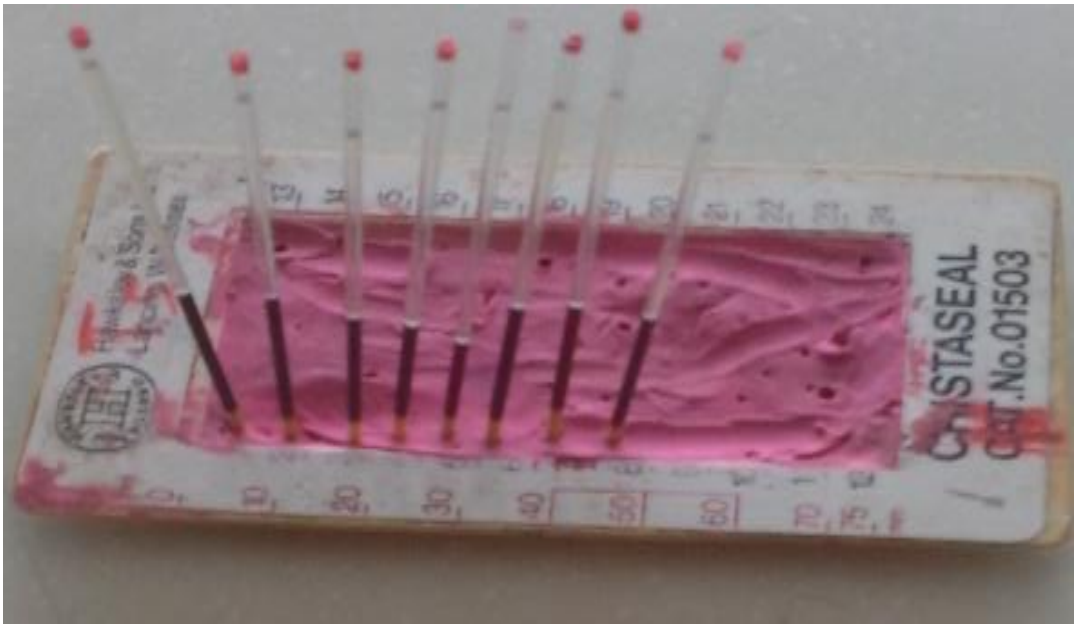

Plate 3.2: Microhaematocrit tubes after centrifugation

3.3.2 Hb determination

The Cyamethaemoglobin method was used to determine Hb concentration (Gillet *et al.*, 2009). Drabkin's solution with a pH 9.6 was used. Five millilitres of the Drabkin's solution was measured using a pipette into a labelled empty test tube. Twenty (20 µL) of whole blood was pipetted and added to the test tube containing the Drabkin's solution to give a 1:250 dilution. The mixture was mixed thoroughly and allowed to stand for about 5 minutes. A blank was used to zero the spectrophotometer and the absorbance values read on a CECIL1000 Series Spectrophotometer (Cecil Instruments, England)

at a wavelength of 540 nm. The haemoglobin was estimated from a standard calibration curve.

In preparing the calibration curve, Cyanmethaemoglobin standards were obtained from Randox Laboratories Limited (Co. Antrim, U.K) and the four standard solutions had the following values corresponding to blood haemoglobin concentration 5.0, 10.0, 15.0 and 20.0 g/dL. The absorbance of these standard solutions was read against distilled water at room temperature at a wavelength of 540 nm. Absorbance values were plotted against haemoglobin concentration and the blood haemoglobin concentrations (g/dL) determined.

3.3.3 Total cell counts (RBC and WBC) determination

The RBC cell counts was determined using formol citrate solution for RBC and the Tuerks solution for the WBC counts (Baker *et al.*, 1971). Twenty (20 µl) of whole blood was aspirated using micropipette and dispense into the tubes using a pipette; the chambers of the improved Neubauer haemocytometer was carefully filled and allowed to stand for five minutes so that the cells can settle down. The counting was done using a light compound microscope at x40 objective magnification. The nuclei of the large oval RBCs was stained violet, and the cytoplasm stained light. The RBCs was counted in the four squares at the corners of the haemocytometer.

Total RBC count was determined using the formula given by Samour (2006):

$$\text{RBC } (10^{12}/\text{L}) = \frac{N}{100}$$

Where:

L= Litre

N = Number of cells counted in 160 small squares

Cells contained in the four outer large squares of the haemocytometer was counted and the total WBC counts was estimated using the formula given by Campbell (1994):

$$\text{WBC } (10^{9}/\text{L}) = \frac{N \times 10 \times 200}{9}$$

L= litre

N = number of cells counted in nine small squares

3.3.4 Determinations of RBC indices

The RBC indices were computed using the formulas provided by Reece and Swenson (2004) below:

$$\text{MCV(fL)} = \left(\frac{PVC}{RBC}\right) \times 10$$

$$\text{MCH(pg)} = \left(\frac{Hb}{RBC}\right) \times 10$$

$$\text{MCHC(g/dL)} = \left(\frac{Hb}{PCV}\right) \times 100$$

3.3.5 Determination of WBC differential counts

In determining the differential WBC counts, thin smears of blood were made from blood samples obtained from venipuncture, on well ethanol-cleaned, grease-free

microscope slides. They were air-dried, fixed in absolute methanol and stained with Giemsa stain.

Stained slides were studied under oil immersion objective at 1000X magnification. Percentages of neutrophils, lymphocytes, monocytes, eosinophils and basophils were all determined based on observation of 200 WBC per film.

3.4 Blood biochemical analysis

The concentrations of glucose, total proteins, albumin, total cholesterol and urea were determined in the serum at weeks 1,3,5,7, and 9 using the Mindray BA -88A Semi-Auto Chemistry Analyser. The various concentrations of the serum biochemical parameters were determined against the concentration of the standard and the blank set in the Mindray BA -88A Semi-Auto Chemistry Analyser. Globulin concentration was computed as the difference between total protein and albumin concentrations.

3.4.1 Measurement of glucose

Glucose was determined quantitatively by mixing 10 µl of serum sample with 1000 µl of the reagent and this was incubated for 5 minutes at 37^0C. The absorbance of the sample (AT) and that of the standard (AS) was measured against the reagent blank at a wavelength of 505 nm and glucose concentration was determined from the formula:

Total glucose (mg/dl) = $\frac{AT}{AS}$ x Concentration of the standard

Where AT = Absorbance of the sample

AS = Absorbance of the standard.

3.4.2 Measurement of total protein

Twenty (20 µl) of serum sample was mixed with 1000ul of the reagent and was incubated for 10 minutes at 20 to 25^{0}C. Total protein concentration was measured against the standard and the blank at a wavelength of 540 nm. The concentration of the protein was determined using the equation:

Total protein (g/dl) = $\frac{AT}{AS}$ x concentration of standard

3.4.3 Measurement of albumin

Five (5 µl) of serum sample was mixed with 1000 µl of the reagent and incubated for 5 minutes at room temperature. The absorbance of the sample (AT) and standard (AS) was measured against the reagent blank at a wavelength of 620 nm. The concentration of albumen was determined using the formula:

Albumen (g/dl) = $\frac{AT}{AS}$ x Concentration of the standard

The globulin concentration was determined by the difference between total protein and albumin concentrations (Kerr, 2002; Harr, 2006).

3.4.4 Measurement of cholesterol

Ten (10 µl) of serum sample was mixed with 1000 µl of the reagent and incubated for 10 minutes at 37^0C. The absorbance of the sample (AT) and the standard (AS) was measured against the reagent blank at 505 nm and cholesterol concentration from from the formula below:

Cholesterol (mg/dl) = $\frac{AT}{AS}$ x Concentration of the standard

3.4.5 Measurement of urea

Quantitative determination of urea in serum was determined by measuring the absorbance of sample (AT) and the absorbance of the standard (AS) against reagent blank at a wavelength of 578 nm and urea concentration was determined by the equation:

Urea (mg/dl) = $\frac{AT}{AS}$ x Concentration of the standard

3.5 Statistical analysis

The survey data collected were coded and entered into Microsoft Excel and exported into the Statistical Package for Social Science [SPSS] (IBM SPSS Statistics, 2016) for analyses. Analytical techniques applied included frequency tables, line graphs and bar charts.

Data from the acceptability, feed intake and growth trial were analysed using the General Analysis of Variance procedure while data from blood sampling was analysed using the Repeated Measures Analysis of Variance procedure of GenStat (VSN International, 2009). The least significant difference procedure of GenStat was used to separate significant means at 5% significance level.

CHAPTER FOUR

4.0 RESULTS

4.1 Study one: Survey on small ruminant production in the Accra Plains

4.1.1 Socio-economic characteristics of respondents

Table 4.1.1a presents the socio-economic characteristics of respondents in the five districts surveyed. Male farmers were dominant (71%) across the five districts. Among the five districts, more male farmers were recorded in Ga Central (90%) compared with the other four.

Over 76% of the respondent farmers were within the active working age group of 31 – 60 years. The religious background of respondents across the districts surveyed indicated, 84% were Christians while 16% were Muslims.

Majority (83%) of the respondents across the districts surveyed were married. Forty seven percent of the respondents had basic education, 20% had secondary education (including vocational/technical education) and 17% were educated up to the tertiary level. Only 16% had no formal education across the five districts surveyed. A large number (62%) of respondents had household size between four and seven across the five districts surveyed.

Within the five districts surveyed, 61% of the respondents had crop farming as their major occupation, 10% were salaried workers, 25% engaged in petty trading while 4% were retirees.

Table 4.1.1a: Socio-economic characteristics of respondents

District	Gender		Age cohort						Religious background		Marital status		
	Male	Female	<= 30	31 – 40	41 – 50	51 – 60	61+		Christian	Moslem	Single	Married	Div'ced
Ga East	70 (14)	30 (6)	2	4	6	5	3		16	4	10 (2)	85 (17)	5 (1)
Ga West	75 (15)	25 (5)	0	6	7	4	3		16	4	5 (1)	95 (19)	0 (0)
Ga Central	90 (18)	10 (2)	3	8	4	2	3		13	7	30 (6)	70 (14)	0 (0)
Shai Osudoku	70 (14)	30 (6)	2	5	2	8	3		16	4	10 (2)	85 (17)	5 (1)
Ada West	50 (10)	50 (10)	2	4	6	5	3		19	1	5 (1)	80 (16)	15 (3)
Total	**71**	**29 (29)**	**9**	**27**	**25**	**24**	**15**		**80**	**20**	**12 (12)**	**83 (83)**	**5 (5)**

Number in parenthesis represent sex of respondents

District	Education background				Household size					Primary occupation			
	None	Basic	Sec/Tech	3 L	<= 3	4 – 7	8 – 11	12 – 15	16+	Farming	S. Work	Artisan	Retired
Ga East	1	7	6	6	2	15	1	1	1	11	2	5	2
Ga West	0	15	4	1	1	17	2	0	0	9	2	9	0
Ga Central	3	5	5	7	9	11	0	0	0	13	4	2	1
Shai Osudoku	3	13	3	1	1	12	6	1	0	16	0	3	1
Ada West	9	7	2	2	1	7	9	2	1	12	2	6	0
Total	**16**	**47**	**20**	**17**	**14**	**62**	**18**	**4**	**2**	**61**	**10**	**25**	**4**

3 L = Tertiary level; S. Work = Salaried worker

Table 4.1.1b: Small ruminant production and management systems of respondents

District	Major crops produced				Purpose for crop		Breeding management			Breed kept		Purpose for SR	
	Maize	Cassava	Mixed	Vegs	Sub'ce	C' cial	Unplanned	Separate	Castration	WAD	Sahelian	Sub'ce	C' cial
Ga East	3	0	2	**3**	2	5	18	2	0	14	3	3	8
Ga West	5	0	1	**6**	1	11	20	0	0	12	0	0	7
Ga Central	2	0	1	**0**	0	3	8	8	4	17	3	2	5
Shai Osudoku	5	1	5	**6**	0	16	19	1	0	27	0	0	7
Ada West	0	9	0	**7**	3	14	20	0	0	24	0	1	4
Total	**15**	**10**	**9**	**22**	**6**	**49**	**85**	**11**	**4**	**94**	**6**	**6**	**31**

District	Management system			Housing		Confinement		Major constraints		Feeding practice		Supplementation	
	Extensive	Semi-Int	Int'sive	Yes	No	Yes	No	D'ses	P. feed	Grazed	Zero-grazed	Yes	No
Ga East	0	16	4	20	0	12	8	13	7	14	6	19	1
Ga West	3	17	0	17	3	11	9	13	7	19	1	20	0
Ga Central	0	19	1	19	1	19	1	20	0	17	3	20	0
Shai Osudoku	3	17	0	15	5	14	6	20	0	20	0	20	0
Ada West	0	20	0	19	1	11	9	18	2	20	0	20	0
Total	**6**	**89**	**5**	**90**	**10**	**67**	**33**	**84**	**16**	**90**	**10**	**99**	**1**

P. feed = Poor feed; D'ses = Diseases; Vegs = Vegetables; Sub'ce = Subsitence; C' cial = Commercial; Semi-Int = Semintensive; Int'sive = Intensive; SR = small ruminant

The major crops produce by the respondents in the five districts included maize (24%) cassava (25%) while 22% produced vegetables such as pepper, tomato and okro. Among the respondents that produce crops in the five districts surveyed, 49% produce for commercial purpose while 3% produce for subsistence as detailed out in Table 4.1.1b.

Across the five districts, 85% were practicing uncontrolled breeding, 11% separate the male animals from the female while 4% castrate undesirable male animals. Majority (74%) of the respondents preferred keeping goats to sheep. Preference for goat to sheep keeping across the five districts was based on ease of management (45%), ease of selling goat meat (28%), preference of chevon to mutton (14%) and ease of making profit (13%).

Other livestock and poultry kept by the respondents at the time of evaluation included cattle (13%), Guinea fowls (11%), local ducks (8%), rabbits (4%), grasscutter (7%), pigs (7%) and local chicken (87%). The intensive system of management where the animals were totally housed was the least practiced (6%).

Ninety percent of the respondents from the five districts surveyed provided housing facility to their animals. Sixty percent of the respondents sometimes confine their animals with 33% allowing their animals to roam throughout the year unconfined as shown in Table 4.1.1b.

Among the five districts surveyed, 84% mentioned diseases and theft as their major constraints while 16% complained of inadequate feed resources especially during the

dry season as detailed out in Table 4.1.1b. Ninety percent of the respondents allowed their animals to graze while 10% practiced the zero grazing.

Majority (90%) of the farmers allowed their animals to graze while 10% were practicing zero grazing where the animals are housed and fed with cut forages. Ninety-nine percent of the respondents were practicing feed supplementation. However, crop residues and agro-industrial by-products were fed as sole supplementary diets but not as formulated feed supplements as no formulated supplements.

4.1.2 Feed resources used by respondents

The available feed resources in the study areas included: crop residues, agro-industrial by-products and natural pasture. The common crop residues included legume residues such as groundnut haulms and cowpea haulms.The agro-industrial by-products included maize bran, wheat bran, corn milling waste, rice bran and cassava peels which most often were purchased.

Grasses cut for small ruminants by respondents in the five districts included *Panium maximum* and *Andropogon gayanus*. The browse species cut for animals by the respondents included *Leucaena, Acacia, Ficus, Samanea* among others. However, the top three browse species used by the farmers were *Ficus exasperata*, *Samanea saman* and *Acacia auriculiformis* in a decreases order of importance. The least ranked feeding resource among the farmers in the study area was palm fronds. Details of the feeding

resources used by farmers in the area is outlined in Table 4.1.1c. Majority (99%) of the farmers indicated that the crop residues and agro-industrial by-products were fed as sole supplements but not as formulated feed supplements.

Table 4.1.1c: Feeding resource and their ranks by respondents

Forage used	Rank	Frequency
Ficus exasperata	1	33
Samanea saman	2	25
Acacia auriculiformis	3	49
Cassava peels	4	16
Mistletoe leaves	5	20
Moringa lucida	6	20
Grewia spp	7	12
Albizzia lebbek	8	18
Mango leaves	9	16
Plantain leaves	10	28
Leucaena leucocephala	11	8
Neem leaves	12	8
Securinega virosa	13	8
Avogado leaves	14	12
Khaya senegalensis	15	12
Pawpaw leaves	16	21
Palm fronds	17	4
Andropogon gayanus	18	9
Panium maximum	19	3
Wheat bran	20	11
Maize bran	21	11
Cowpea haulms	22	3
Corn milling wastes	23	9

4.1.3 Training in ruminant production

Twenty-one percent of the smallholder farmers in the five districts surveyed received training in how to keep ruminants while majority (79%) had not received any form of training in ruminants keeping. The institutions that offered the training to the respondents are detailed in Figure 4.1.1. Out of the 21% of the respondents who indicated that they had received some training, seven percent obtained their training on ruminant production from Animal Research Institute (ARI) and Adventist Development and Relief Agency (ADRA) while 14% were trained by Ministry of Food and Agriculture (MoFA) as shown in Figure 4.1.1.

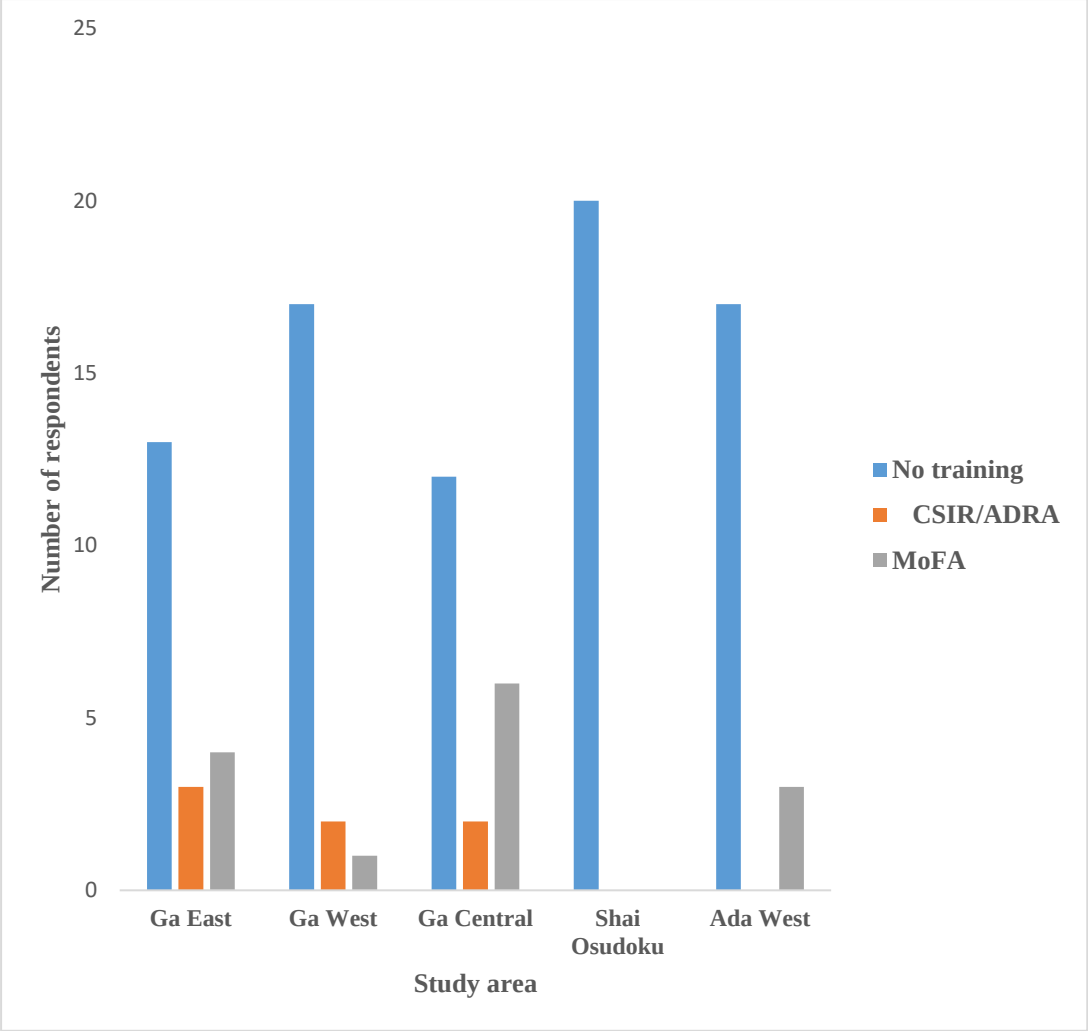

Figure 4.1.1: Status of training and institutions that offered training to respondents

ARI = Animal Research Institute

ADRA = Adventist Development and Relief Agency

MoFA =Ministry of Food and Agriculture

4.2 Study 2: Intake, digestibility and growth response of sheep fed Andropogon grass hay and Samanea, Acacia and Ficus leaf meal supplements

4.2.1 Chemical composition of feed ingredients

The chemical composition of the basal diet (grass hay), the three browses (*Samanea saman, Acacia auriculiformis* and *Ficus exasperata*) and cassava peels are presented in Table 4.2.1. The basal diet, the leaf meals of the three browses and cassava peels had comparable dry matter contents (range 89.9 to 94.6%) and organic matter (range 80.8 to 87.2%) contents. Crude protein level was higher in the browses (range15.9 to 21.9%) than cassava peel (2.1%) and the hay (6.7%). Total ash content of 12.6% for the grass hay was higher compared to the rest of the feed ingredients. The three browses and the cassava peels had total ash content ranging from 3.7% to 8.9%.

The NDF was also lower in the three browses (range 42.9 to 60.7%) and cassava peels (36.6%) than the grass hay (73.8%). Except for Acacia (49.5%), ADF was lower in the browses (range 36 to 39.7%) and cassava peels (27.4%) than the hay (44.9%). Cassava peels had the highest lignin content of 9.7% while Ficus leaves had the lowest lignin content of 3.7%.

Table 4.2.1: Chemical composition of leaf meals of browses, cassava peel meal and *Andropogon gayanus* hay

Ingredient (%)	Grass hay	Samanea	Acacia	Ficus	C. Peel
DM	89.9	92.7	93.4	91.9	94.6
CP	6.7	21.9	16.4	15.9	2.1
OM	80.8	83.8	87.2	87.2	80.9
NDF	73.8	59.8	60.7	42.9	36.3
ADF	44.9	39.7	49.5	36.4	27.4
Lignin	6.1	6.8	6.2	3.7	9.7
Total ash	12.6	8.9	6.2	3.7	7.3

C. Peel = Cassava peel

4.2.2 Chemical composition of the supplements

The chemical composition of the supplements used in Study 2 as shown in Table 4.2.2. The dry matter, organic matter, NDF and lignin contents were similar and ranged from 90.2 to 92.5%, 83.7 to 85.9%, 41.3 to 44.5%, and 3.4 to 4.7% respectively. Supplement 3 (Ficus leaf meal based supplement) had the highest crude protein content (21.5%) while supplement 4 (Cassava peel based supplement) had the least (16.3%). Supplement 4 (Cassava peel based supplement) had the highest ADF while supplement 3 (Ficus leaf meal based supplement) had the least (14.6%).

Table 4.2.2: Chemical composition of the experimental supplements

Nutrient	Supplement			
	1	2	3	4
DM	92.5	91.7	90.2	91.2
CP	18.3	20.5	21.5	16.3
OM	85.9	84.7	83.7	84.8
NDF	41.6	44.5	43.4	41.3
ADF	30.2	29.6	14.6	30.6
Lignin	3.8	4.7	4.5	3.4

DM = Dry matter; CP = Crude protein; OM = Organic matter; NDF = Neutral detergent fibre; ADF = Acid detergent fibre; 1 = Samanea leaf meal; 2 = Acacia leaf meal; 3 = Ficus leaf meal; 4 = Cassava peel meal

4.2.3: Acceptability of sheep for the supplements

The acceptability of sheep for the three browses and cassava peel meal supplements is shown in Table 4.2.3. The Samanea leaf meal (T_1) and cassava peel meal (T_4) based supplements were more acceptable ($p < 0.05$) to the sheep (section 3.2.4) compared to the rest. The supplement least accepted was the Ficus leaf meal (T_3) based supplement ($p < 0.05$).

Table 4.2.3: Acceptability of Samanea, Acacia, Ficus and Cassava peel meal supplements fed to the West African Dwarf sheep

Supplements (%)	Means of intake (g)
T_1	195.8^a
T_2	111.3^b
T_3	57.6^c
T_4	223.3^a
SED	*24.16*
p-value	< 0.001

Means in the same column with different superscript are significantly different ($p < 0.05$); SEM = Standard error of means; LSD = Least significant difference; T_1 = Grass hay + Samanea leaf meal concentrate T_2 = Grass hay + Acacia leaf meal concentrate T_3 = Grass hay + Ficus leaf meal concentrate; T_4 = Grass hay + Cassava peel meal concentrate

4.2.4: Influence of supplements on voluntary intakes in sheep

The total intakes of dry matter, crude protein, organic matter, NDF, ADF and lignin are shown in Table 4.2.4. The total dry matter intake ranged from 592.87 to 657.18g/day and this was found to be similar ($p > 0.05$) in all the treatments. Sheep on Acacia leaf meal (T_2) and Ficus leaf meal based supplements (T_3) had significantly ($p < 0.05$) higher crude protein intake than those on Samanea leaf meal (T_1) and cassava peel meal (T_4) based supplements. Also sheep on Samanea leaf meal based supplement (T_1) had higher ($p < 0.05$) crude protein intake than those on the cassava peel meal based supplement (T_4). The crude protein intake for sheep that were fed cassava peel meal based supplement was the least among all the four test diets. Crude protein intake ranged from 59.63 to 67.01%. Sheep on T_1, T_2 and T_3 had significantly ($p < 0.05$) higher organic matter intake than those on T_3.

With respect to NDF, intake was significantly ($p < 0.05$) higher in sheep on Ficus leaf meal based supplement (T_3) than those on other treatments. The NDF intake ranged from 72.98 to 85.98g/day. The ADF intake on the other hand was in the range of 25.44 to 54.65g/day and was found to be significantly ($p < 0.05$) higher in sheep on Samanea leaf meal (T_1) and cassava peel meal (T_4) based supplements than those on Acacia leaf meal (T_2) and Ficus leaf meal (T_3) based supplements. Also ADF intake was significantly ($p < 0.05$) higher in sheep on Acacia leaf meal based supplement (T_2) than those on the treatment made up of Ficus leaf meal based supplement (T_3).

Sheep fed the browse leaf meal based supplements (T_1, T_2 and T_3) had similar lignin intake which was higher ($p < 0.05$) than those fed the cassava peel meal based supplement (T_4).

Table 4.2.4: Influence of supplements on voluntary feed intake of the West African Dwarf sheep

Parameter (g/day)	Treatments				LSD	SEM	P-value
	T_1	T_2	T_3	T_4			
DMI	657.18[a]	592.87[a]	611.62[a]	633.08[a]	180.8	46.06	0.78
CPI	63.69[b]	67.01[a]	66.32[a]	59.63[c]	2.516	1.277	< 0.001
OMI	533.6[a]	520.9[a]	497.3[b]	534.4[a]	18.53	9.40	< 0.001
NDFI	74.36[b]	76.75[b]	85.98[a]	72.98[b]	4.025	2.042	< 0.001
ADFI	54.65[a]	50.81[b]	25.44[c]	53.79[a]	2.283	1.158	< 0.001
Lignin intake	35.49[a]	36.56[a]	36.17[a]	34.14[b]	1.239	0.629	< 0.001

Means in the same row with different superscript are significantly different ($p < 0.05$); SEM = Standard error of mean; LSD= Least significant difference; T_1 = Grass hay + Samanea leaf meal concentrate; T_2 = Grass hay + Acacia leaf meal concentrate; T_3 = Grass hay + Ficus leaf meal concentrate; T_4 = Grass hay + Cassava peel meal concentrate

4.2.5 Digestibility of nutrients by WAD sheep fed basal diet of Andropogon gayanus hay and supplements

Sheep that were fed the three browses (Samanea, Acacia and Ficus) leaf based supplements (T_1, T_2 and T_3) had higher ($p < 0.05$) dry matter digestibility than those fed the cassava peel meal based supplement (T_4) as shown in Table 4.2.5. Within the three browses, the data showed that Samanea leaf meal based supplement (T_1) had the highest dry matter digestibility value of 62.35% and this was significantly ($p < 0.05$) higher than the digestibility of 60.33% for Acacia leaf meal based supplement (T_2). However, dry matter digestibility value of Ficus leaf meal based supplement (61.22%) was similar ($p > 0.05$) to both Samanea leaf meal (T_1) and the Acacia leaf meal (T_2) based supplements.

The crude protein digestibility followed the same pattern as obtained for ths dry matter digestibility. They were higher ($p < 0.05$) in sheep fed the browse meal based supplements compared to those fed the cassava peel meal based supplement which had the least. The Samanea leaf meal (T_1) based supplement had the highest ($p < 0.05$) crude protein digestibility of 57.25%. The results also showed that sheep fed the Samanea leaf meal based supplement (T_1) had significantly ($p < 0.05$) higher organic matter digestibility than those on the other treatments (T_1, T_2 and T_3). Also those on Ficus leaf meal based supplement (T_3) had higher ($p < 0.05$) organic matter digestibility than those on Acacia leaf meal (T_2) and cassava peel meal (T_4) supplements. The organic matter digestibility in this study ranged from 46.31 to 52.25%.

NDF digestibility was found to be significantly ($p < 0.05$) higher in sheep on Samanea leaf meal (T_1) and Ficus leaf meal (T_3) supplements compared to those on Acacia leaf meal (T_2) and cassava peel meal (T_4) supplements. The NDF digestibility in this study ranged from 34.9 to 41.57%. The ADF digestibility was significantly ($p < 0.05$) higher in sheep on Samanea leaf meal (T_1), Ficus leaf meal (T_3) and cassava peel meal (T_4) supplements than those on Acacia leaf meal supplement (T_2). Although sheep on Samanea leaf meal and cassava peel meal based supplements had similar ($p > 0.05$) ADF digestibility, they were significantly ($p < 0.05$) higher than sheep on Ficus leaf meal supplement. The ADF digestibility in this study ranged from 22.30 to 33.47% as shown in Table 4.2.5.

Table 4.2.5: Digestibility of components of feed as influenced by supplementation

Fraction (%)	Treatments				LSD	SEM	P-value
	T_1	T_2	T_3	T_4			
DMD	62.35^{a}	60.33^{b}	61.22^{ab}	57.10^{c}	1.314	0.655	<0.001
CPD	57.25^{a}	56.30^{b}	56.25^{ab}	51.10^{c}	1.314	0.553	<0.001
OMD	52.25^{a}	47.22^{c}	49.43^{b}	46.31^{c}	1.790	0.892	<0.001
NDFD	40.62^{a}	36.29^{b}	41.57^{a}	34.90^{b}	1.993	0.993	<0.001
ADFD	32.87^{a}	22.30^{c}	25.64^{b}	33.47^{a}	2.076	1.034	<0.001

Means in the same row with different superscripts are significantly different ($p < 0.05$); SEM = Standard error of mean; LSD = Least significant difference; DMD = Dry matter digestibility, CPD = Crude protein digestibility, OMD = Organic matter digestibility, NDFD = Neutral detergent fibre digestibility, ADFD =Acid detergent fibre digestibility T_1 = Grass hay + Samanea leaf meal concentrate; T_2 = Grass hay + Acacia leaf meal concentrate; T_3 = Grass hay + Ficus leaf meal concentrate; T_4 = Grass hay + Cassava peel meal concentrate

4.2.6 Daily weight gain and FCE of WAD sheep fed basal diet of Andropogon gayanus hay and supplements

The daily weight gain and feed conversion efficiency of the WAD sheep are detailed in Table 4.2.6. There was no significant ($p > 0.05$) differences in average daily weight gain of sheep fed T_1, T_2 and T_4 but these were lower ($p > 0.05$) sheep on T_3. The values ranged from 37.16 to 101.35g/d. The feed conversion efficiency of sheep was also not significantly ($p > 0.05$) different across dietary treatments. The values ranged from 0.08 to 0.24.

Table 4.2.6: Feed intake and growth parameters of the test diets

Parameter	Treatments				P-value
	T_1	T_2	T_3	T_4	
Initial weight (kg)	15.5	14.5	12.5	13.5	0.32
Final weight (kg)	18.25	17.25	20.0	17.75	0.57
ADG (g/day)/DM	37.16^b	37.16^b	101.35^a	57.43^b	0.04
Feed intake (g)	657.18	592.87	611.62	633.08	0.78
FCE	0.24	0.28	0.08	0.18	0.48

Means in the same row with different superscripts are significantly different ($p < 0.05$); ADG = Average daily gain in weight; FCE = Feed coversion efficiency; T_1 = Grass hay + Samanea leaf meal concentrate; T_2 = Grass hay + Acacia leaf meal concentrate; T_3 = Grass hay + Ficus leaf meal concentrate; T_4 = Grass hay + Cassava peel meal concentrate

4.3 Haematological parameters in WAD sheep fed basal diet of Andropogon gayanus hay and supplements

Details of the effects of the supplements on some haematological parameters of the West African Dwarf sheep is shown in Table 4.3.1. Analysis of the data indicated that the test diets did not significantly ($p > 0.05$) affect most of the haematological parameters measured except monocytes and neutrophils.The values obtained were 13.27 to 15.46g/dL, 29.20 to 35.60%, 10.63 to 11.94 x 10^{12}g/L, 2.78 to 2.95fL, 1.24 to 1.39pg and 43.43 to 46.74 g/dL for Hb, PCV, WBC, MCV, MCH and MCHC respectively. The WBC counts and their differentials were similar ($p > 0.05$) across all the dietary treatments. The range of values obtained were 4.34 to 4.96 x 10^9/L, 56.90 to 63.80%, 34.60 to 39.30%, 0.80 to 1.60%, 0.50 to 2.3% and 0.09 to 0.22% for WBC, neutrophils, lymphocytes, eosinophils, monocytes and basophils respectively.

Sheep that were fed the cassava peel meal supplement (T_4) had significantly ($p < 0.05$) higher neutrophils value than those on Samanea leaf meal based supplement (T_1). The PCV value for sheep on Acacia leaf meal and Ficus leaf meal (T_2 and T_3) were however not significantly ($p > 0.05$) different from sheep on T_1. Sheep fed the cassava peel based supplement (T_4) had lower ($p < 0.05$) monocyte levels than those fed Samanea (T_1) and Acacia leaf meal (T_2) based supplements.

Table 4.3.1: Haematological parameters in West African Dwarf sheep fed basal diet of *Andropogon gayanus* hay and supplements

Parameters	Treatments				SEM	P-value
	T_1	T_2	T_3	T_4		
Haemoglobin (g/dL)	13.27	15.27	15.33	15.46	1.007	0.162
PCV (%)	29.20	33.60	32.80	35.60	2.054	0.291
RBC ($x10^{12}$g/L)	10.63	11.94	11.80	11.24	0.660	0.160
MCV (fL)	27.80	27.87	28.73	29.45	0.135	0.577
MCH (pg)	12.40	12.87	13.26	13.92	0.065	0.157
MCHC (g/dL)	45.44	45.24	46.74	43.43	0.149	0.053
WBC($x10^9$/L)	4.37	4.96	4.34	4.87	0.394	0.641
Neutrophils (%)	56.90^{b}	61.30^{ab}	58.40^{ab}	63.80^{a}	4.37	0.037
Lymphocyte (%)	39.20	34.60	39.30	34.70	4.10	0.487
Eosinophils (%)	1.60	1.50	0.80	0.80	0.797	0.625
Monocytes (%)	2.20^{a}	2.30^{a}	0.90^{ab}	0.50^{b}	0.731	0.050
Basophils (%)	0.09	0.11	0.22	0.18	0.102	0.596

Means with different superscripts are significantly different ($p < 0.05$) T_1 = Grass hay + Samanea leaf meal concentrate; T_2 = Grass hay + Acacia leaf meal concentrate; T3 = Grass hay + Ficus leaf meal concentrate; T_4 = Grass hay + Cassava peel meal concentrate.

The level of Hb and PCV in the Samanea and Cassava peel based diets decreased with time during the period of sampling whilst the other haematological parameters remained relatively constant (Figures 4.3.1 to 4.3.5).

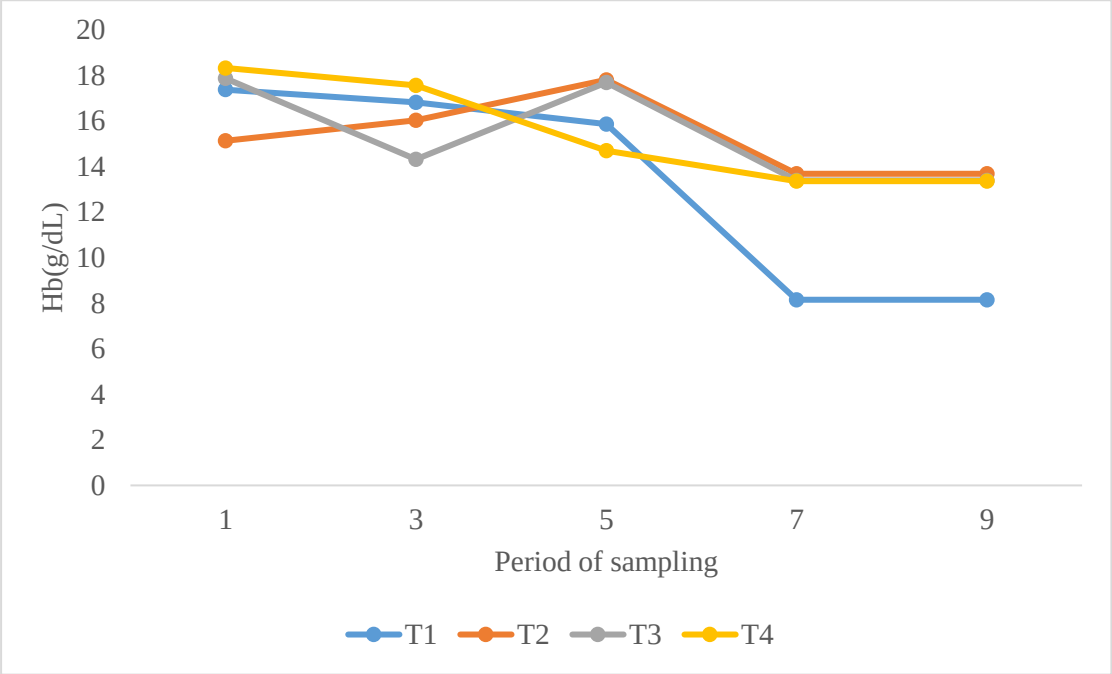

Figure 4.3.1**:** Changes in haemoglobin concentrations in West African Dwarf sheep

T_1 = Grass hay + Samanea leaf meal concentrate; T_2 = Grass hay + Acacia leaf meal concentrate; T_3 = Grass hay + Ficus leaf meal concentrate; T_4 = Grass hay + Cassava peel meal concentrate.

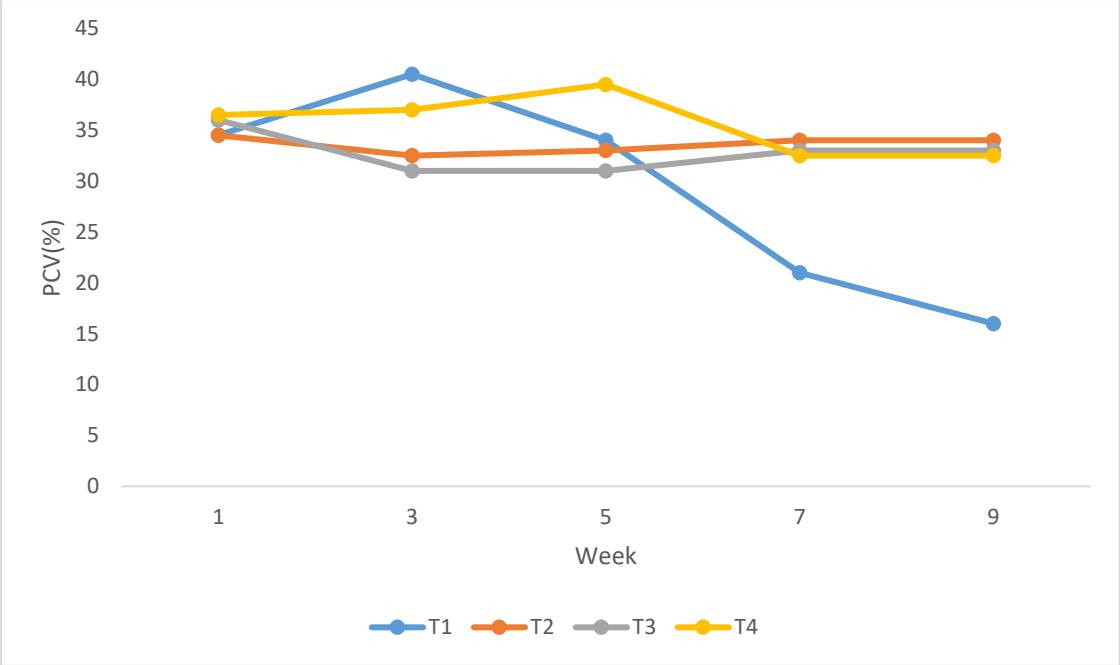

Figure 4.3.2: Changes in PCV levels in West African Dwarf sheep

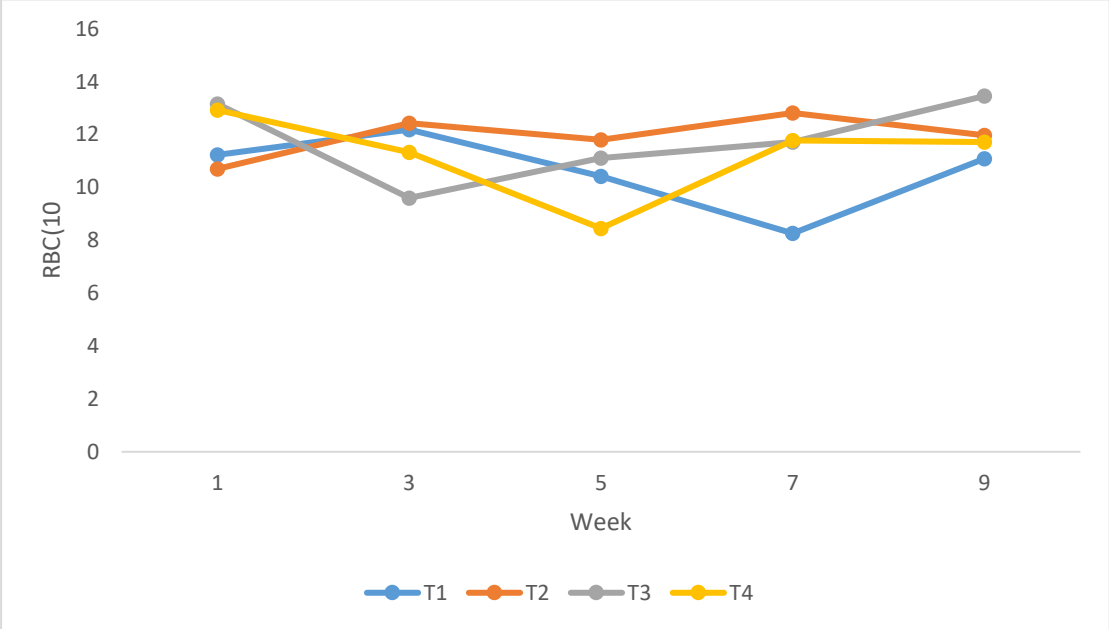

Figure 4.3.3: Changes in RBC concentration in West African Dwarf sheep

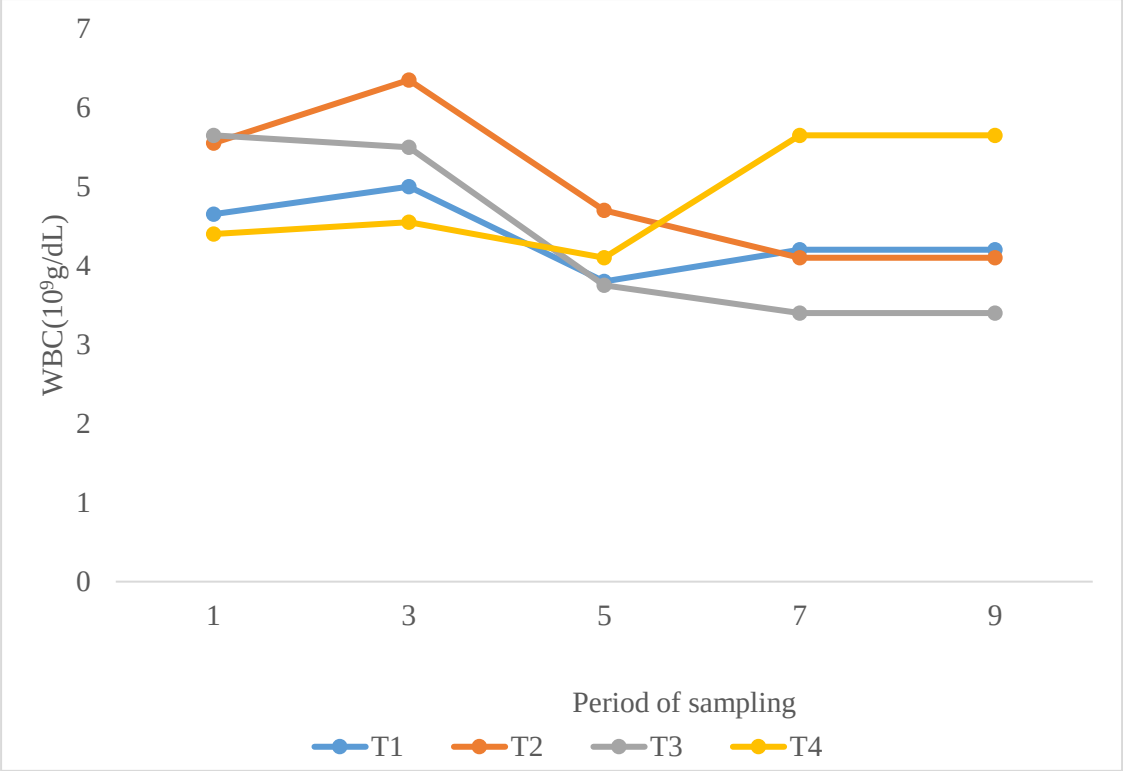

Figure 4.3.4: Changes in WBC concentrations in West African Dwarf sheep

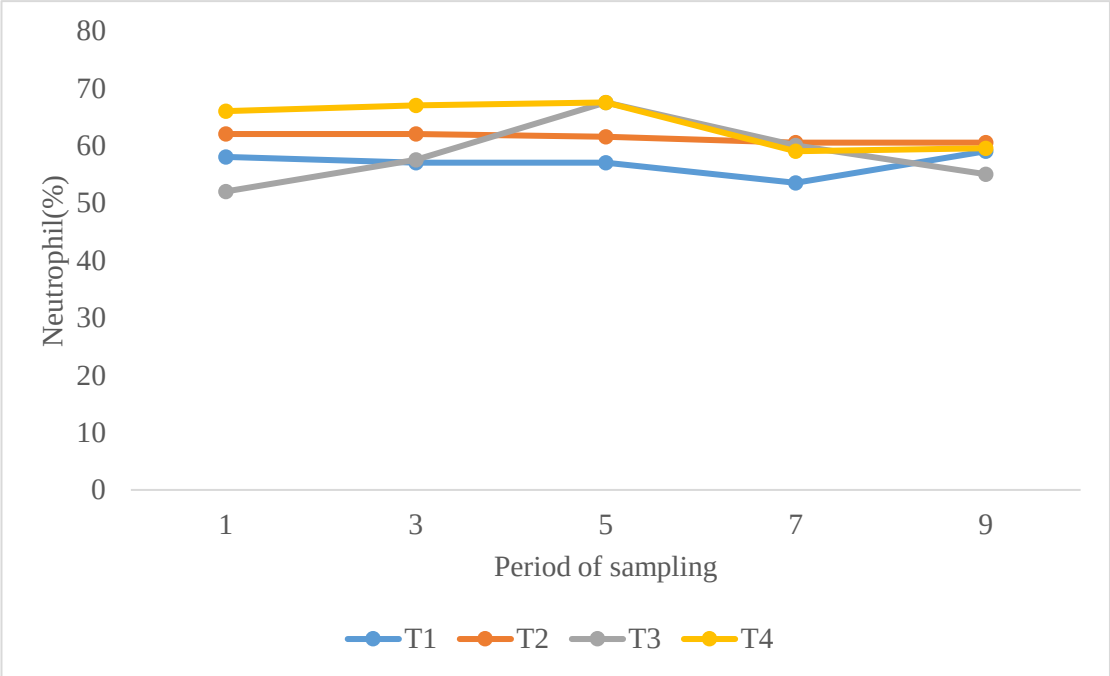

Figure 4.3.5: Changes in neutrophils concentrations in West African Dwarf sheep

4.4 Serum biochemical parameters the WAD sheep fed basal diet of Andropogon gayanus hay and supplements

The effect of the three browse species leaf meal and cassava peel meal supplements on serum biochemical parameters of West African Dwarf sheep is shown in Table 4.4.1. Dietary treatments did not significantly ($p > 0.05$) affect all the serum biochemical parameters determined except total protein which was significantly ($p < 0.05$) higher in sheep on the Acacia leaf meal (T_2) based supplement than those on the Samanea leaf meal (T_1) Ficus leaf (T_3) and Cassava peel meal (T_4) based supplements.

Table 4.4.1: Serum biochemical parameters in West African Dwarf sheep fed basal diet of *Andropogon gayanus* hay and supplements

Parameters	Treatments				SEM	P-value
	T_1	T_2	T_3	T_4		
Glucose (mmol/L)	1.96	1.54	1.72	1.57	0.200	0.108
Total protein (g/L)	60.46^b	64.38^a	61.48^b	61.57^b	0.65	0.030
Albumin (g/L)	36.96	38.43	37.07	37.37	0.776	0.374
Globulin (g/L)	23.50	25.95	24.41	24.14	1.228	0.388
T. cholesterol (mmol/L)	1.40	1.50	1.479	1.79	2.87	0.497
Urea (mmol/L)	9.51	9.67	8.71	9.21	0.356	0.492

Means with different superscripts are significantly different ($p < 0.05$) T_1 = Grass hay + Samanea leaf meal concentrate; T_2 = Grass hay + Acacia leaf meal concentrate; T3 = Grass hay + Ficus leaf meal concentrate; T_4 = Grass hay + Cassava peel meal concentrate; T. cholesterol = Total cholesterol.

Generally, the concentrations of most of the serum biochemical constituents remained relatively stable and the trends demonstrated were similar across the dietary treatments. However, cholesterol concentrations across dietary treatments dropped from week 1 to week 5 to the lowest level and thereafter remained stable (Figures 4.4.1 to 4.4.6).

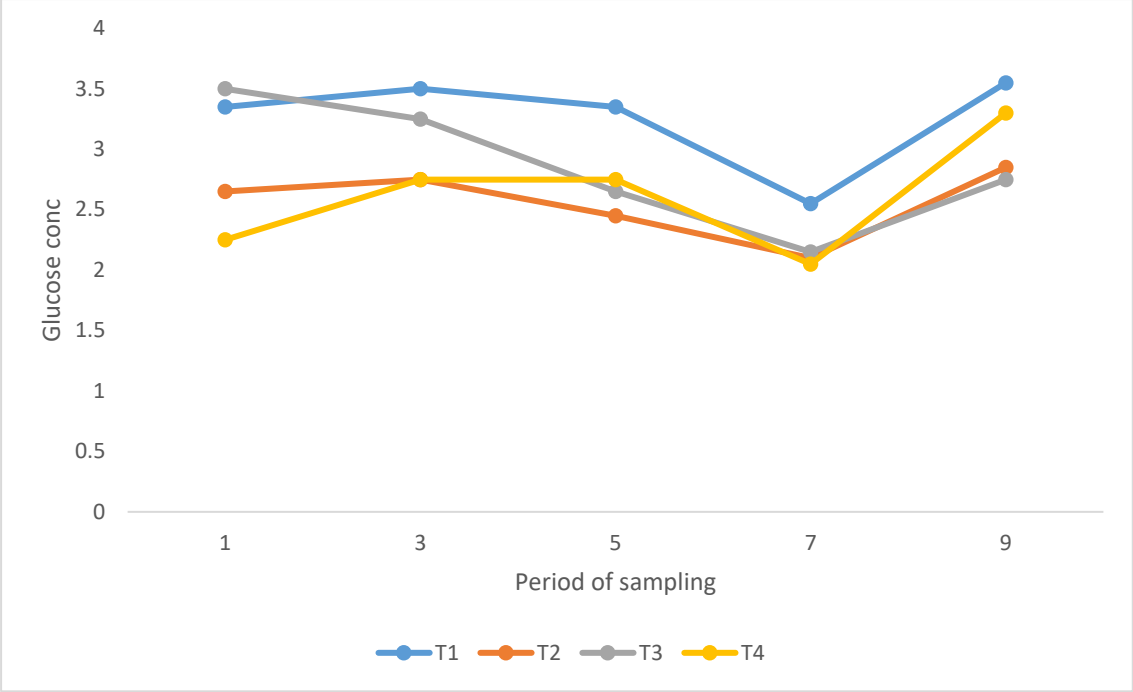

Figure 4.4.1: Changes in glucose concentrations in West African Dwarf sheep

1 = Samanea leaf meal; 2 = Acacia leaf meal; 3= Ficus leaf meal concentrate; 4 = Cassava peel meal concentrate

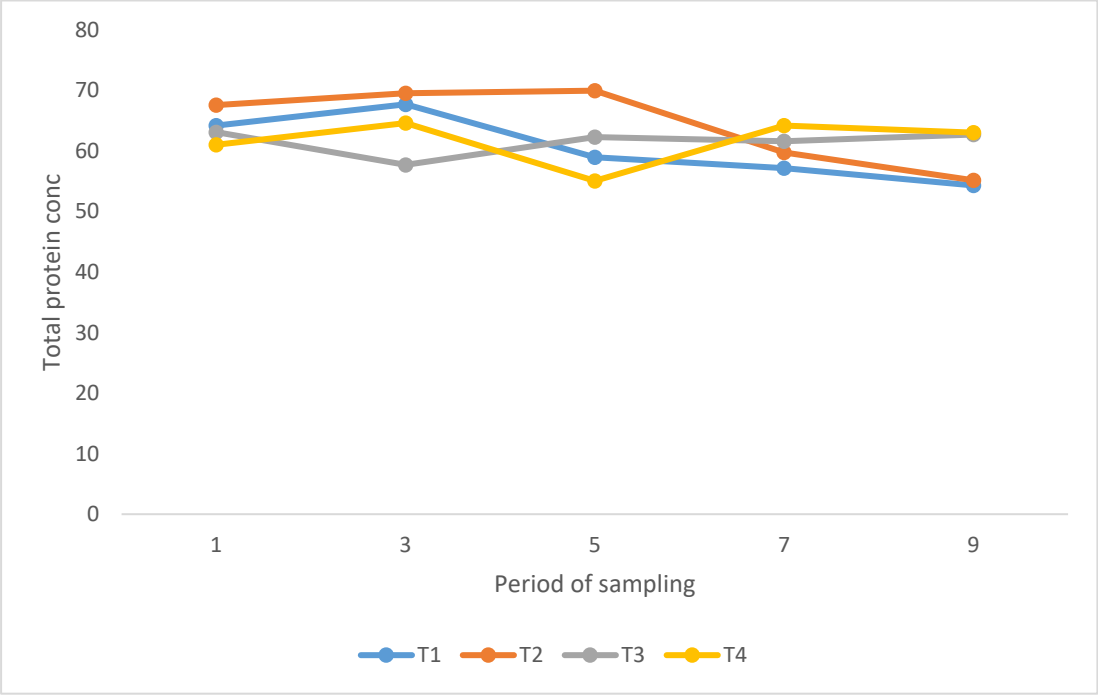

Figure 4.4.2: Changes in total protein concentrations in West African Dwarf sheep

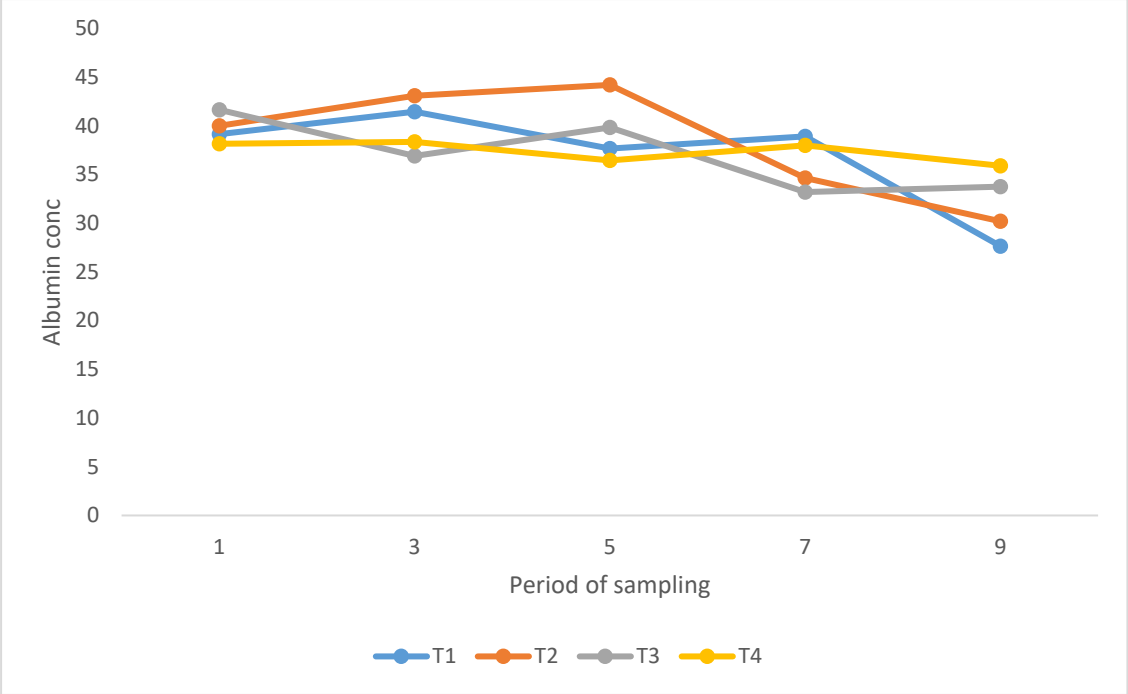

Figure 4.4.3 Changes in albumin concentrations in West African Dwarf sheep

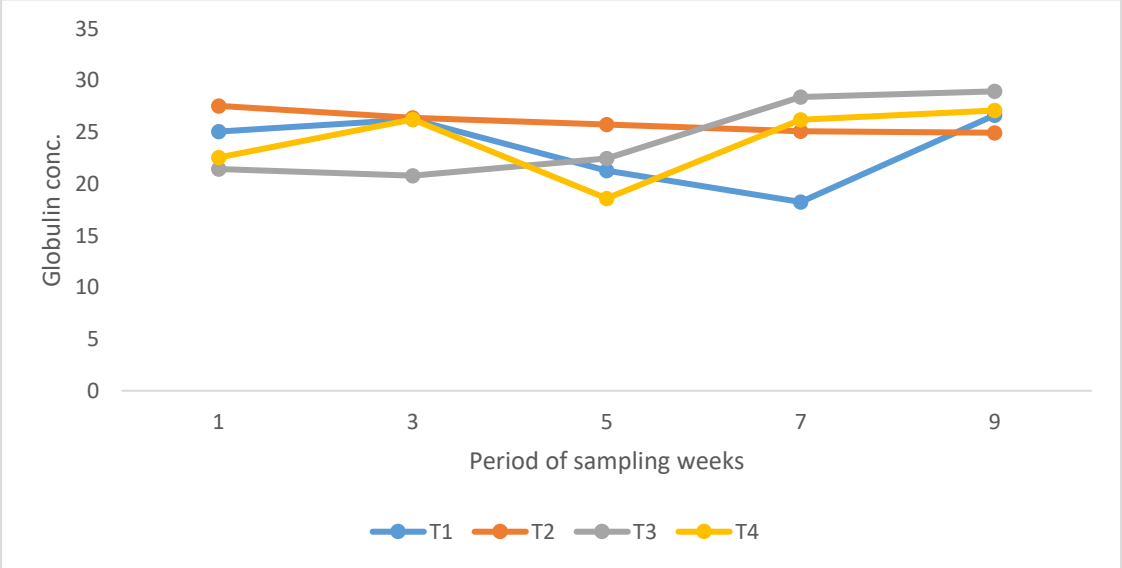

Figure 4.4.4 Changes in globulin concentrations in West African Dwarf sheep

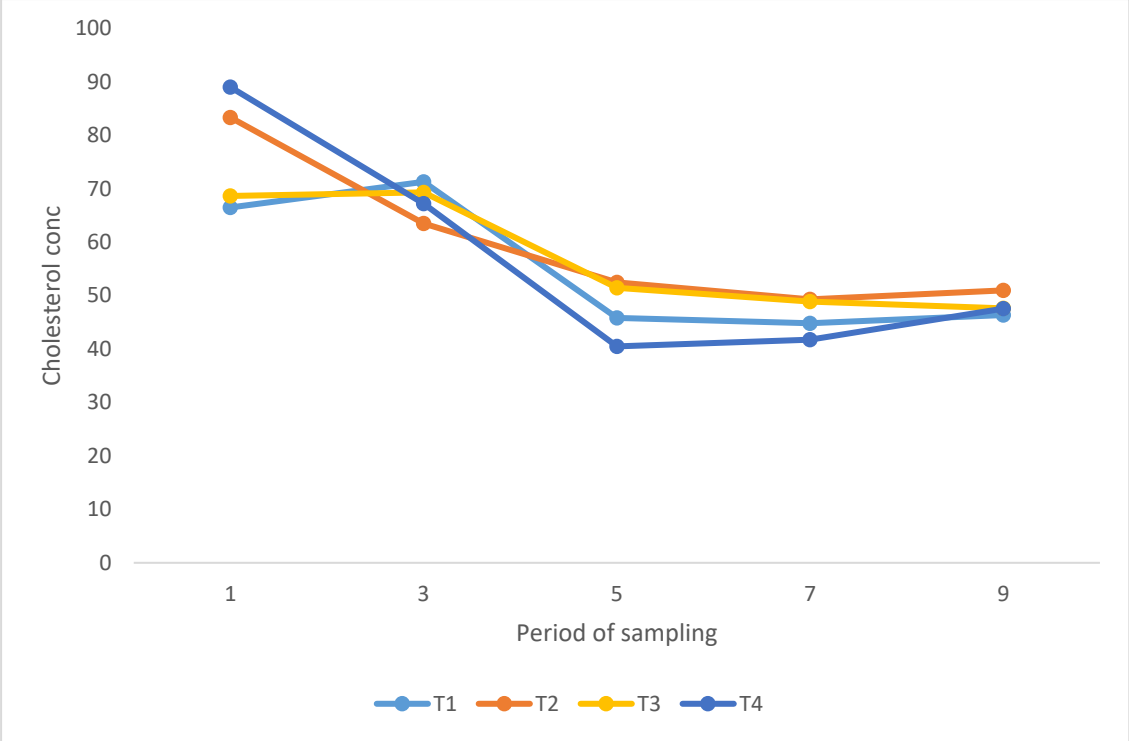

Figure 4.4.5: Changes in cholesterol concentrations in West African Dwarf sheep

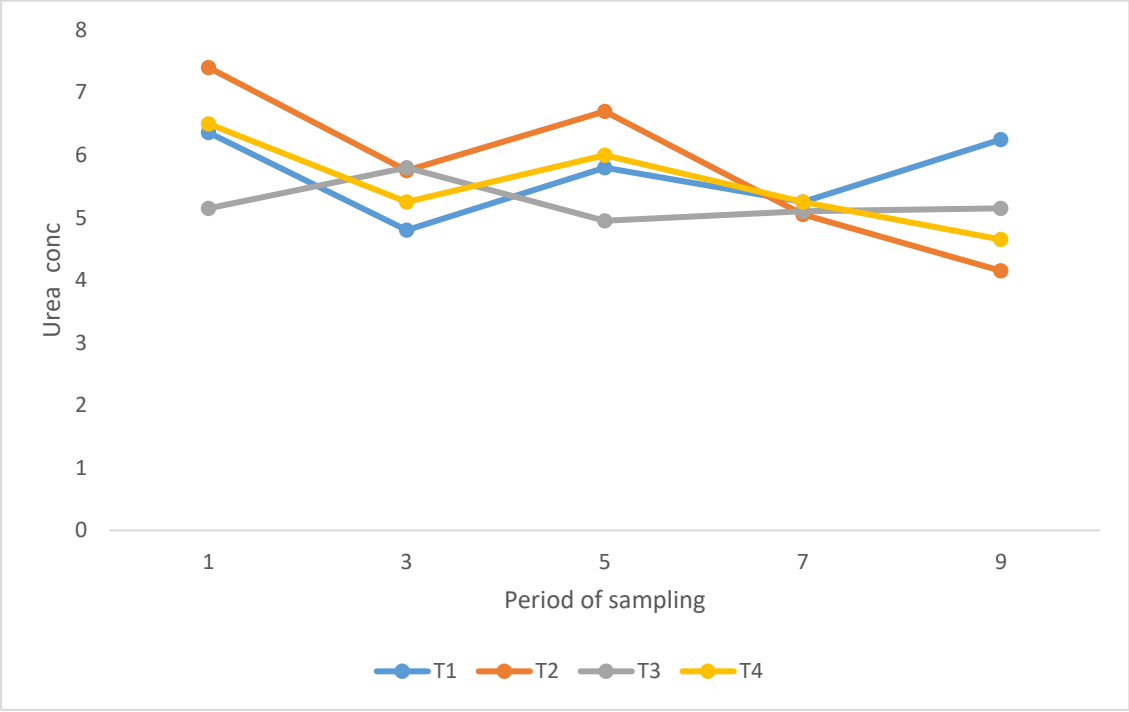

Figure 4.4.6: Changes in urea concentrations in West African Dwarf sheep

CHAPTER FIVE

5.0 DISCUSSION

5.1 Study one: Survey on small ruminant production in the Accra Plains

5.1.1 Socio-economic characteristics of respondents

The high proportion of males among the respondents may be attributed to societal customs and norms in sub-Sahara African countries where males control household productive assets. According to the 2010 population and housing census of Ghana, 65.3% of households are headed by males with female-headed households constituting the remaining 34.7% (GSS, 2013).

The high proportion of male farmers is very important for transferring and adoptions of technology since men are mostly the decision-makers in most African societies as observed by Turkson and Naandam (2006). Similar results have also been reported in Ghana and Benin. For instance, Baah *et al.* (2012) in their study on small ruminant production characteristics in urban households in Ghana reported that males dominate in the decision making process. In southern Benin, 60% of male small ruminant farmers were also reported to be household heads (Dossa *et al.,* 2008). In contrast, Fakoya and Oloruntoba (2009) reported a high female participation in small ruminant keeping in Ogun-state, Nigeria. The contrasting reports of the different studies could be due to differences in the socio- economic and cultural backgrounds of the respondents. Besides, the present study also interviewed household heads rather than actual owners of the animals.

The high percentage of farmers in the active age group is very good for the livestock industry since they are energetic to do resilient work at such an age. Although the data indicated that 47% of the respondents across the five districts surveyed had basic education, 45% of the respondents in Ada West district had not benefitted from any form of formal education. This may militate against access, adoption and application of appropriate technologies to improve on the productivity of their animals (Marinda *et al*., 2006).

Majority (62%) of the respondents in this study were found to live in households made up of 4 – 7 members with an average of 5.6 people in a household. These large families could serve as source of labour for livestock production and other economic activities as reported by Makeham and Malcolm (1986). This results compares favourably to that of the last population and housing census of Ghana, conducted in 2010 which reported a national average household size of 4.4 for the Greater Accra region (GSS, 2013).

The choice of crops grown by the respondents could be attributed to the agro ecological conditions together with the diet preferences and /or local customs in the study areas. The large number of respondents producing crops for commercial purpose is in consonance with the assertion that agriculture is the main source of income and livelihood of the rural households in line with the report of MoFA (2007) on sources of households' income. Amole and Ayantunde (2016) reported similar findings in Niger.

The high number (85%) of the respondent that allow male and female animals to move together (unplanned breeding) is a characteristic of small ruminant farmers in the rural areas. This can be attributed to the poor housing and the high cost of constructing appropriate housing structures for animals as reported by Oppong-Anane (2010). However, the high percentage (94%) of the respondents that kept the West African Dwarf breed of both sheep and goat agreed with other reports that these breeds are common in Ghana and can withstand most tropical diseases and the stresses of the weather (Charray *et al.*, 1992; Koney, 2004).

The commercial purpose of raising small ruminants by the farmers compares favourably with the findings by Baah *et al.* (2012) who reported financial motivation as very important in raising sheep and goats among urban households. Small ruminant production is therefore not a subsistent activity but commercial, although on small scale. The diverse reasons for venturing into sheep and goats production among the districts surveyed is an indication of the numerous roles small ruminants play in the livelihood of the people. Hence, strategies to ensure a sustainable improvement in the traditional small ruminant production system should be developed to address the diverse bottlenecks militating against this industry in Ghana.

The high percentage (89%) of the farmers that were practicing semi-intensive system is not surprising as the system is a peculiar characteristics of smallholder farmers where the animals are always kept in poor housing structures when they return from grazing in the evening. Although a high percentage of the respondents offered some form of housing facility to their animals, such facilities were generally poor and this can be attributed to

the fact that most of the farmers are still involved in small scale commercial production which is characterised by low inputs. The high cost of constructing appropriate housing structures for animals is another constraint as observed in a report by Oppong-Anane (2010).

The major constraints to sheep and goat production ranks diseases and its associated mortality as being the major problem for the farmers contacted and this agrees with the report of Clottey *et al.* (2007). Poor and inadequate feeding and health care were also major hindrance to small ruminant production in the areas surveyed and these contributed significantly to the susceptibility of the animals to many infections and mortalities as reported earlier by Opong-Anane (2013).

The present findings on feeding confirm earlier report that small ruminant production system in Ghana mostly depend on grazing of natural pastures with the occasional use of crop residues and agro-industrial by-products as supplements (MoFA, 2011).The seasonal scarcity of feed resources in the study area during dry season reported in this study is similar to the report from other places in the tropics and is a major constraint to ruminant production where animals depend largely on natural pasture (Annor *et al.* 2007).

Notwithstanding the constraints identified, the current study revealed the existence of potential feed resources for livestock production that can be exploited to satisfy the protein requirements of the study area. Previous reports also indicated that most rural communities are endowed with good resources and opportunities for livestock production (Duku *et al.*, 2010; Opong-Anane, 2013; Adams and Ohene-Yankyera, 2014).

With supplementary feeding, wastes from cassava and maize stover were mostly used as feed supplements for small ruminants especially during the dry season when feed scarcity is most prevalent. The feed available for ruminants during this dry season in the tropics can be described as high fibre and low-protein feeds with low digestibility and include residues from cereal crops such as maize, stover and straw of sorghum rice and dry grass (Jayasuriya 2002). The poor nutrients characteristics of these feeds tend to limit small ruminant daily intake (Owen and Jayasuriya, 1989) and reduce the ability of animals to satisfy their nutritional requirement leading to weight loses (Smith, 2010).

The positive relationship of annual feed availability with rainfall pattern in which natural pasture become more available across districts at the peak of rainy season and after crops harvest in this study agrees with the report that feed availability is a function of land use and rainfall pattern (Jayasuriya, 2002). In line with this current results, Annor *et al.* (2007) indicated that feed become more available and accessible to ruminant only after crop harvest when animals are allowed to graze freely.

Most of cereal crop residues are also deficient in fermentable carbohydrates resulting in relatively low organic matter digestibility (Jayasuriya, 2002).

Apart from cassava peels other agro-industrial by-products such as wheat bran, maize bran and rice bran were being used by the farmers for supplementary feeding during the dry season. Browse plants such as *Acacia auriculiformis, Samanea saman, Ficus exasperata, Gliricidia sepium* and *Leucaena leucocephala* which have high crude protein 250–350 g of crude protein/kg DM (Jayasuriya, 2002) were also available for ruminant feeding in the study area.

5.1.2 Training in ruminant livestock production

The lower percentage (21%) of farmers that received some training in ruminant production calls for increase effort to train farmers in ruminant livestock production. More institutions should be involved in the training of farmers on ruminant production.

5.7 Study 2: Intake, digestibility and growth response of sheep fed Andropogon grass hay and Samanea, Acacia and Ficus leaf meal supplements

5.7.1 Chemical composition of feed ingredients

The crude protein value of *Samanea saman* leaf (21.9%) was similar to the value of 20 % reported by García *et al*. (2008) for the same species. High levels of crude protein in the *Samanea saman* leaf meal means there may be more protein made available to the rumen microbes which could lead to increase in digestibility of the feed resulting in increase in productivity especially when fed to sheep in the dry season.

The crude protein content of the *Acacia auriculiformis* leaf meal (16.4%) was lower than the reported value of 20.16% by Devendra and McLeroy (1982) for the same browse species. The differences could be attributed to agronomic factors such as application of various levels of nitrogen fertilizers, time of harvest, field drying and storage. Similar findings have been reported in Italian rye grass for its dry matter yield, which varied from 18.88% to mainly due to different harvesting time (Bittante and Andrighetto, 1982). The crude protein content of the *Ficus exasperata* leaf meal (15.9%) was comparable to the reported value of 14.0% by Rothmans *et al*. (2006). The lowest crude protein content was observed for cassava peels (2.1%). This was similar to 2.63% reported by Akpabio *et al.* (2012) and was comparable to the value 3.93% reported by Baiden and Obese (2010).

The NDF (59.8%) and ADF (39.7%) of *Samanea saman* leaf meal were higher than the values 41.50% and 28.70% reported for Gliricidia leaves (Mpairwe *et al*., 1998). Juárez *et al.* (2004) obtained values of 40 to 54% and 17 to 39% for some forage tree legumes. The NDF (60.7%) and ADF (49.5%) contents for *Acacia auriculiformis* leaf meal

compares favourably with reported values of 61.5 and 54.2% by Salem *et al.* (2006) for *Eucalyptus camaldulensis* browse species but higher than the values 41.50% and 28.70% reported for Gliricidia leaves (Mpairwe *et al*., 1998)..

The NDF(42.9%) and ADF(36.4%) values obtained for the *Ficus exasperata* leaf meal in the present study was within the values of NDF and ADF for Ficus leaves reported by Addo-Kwafo (1996), Sottie *et al.* (1998) and Annan and Tuah (1999). The NDF (36.3%) and ADF (27.4%) for dried cassava peels were the least among the ingredients. This means cassava peels will have higher digestibility when given as a feed. The NDF and ADF values of the dried cassava peels were comparable to 34% and 24.6% values respectively reported by Ifut (1987) and Bawala *et al*. (2007). The lignin contents obtained for *Samanea saman* leaf meal (8.8%), *Acacia auriculiformis* leaf meal (6.2%), *Ficus exasperata* leaf meal (3.7%) and dried cassava peel meal (9.7%) fell within the range of 6 and 14% reported by Juárez *et al*. (2004) for tree legumes.

The higher crude protein contents of the leaf meals (*Samanea saman*, *Acacia auriculiformis* and *Ficus exasperata*), their lower NDF as well as their relative higher organic matter contents than the *Andropogon gayanus* hay (basal diet) suggest their ability to provide essential nutrients that may be limiting in the basal diet.

5.7.2 Acceptability of sheep for the supplements

The sheep accepted Samanea leaf meal and cassava peel meal based supplements more than the rest. Small ruminants prefer sweet and generally reject bitter plants (Krueger *et al.*, 1974). A number of factors may influence acceptability of feed by small ruminants. Provenza *et al.* (1994) reported that plant physical structure and chemical composition are the most vital factors that influence preference for food. Oldham and Alderman (1980) reported that sometime a*d libitum* intake by animals is increased by an increase in crude protein content of diets.

5.7.3 Influence of supplements on voluntary intakes in sheep

Total dry matter intake was similar ($p > 0.05$) among dietary treatments (Table 4.2.4). The level of dry matter intake is known to be influenced by several factors, such as environmental conditions especially climate, type of management, body composition of animals (composition of body fat), feed composition and quality, genetic factors and weight of animals (ARC, 1980). An animal's feed intake is highly affected by the palatability and digestibility of the feed as observed by Mattewman (1977).

The increased crude protein intake of sheep on Acacia leaf meal (T_2) and Ficus leaf meal (T_3) supplements compared to the Samanea leaf meal (T_1) and cassava peels based supplements (T_4) could be attributed to the ability of the Acacia leaf meal and Ficus leaf meal supplements to have improved the rumen environment thus enabling rumen microbes to degrade fibrous portions of the diet. High crude protein intake makes available nitrogen needed to improve the rumen's eco-system and increase the animal's ability to

digest fibrous portions of forage. The lowest crude protein intake of sheep on the cassava peel meal supplement (T_4) could be attributed to the low level of crude protein in that supplement (16.3%; Table 4.2.2) fed to the animals. Odedire and Oloidi (2014), reported a decrease in crude protein intake due to reduced palatability of the diet when West African Dwarf goats were fed supplements containing increasing levels of wild sunflower.

The lower organic matter intake in T_3 (Ficus based supplement) could be attributed to the high levels of anti-nutritional factors, such as alkaloids, saponins, cyanogenic glycosides and tannins contained in the Ficus leaf meal diet that could potentially have adverse effects on nutrient utilisation as reported by Ijeh and Ukwemi (2007). The higher NDF intake in T_3 can be attributed to the higher crude protein level (21.5%) in Ficus based meal supplement which could have improved rumen environment aiding rumen microbial fermentation thereby increasing dry matter intake and consequently, NDF intake. The high intake of ADF in T_1 and T_4 could be attributed to moderate quantities of antinutritional factors in the Samanea leaf meal as reported earlier by Obasi *et al*. (2010) and tolerable levels of cyanogenic glycosides in the dried cassava peel meal supplement. The lower levels of these anti-nutritional factors might have not have adversely influenced the rumen environment but aided in ADF digestion thereby increasing its intake. However, the high intake of ADF in T_2 (*Acacia auriculiformis* leaf meal) based supplement compared to T_3 (*Ficus exasperata* leaf meal) based supplement could be attributed to the presence of galactose, arabinose, rhamnose methylglucuronic acid and glucuronic acid in the *Acacia auriculiformis* leaf supplement that could have supported fibrolytic microbes in the rumen by increasing the proximity between substrates and microbes as reported by (Morgavi *et al.*, 2000). This might have enhanced the stimulation of bacterial activity and consequently

causing faster fermentation rate and substrate degradation as reported by Castillejos *et al.* (2007).

The lower lignin intake in sheep on T_4 compared to T_1, T_2 and T_3 could be attributed to an imbalance or inadequacy of nutrients especially crude protein intake in sheep on T_4 (Table 4.2.4) which might have resulted in reduced rumen ammonia production and microbial growth and activity. This could indirectly slow down the rates of digestion and passage and subsequently reduce intake as reported by Preston and Leng (1984).

5.7.4 Digestibility of nutrients by WAD sheep fed basal diet of Andropogon gayanus hay and supplements

The lower dry matter digestibility in sheep on T_4 (cassava peel based supplement) compared to sheep on T_1, T_2 and T_3 (Table 4.2.5) could be attributed to anti-nutritional factors such as cyanogenic glycosides in the cassava peel meal supplement that might have slowed down dry matter digestibility. Anti-nutritional factors are known to interfere with normal digestion, metabolism and absorption of nutrients (Harborne, 1993).

The higher crude protein intake of sheep on the browse leaf meal supplements over the cassava peel supplement could have enhanced the digestibility of crude protein in these supplements than the Cassava peel based supplement. The presence of cyanogenic glycosides in the cassava peel meal (T_4) supplement could have inhibited the effective digestion of protein by the rumen microbes. The leaves of forages are high in readily

degradable nitrogen as reported by NRC (2000) and some by-pass protein. Inclusion of such browses in ruminant diets will cause faster fermentation rate and substrate degradation hence increasing dry matter intake.

The high digestibility of organic matter of sheep on the Samanea leaf meal and Ficus leaf meal supplements (T_1 and T_3) could be due to the provision of adequate nutrients to the rumen microbes with consequent improvement in organic matter intake. The decreased organic matter digestibility of sheep on the Acacia leaf meal and Cassava peel meal based supplements (T_1 and T_4) could be due to high levels of anti-nutritional factors in the Acacia leaf meal (tannins and triterpenoids) and the Cassava peel meal (cyanogenic glycoside) adversely affecting rumen microbial activity resulting in lower organic matter digestibility. The lower crude protein digsestibility in T_4 could have accounted for the lowest organic matter digestibility for sheep on the Cassava peel meal based diet.

The high NDF digestibility in sheep on T_1 and T_3 can be attributed to moderate concentrations of secondary metabolites (saponins, steroids, alkaloids, flavonoids, tannins and resins) in the Samanea leaf meal and Ficus leaf meal (saponins, cyanogenic glycosides and tannins) supplements that might have had positive influence on rumen microbes as several researchers have reported secondary metabolites having positive impacts on rumen fermentation due to their low or moderate concentrations (Jiménez-Peralta *et al.*, 2011; Salem *et al.*, 2014). The low crude protein level in the Cassava peel meal (T_4) supplement could have inhibited rumen activity thus decreasing digestibility of NDF of sheep on that diet. The higher ADF digestibility in sheep on T_1 and T_4 compared to those

on T_1 and T_3 (Table 4.2.5) could be attributed to the low lignin contents in supplements T_1 and T_4 (Table 4.2.5). High fibre content in plant material is known to reduce digestibility (Jayasuriya, 2002).

5.8 Daily weight gain and FCE of sheep fed basal diet of Andropogon gayanus hay and supplements

All the four diets tested in this experiment were good enough for the sheep since they all promoted growth and there was no loss of weight. The daily weight gains (37.16, 37.16 and 57.43 g/day) respectively of T_1, T_2 and T_4 (Table 4.2.6) were comparable with the 16-48 g/d reported by Adu *et al.* (1992) when they fed crop stover supplemented with lablab to sheep, but were lower compared to the 79-91 g/d reported by Baiden *et al.* (2007) for sheep fed basal diet of rice straw and supplemented with cassava peels.

The similar feed conversion efficiency values obtained in the present study across dietary treatments could be linked to equal ability of the test diets to have improved the rumen environment which helped in utilization of diets in sheep for growth.

5.9 Haematological parameters of WAD sheep fed basal diet of Andropogon gayanus hay and supplements

The similar concentrations of the haematological parameters in all the test diets suggest that the inclusion of Samanea, Acacia, Ficus and Cassava peel based supplements did not have adverse or detrimental effects on the health of the sheep. This suggests the quality of the supplementary diets were good enough to maintain good and healthy functions of the sheep.

The relatively lower haemoglobin level in sheep on T_1 compared to the other treatments may account for the lower PCV levels of sheep on that treatment (Table 4.3.1). Haemoglobin levels are positively correlated with PCV (Turkson and Ganyo, 2015). The haemoglobin and PCV levels of 13.27 to 15.46g/dL and 29.20 to 35.60% respectively obtained in the present study were within the normal physiological range of 9 to 15 g/dL and 27 to 45% respectively reported for sheep (The Merck Veterinary Manual, 2010). This suggest similar ability of the dietary treatments in augmenting the production of haemoglobin and RBCs for efficient transportation of gases (oxygen and carbon dioxide) during respiration. Baiden and Obese (2010). Konlan *et al.* (2012) and Dougba (2017) in an earlier study reported haemoglobin and PVC ranges of 12.41 to 13.60 g/dL and 27.45 to 29.43% respectively for the same breed of sheep fed fattening diets containing various agro-industrial by-products.

Total RBC counts range of values (10.63 to 11.94 x 10^{12}/L) was within the normal physiological range of 9 to 15 x 10^{12}/L reported for sheep (The Merck Veterinary Manual,

2010) indicating the efficient synthesize of RBCs across the dietary treatments. The MCV, MCH and MCHC values obtained in the present study were comparable to the normal physiological range for sheep. The MCV values (27.8 to 29.5fL) was within the normal physiological range (28 to 40 Fl) reported for sheep (The Merck Veterinary Manual, 2010).The range of values for MCH (12.4 to 13.9 pg) and MCHC (43 to 46.7g/dL) obtained in the present study compared favourably with the MCH range of 13.47 to 15.12 pg and MCHC range of 41.2 to 51.2g/dL obtained for West Africa Dwarf sheep fed basal diet of rice straw and supplemented with graded levels of neem leaf meal concentrate diet (Dougba, 2017).

The total WBC counts (4.34 to 4.87 x 10^9/L obtained in the present study were within the normal range of 4 to 12 x 10^9/L reported for sheep (The Merck Veterinary Manual, 2010).This suggests the test diets supplied enough nutrients for the production of WBCs to adequately defend the body against infections. Konlan *et al*. (2012) reported a range of 8.37 to 9.30 x 10^9 for the West African Dwarf sheep fed a basal diet of rice straw and groundnut haulms with graded levels of shea- nut cake concentrate supplement. Also the WBC differential counts across dietary treatments were within the normal ranges reported for sheep (The Merck Veterinary Manual, 2010). This suggest equal ability of the sheep to fight infection when fed diets with inclusion of *Samanea saman*, *Acacia auriculiformis* and *Ficus exasperata* leaf meal based supplements and cassava peel meal supplement. The distribution of WBC observed in the present study were comparable with the range of values reported for the same breed of sheep by Baiden and Obese (2010) and Konlan *et al.* (2012).

5.10 Serum biochemical parameters of WAD sheep fed basal diet of Andropogon gayanus hay and supplements

Blood biochemical indices provide useful information in the physiological status of animals and hence serve as a tool in determining normal healthy state of animals (Bellows *et al.*, 1963). The non significant difference in the concentrations of all the blood biochemical indices across the dietary treatments except total protein concentration suggest that the inclusion of leaf meal supplements based on (Samanea, Acacia , Ficus) and Cassava peel meal based supplements did not have adverse effects on the physiology of the West African Dwarf sheep.

The similar concentration of serum glucose across dietary treatments suggest the inclusion of the browse species leaf meal and cassava peel based supplements did not adversely deprived the sheep of energy for metabolic activities. The range of values (1.54 to 1.96 mmol/L) obtained in the present study was however, lower than the 2.85 to 3.10 mmol/L range of values reported for West Africa Dwarf sheep fed basal diet of rice straw and supplemented with varying levels of neem leaf meal concentrate diets (Dougba, 2017).

Serum concentrations, total protein, albumin and globulin serve as indicators of protein status (Ndlovu *at al.,* 2007). Also, circulating concentrations of globulin usually give indication of an animal's immune state and its response to fighting diseases and infections (Kapele *et al*., 2008). The high total protein concentration of sheep on T_2 than those on T_1, T_3 and T_4 may be accounted for by the higher CP intake of sheep on diet T_2 than those on the other diets. The values obtained for total protein concentrations, averaged 60.46 to 64.38 g/L were within the normal physiological value of 59 to 78 g/L reported for sheep (The Merck Veterinary Manual, 2010). The total protein concentrations were comparable

to the 56.00 to 61.34 g/L reported for the same breed of sheep fed basal diet of rice straw and groundnut haulms with graded levels of shea nut cake concentrate supplement (Konlan *et al.,* 2012), but lower than the 72.3 to 83.3 g/L reported for the same breed of sheep (Dougba, 2017). The age, type of diet fed and physiological state of the sheep used may account for the differences. The concentrations of serum albumin (36.96 to 38.43 g/L) were similar to the reported normal physiological values of 27 to 37 g/L reported for sheep (The Merck Veterinary Manual, 2010). However, globulin concentrations (23 to 24 g/L) obtained in the present study were lower than the reported normal physiological values of 39 to 60 g/L in sheep (The Merck Veterinary Manual, 2010). The low globulin concentrations in the sheep may indicate low ability of the sheep to resist infections or diseases. However, all the sheep used in the study were healthy and did not show any signs of disease throughout the study. The normal and similar total protein and albumin concentrations in sheep fed the various supplements indicates that the inclusion of leaf meal and cassava peel supplements did not adversely influence the availability of protein to the sheep, their immune status and ability to fight diseases.

The range of values for total cholesterol (1.41 to 1.5mmol/L) was within the reported normal physiological range of 1.1 to 2.3mmol/L in sheep (the Merck Veterinary Manual, 2010). However, the concentrations of serum urea (range 8.71 to 9.67mmol/L) in the present study was close to the normal physiological upper range value of 9.3 mmol/L reported for sheep (The Merck Veterinary Manual, 2010), but lower than the values 13.26 to 16.32mmol/L reported for West African Dwarf sheep fed basal diet of rice straw and supplemented with varying levels of neem leaf meal concentrate diets (Dougba, 2017). The difference may be attributed to the type of diet fed to sheep in these studies.

CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

The following conclusions are made:

- Small ruminant production in the Accra plains is mostly on small scale basis with keepers feeding a wide array of feed resources available in their locality.
- The *Samanea saman, Acacia auriculiformis, Ficus exasperata* and Cassava peels available to the small ruminant keepers can be used to prepare supplement that are acceptable to the animals and can improve performance on low quality basal diets.
- The samanea leaf meal and cassava peel based diets were more acceptable to the WAD sheep and improved dry matter intakes.
- Sheep fed Samanea leaf meal based supplement had the highest dry matter, crude protein and organic matter digestibilities than those on Acacia, Ficus and Cassava peel based supplements.
- The selected browse species and cassava peel based supplements did not adversely affect the physiology and health of the sheep since the concentration of the haematological and serum biochemical parameters were all within the normal ranges reported for sheep.

6.2 Recommendations

The following recommendations are being made:

- It is recommend that supplement containing up to 70% *Samanea saman*, *Acacia auriculiformis* and *Ficus exasperata* leaf meal can be used in the diet of WAD sheep since their inclusion improved growth and digestibility of the basal diet.
- Further research should be conducted to determine the effect of *Samanea saman*, *Acacia auriculiformis* and *Ficus exasperata* leaf meal on rumen pH and microbial population in sheep.
- Studies to determine the effect of diets containing *Samanea saman*, *Acacia auriculiformis* and *Ficus* leaf meal on meat quality and reproductive performance of sheep should be undertaken.

REFERENCES

Abbiw, T. (1990). Study of Tropical shrubs and plant. *Journal of Biogeorge. 23, 591-602.*

Abd-Alla, M. F., El-Negoumy, S. I., El-Lakany, M. H. and Saleh, N. A. (1980). Flavonoid glycosides and the chemosystematics of Eucalyptus camaldulensis. *Phytochemistry*, *19*(12), 2629-2632.

Adams, F. and Ohene-Yankyera, K. (2014). Determinants of factors that influence small ruminant livestock production decisions in Northern Ghana: Application of Discrete Regression model. *Journal of Biological and Agriculture Healthcare*, *27*, 310-321.

Addo-Kwafo, A. (1996). *Propagation, Forage Production and Forage Quality of Some Ghanaian Browse Plants*, PhD Thesis, University of Ghana.

Adebayo, G. I., Alabi, O. T., Owoyele, B. V. and Soladoye, A. O. (2009). Anti-diabetic properties of the aqueous leaf extract of Bougainvillea glabra (Glory of the Garden) on alloxan-induced diabetic rats. *Records of Natural Products*, *3*(4), 187.

Adegbola, A.A., Smith, O.B. and Okeudo, N. J. (1988). Responses of West African Dwarf sheep fed cassava peel and poultry manure-based diets. Proceedings of the first joint workshop held in Lilongwe, Malawi PANESA/ARNAB, Addis Ababa, Ethiopia. pp 357-366.

Adjorlolo L.K. (1999). Studies on *Mucuna pruiences* forages as a protein supplement for sheep on straw-based diet. M.Phil. Thesis, Department of Animal Science, Faculty of Agriculture, University of Ghana, Legon.

Ajila, C., Aalami, M. Krishnarau, L. and Prasada rao, U. (2010). Mango peel powder: A potential source of antioxidant and dietary fibre in macaroni preparations. *Innovative Food Science & Emerging Technologies, 11, 219-224. 10.1016/j.ifset.2009.10.004.*

Akin, M., Aktumsek A. and Nostro A. (2010). Antibacterial activity and composition of the essential oils of *Eucalyptus camaldulensis* Dehn. and Myrtus communis L. growing in Northern Cyprus. African Journal of Biotechnology, 9, 531-535.

Akpabio, U. D., Akpakpan, A. E., Udo, I. E. and Nwokocha, G. C. (2012). Comparative study on the physicochemical properties of two varieties of cassava peels (*Manihot utilissima* Pohl). *International Journal of Environment and Bioenergy*, *2*(1), 19-32.

Alhassan, W. S., Karbo, N., Aboe, P. A. T. and Oppong-Anane, K. (1999). Ghana's savannah rangelands: Agro-ecology, current improvement and usage practices, research needs and sustainable management criteria. Council for Scientific and Industrial Research, Accra, Ghana.

Amole, T.A. and Ayantunde, A.A. (2016). Assessment of existing and potential feed resources for improving livestock productivity in Niger. *International Journal of Agricultural Research*, *11*(2), 40-55.

Anderson, R.M. and May, R.M., (1978). Regulation and stability of host-parasite population interactions: I. Regulatory processes. *The Journal of Animal Ecology*, 11, 219-247.

Anderson, S.J., Klopfenstein, T.J. and Wilkerson, V.A. (1988). Escape protein supplementation of yearling steer grazing smooth brome pasture. Journal of *Animal Science,* 66, 237-242.

Annan, P. and Tuah, A.K. (1999). *Ficus exasperata* as supplement to cassava peels fed to Djallonke sheep. Proceedings of the 11th Biennial Conference held at KNUST, Kumasi, Ghana.

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

AOAC, (2004). Harmonisation of Analytical Terminology in Accordance with International Standards. http://www.aoac.org/intaffairs/analytical_terminology.htm.

ARC, (1980). Agricultural Research Council. The nutrient requirements of farm livestock no 2. Ruminants, London.

Archibeque, S. L., Burns, J.C. and Huntington, G.B. (2001). Urea flux in beef steers: Effects of forage species and nitrogen fertilisation. *Journal of Animal Science 79, 1937–1943.*

Asafu-Adjei, K., and Dantankwa, A. (2001). Policies for improving the competitiveness of smallholder livestock producers in Ghana. Challenges and opportunities. In Proceedings of a workshop policies for improving the competitiveness of smallholder livestock producers in the central corridor of West Africa. Implications for trade and regional integration. Abidjan, Cote d'ivore.

Asfari, Z., Weiss, J., Pappalardo, S. and Vicens, J. (1993). Synthesis and properties of double-calix [4]-arenes, doubly-crowned calix [4]-arenes, and double-calix-crowns. *Pure and Applied Chemistry*, *65*(3), 585-590.

Atasoglu, C. Newbold, C.J. and Wallace, R.Y. (2001). Incorporation of ammonia by cellulolytic ruminal bacterial, fibrobacter succinogenes, Ruminococcus albus and Ruminococcus flavefaciens. *Applied Environmental Microbiology. 67, 2819-2822.*

Atasoglu, C., Guliye, A.Y and Wallace, R.Y. (2004). Use of stable isotopes to measure de novo synthesis and turnover of amino acid-C and –N in mixed micro-organisms from the sheep rumen in-vitro. *British of Journal Nutrition. 91:235-261.*

Atoui, A.K., Mansouri, A., Boskou, G. and Kefalas, P. (2005). Tea and herbal infusions, their antioxidant activity and phenolic profile. *Food Chemistry*, *89*(1), 27-36.

Atuhaire, A. M., Mugerwa, S., Okello, S., Lapenga, K. O., Kabi, F. and Kabirizi, J. M. (2014). Prioritisation of crop residues for improving productivity on smallholder dairy farming households in the Lake Victoria Crescent, Uganda. *Open Journal of Animal Sciences*, *4*(02), 103.

Baah, J., Tait, R.M. and Tuah, A.K. (2011). Selecting browse plants to supplement cassava peel based diet for peri-urban small ruminants. *Small Ruminant Research*. 96, 36-40.

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

Baiden, R. Y. and Obese, F. Y. (2010). Performance of West African Dwarf sheep (the Djallonké) fed fattening diets containing agro-industrial by-products in Ghana. *Ghanaian Journal of Animal Science, 5, 60-65.*

Baiden, R.Y., S.W.A. Rhule, H.R. Otsyina, E.T. Sottie and G. Ameleke (2007). Performance of West African dwarf sheep and goats fed varying levels of cassava pulp as a replacement for cassava peels. *Livestock Research for Rural Development*, 19(3), Article # 35.

Baker, P. J., Stashak, P. W., Amsbaugh, D. F. and Prescott, B. (1971). Characterization of the antibody response to Type III pneumococcal polysaccharide at the cellular level: II. Studies on the relative rate of antibody synthesis and release by antibody-producing cells. *Immunology*, *20*(4), 481.

Ballard, C. Mjoo, S., Mandebvu, P., Sniffen, C.D., Emmanuel, S.M., Carter, M.P. (2001). Effect of feeding energy supplement to dairy cow pre and postpartum intake milk yield and incidence ketosis. *Animal Feed Science and Technology* 93, 55-69.

Bamualim, A., Weston, R. H., Hogan, J. P. and Murray, R. M. (1984). The contributions of *Leucaena leucocephala* to post ruminal digestible protein for sheep fed tropical pasture hay supplemented with urea and minerals. Proceedings of the Australian Society of Animal Production, 15, 255-258.

Batish, D. R., Singh, H. P., Kohli, R. K. and Kaur, S. (2008). Eucalyptus essential oil as a natural pesticide. *Forest Ecology and Management*, *256*(12), 2166-2174.

Bawala, T. O., Akpan, U., Ogunnowo, A. O., Fasae, O. A. and Sogunle, O. M. (2007). Influence of Mg supplementation on the haematological indices of young West African Dwarf (WAD) goats. In *Proc. of the 32 nd Annual Conf. of NSAP* pp. 76-78.

Begum, S., Hassan, S. I., Siddiqui, B. S., Shaheen, F., Ghayur, M. N. and Gilani, A.H. (2002). Triterpenoids from the leaves of sidiumguajava. *Phytochemistry*, *61*(4), 399 403.

Bellows, R.A., Pope, A.L., Meyer, R.K., Chapman, A.B. and Casida, L.E. (1963). Physiological mechanisms in nutritionally-induced differences in ovarian activity of mature ewes, *Journal of Animal Science, 22, 93-100.*

Bittante, G. and Andrighetto, I. (1982). Conservation of lolium multiflorum lam. Quantitative and qualitative modifications during hay-making and ensiling, *Zootecnicae Nutrizione Animale*, Italian, 8, 44-45.

Bondi, A. A. (1987). Animal nutrition. John Wiley and Sons Ltd.

Breazile, J. E. (1971). Textbook of veterinary physiology.

Brooker M.I.H. and Kleinig, D.A. (2006). Field Guide to Eucalyptus, South-eastern Australia, 3rd edition. Bloomings, Melbourne, Vol.1.

Bryant, J. P., Provenza, F. D., Pastor, J., Reichardt, P. B., Clausen, T. P. and du Toit, J. T. (1991). Interactions between woody plants and browsing mammals mediated

by secondary metabolites. *Annual Review of Ecology and Systematics*, *22*(1), 431-446.

Buniyamin, A. A., Eric, K. I. Q. and Fabian, C. A. (2007). Pharmacognosy and Hypotensive evaluation of *Ficus exasperata* Vahl (moraceae) leave. *Acta Poloniae Pharmaceutica-Drug Research*, *64*(6), 543-546.

Burkill, H. M. (1985). The useful plants of West Tropical Africa. 2nd Edition. Volume 1, Families A– D. Royal Botanic Gardens, Kew, Richmond, United Kingdom. 960pp.

Burkill, H. M. (1997). The useful plants of tropical West Africa. *4* 3rd Ed. Royal Botanic Gardens Kew. pp 166-179.

Busquet, M., Calsamiglia, S., Ferret, A. and Kamel, C. (2006). Plant extracts affect in vitro rumen microbial fermentation. *Journal of Dairy Science*, *89*(2), 761-771.

Butler, L. G. and Rogler, J. C. (1992). Biochemical mechanisms of the anti-nutritional effects of tannins. In *ACS Symposium series* American Chemical Society, 506, 298-298.

Campbell, T.W. (1994). Haematology. In: Ritchie, B.W., Harrison, G.J. and Harrison, L.R. (Eds). Avian Medicine: Principles and Application. Wingers Publishing. Lake worth, Florida, pp 176- 198.

Castillejos, L., Calsamiglia, S., Mart´ın-Tereso, J. and Ter -Wijlen, H. (2007). *In vitro* evaluation of effects of ten essential oils at three doses on ruminal fermentation of high concentrate feedlot-type diets. *Animal Feed Science Technology*, *145*, *259-270.*

Cecconello, A. M., De Antoni, C. and Koller, S. H. (2003a). Práticas educativas, estilos parentais e abuso físico no contexto familiar. *Psicologia em estudo*, *8*(spe), 45-54.

Cecconello, G.C., Benezra, M.S. and Ovispo, N.E. (2003b). Composición química y degradabilidad ruminal de los frutos de algunas especies forrajeras leñosas de un bosque seco tropical. *Zootecnia Tropical.* 21, 149.

Charray, J., Humbert, J. M. and Levif, J. (1992). Manual of sheep production in the humid tropics of Africa. CAB International.

Chumpawadee, S. and Pimpa, O. (2009). Effect of Fodder Tree as Fiber Sources in Total Mixed Ration on Feed Intake, Nutrient Digestibility, Chewing Behavior and Ruminal Fermentation in Beef Cattle. *Journal of Animal and Veterinary Advances.* 8, 1279.

Church, G. M. and Gilbert, W. (1984). Genomic sequencing. *Proceedings of the National Academy of Sciences*, *81*(7), 1991-1995.

Cjodova', D., Tùmová, E., Härtlová, H., Fučíková, A., Volek, Z., Vlčková, J.(2016). Changes of haematological and biochemical induces with age in rabbits with *ad-libitum* and limited feed intake *Acta Veterinarian*. *BRNO,* 86, 29-35

Clottey, V. A., Gyasi, K. O., Yeboah, R. N., Addo-Kwafo, A. and Avornyo, F. K., (2007). The small ruminant production system in Northern Ghana: A value network analysis. *Livestock Research for Rural Development.* 19 (11).

Coles, E. H. (1967). Veterinary Clinical Pathology. W.B. Sauders, US.

Conklin, N.L., McDowell, R.E. and Van Soest, P.J. (1991). Ranking twenty-two tropical browse species from Guanacaste, Costa Rica. *Turrialba*, 41, 615.

Cooper, S. M. and Owen-Smith, N. (1985). Condensed tannins deter feeding by browsing ruminants in a South African savanna. *Oecologia*, *67*(1), 142-146.

de Oliveira, K., Costa, C., Bittar, C.M.M., dos Santos, V.P., Oliveira, V.A.B and de Sá, J.C. (2012). Indigestible cellulose and lignin in determining feces production and apparent digestibility in horses. *Acta Scientiarum, Animal Sciences*.

Delgado, D. C; Hera, R.; Cairo, J and Orta, Y. (2014). Samanea saman, a multi-purpose tree with potentialities as alternative feed for animals of productive interest. *Cuban Journal of Agricultural Science,* 48, 3.

Demeyer, D. and Fievez, V. (2004). The synthesis of rumen bacterial protein limited by the availability of pre-formed amino acids. *British Journal of Nutrition*. 91,175-176.

Devendra, C. and McLeroy, G. B. (1982). Goat and and sheep production in the tropics. Longman Group Limited, Longman House, Burnt Mill, Harlow, Essex, UK. pp 271.

Dewhurst, R.J., Delaby, L., Moloney, A., Boland, T. and Lewis, E. (2009). Nutritive value of forage legumes used for grazing and silage. *Irish Journal of Agricultural and Food Research*. 48, 310-317.

Dicko-Toure, M. S. (1980). The contribution of browse to cattle fodder in the sedentary system of the Office du Niger. *Browse in Africa*, 43, 313-319.

Dossa, L. H., Rischkowsky, B., Birner, R. and Wollny, C. (2008). Socio-economic determinants of keeping goats and sheep by rural people in southern Benin. *Agriculture and Human Values*, *25*(4), 581.

Dougba, D.T. (2017). Effects of neem leaf meal supplementary diets on blood profiles of West African Dwarf sheep, M. Agric. Dissertation. Department of Animal Science. University of Ghana, Legon.

Duku, S., van der Zijpp, A. J. and Howard, P. (2010). Small ruminant feed systems: perceptions and practices in the transitional zone of Ghana. *Journal of Ethnobiology and Ethnomedicine*, *6*(1), 11.

Duncan, A, York L, Lukuyu B, Samaddar A and Stür W. (2012). Feed Assessment Tool (FEAST) Questionnaire for Facilitators (Version 5.3); A systematic method for assessing local feed resource availability and use with a view to designing intervention strategies aimed at optimizing feed utilisation.

Durr, P.A. (2001). The biology, ecology and agroforestry potential of the raintree, *Samanea saman* (Jacq.) Merr. *Agroforestry Systems*, 51, 223.

Egyir, I. K. (1994). Studies on the utilisation of urea ammoniated straw and urea molasses block supplement as dry season feedstuffs by sheep in Ghana. M.Phil Thesis. Faculty of Agriculture, University of Ghana, Legon.

Escobar, N. (1972). Flora tóxica de Panamá. Editorial Universitaria, Panamá City, Panamá, pp 150–151.

Etim, N.N., Enyenihi G.E., Akpabio U., Offiong E.E.A. (2014). Effects of nutrition on haematology of rabbits: a review. *European Scientific Journal* 10, 1857-7881.

Fahey, G.C. and Berger, L.L. (1988). Carbohydrate nutrition of ruminants. In: D.C. Church (ed.). The Ruminant Animal: Digestive Physiology and Nutrition. pp 269.

Fakoya, E. O. and Oloruntoba, A. (2009). Socio-economic determinants of small ruminant production among farmers in Osun state, Nigeria. *Journal of Humanities, Social Sciences and Creative Arts*, *4*(1), 90-100.

Falahati, M., Omidi Tabrizib, N. and Jahaniani, F. (2005). Anti dermatophyte activities of Eucalyptus camaldulensis in comparison with Griseofulvin. *Iranian Journal of Pharmacology and Therapeutics*, *4*(2), 80-0.

Ferreira, D. and Bekker, R. (1996). Oligomeric proanthocyanidins: naturally occurring O-heterocycles. *Natural Product Reports*, *13*(5), 411-433.

Fomunyam, R.T. and Maffeja, F. (1987). Cassava by-produces in rabbit and sheep diets. In: Little, D.A. and Said, A.N. (eds). Utilisation of Agricultural by-products as livestock feeds in Africa, ILCA, Addis Ababa, pp 103-107.

Foo, L.Y, Newman, R., Waghorn, G.C., McNabb, W.C. and Ulyatt, M.J. (1996). The proanthocyanidins of *Lotus corniculatus*. *Photochemistry* 41, 617–624.

Food and Agriculture Organisation (FAO) (2005). Aquastat, Country Profile Ghana, Food and Agriculture Organisation, Rome, Italy.

Frandson, R. D. (1986). Blood and other body fluids. Anatomy and Physiology of Farm Animals. 4th edition, Lea and Febiger, Philadelphia, 233-255.

Furstenburg, D. and Van Hoven, W. (1994). Condensed tannin as anti-defoliate agent against browsing by giraffe (*Giraffa camelopardalis*) in the Kruger National Park. *Comparative Biochemistry and Physiology Part A: Physiology*, *107*(2), 425-431.

Gakuubi, M. M. (2016). Steam distillation extraction and chemical composition of essential oils of *Toddalia asiatica* L. and *Eucalyptus camaldulensis* Dehnh. *Journal of Pharmacognosy and Phytochemistry*, *5*(2), 99.

Garai, S. and Mahato, S.B. (1997). Isolation and structure elucidation of three triterpenoid saponins from *Acacia auriculiformis*. Photochemistry, *44*(1), 137-140.

García, D.E., Medina, M.G., Cova, L.J., Torres, A., SocaM., Pizzani, P., Baldizán, A. and Domínguez, C.E. (2008). Preferencia de vacunos por el follaje de doce especies con potencial para sistemas agrosilvopastoriles en el Estado Trujillo, Venezuela.Pastos y Forrajes 31:1.

Gatenby, R. M. (2002). The Tropical Agriculturist, Sheep. CTA, Macmillan publishers, Malaysia.

Gbile, Z. O. and Adesina, M. O. (1986). Ethnobotany taxanomy and conservation of medicinal plants: In: The state of medicinal plant research in Nigeria. *Sofowora AO (ed)*, 19.

Ghana Statistical Service (2013). 2010 population and housing census. National Analytical report.

Ghana Statistical Service (2014). The Ghana Living Standards Survey, Round 6: Poverty Profile in Ghana. Ghana Statistical Service, Accra.

Gillet, P., Boei, L. and Jacobs, J. (2009). Practical Note: Tropical Haematology. Antwerpen: Prince Leopold Institute of Tropical Medicine.

Goodchild, A.V. (1990). Use of leguminous browse foliage to supplement low quality roughages in ruminants. PhD. Thesis, University of Queensland, Australia.

Groff, E. and Wu, Z. (2005). Milk production and nitrogen excretion of dairy cows fed different amounts of protein and varying proportions of alfalfa and corn silage. *Journal of Dairy Science*, 88(10), 3619-3632.

Gutteridge, R. and Shelton, H. (1993). The scope and potential of tree legumes in agroforestry. *Agroforestry Systems*, 23(2-3), 177-194.

Hallan, P. (1979). Population dynamics of Fig wasps from *Ficus exasperata* Vah,. Proc. Kon, Ned. Akad –We Ser. C. 87, 365-375.

Harborne, J. B. (1993a). Advances in chemical ecology. *Natural Product Reports*, *10*(4), 327-348.

Harborne, J. B. (1993b). Do natural plant phenols play a role in ecology?. In: nternational symposium on natural phenols in plant resistance 381, 36-45.

Harr, K.E. (2006). Diagnostic values of biochemistry. In: Harrison G.J. and Lightfoot T.L. (Eds). Clinical Avian Medicine. Vol. II Spix Publishing, Inc., Palm Beach, Florida. pp 612-630.

Hart, K. J., Yáñez-Ruiz, D. R., Duval, S. M., McEwan, N. R. and Newbold, C. J. (2008). Plant extracts to manipulate rumen fermentation. *Animal Feed Science and Technology*, *147*(1-3), 8-35.

Haslam, E. D. W. I. N. (1993). Polyphenols-phytochemical chameleons. In annual Proceedings-Phytochemical Society of Europe, Oxford University Press. Vol 34, pp 214.

Henning, P.H., Steyn, D.G. and Meissner, H.H. (1991). The effect of energy and nitrogen supply pattern on rumen bacterial growth in vitro. Animal Health and Production, 53,165-175.

Hespel, R.B. (1979). Efficiency of growth by ruminal bacteria, Federation Proceedings 38, 2707-2712.

Heuzé, H., Tran, G. B. D., Archimède, H. and Lebas, F. (2012). Cassava peels, cassava pomace and other cassava tubers by-products. Feedipedia. Org and Tables Régions Chaudes. A project by INRA, CIRAD and AFZ with the support of FAO.

IBM SPSS Statistics (2016). IBM Corporation, USA. Release 24.0.0.0

Ibrahim, H. (1994). Small Ruminant Production Techniques. ILRI Manual 3 Nairobi, Kenya. pp 207.

Ifut, O. J. (1987). The chemical Composition and in *vitro* organic matter digestibility of some browse plants in Nigeria, M.Sc Thesis, Department of Animal Science University of Ibadan, Nigeria.

Ijeh, I. I. and Ukwemi, A. I. (2007). Acute effect of administration of ethanol extract of *Ficus exasperata* on kidney function inalbino rats. *Journal of Medical Plant Research, 1, 27 – 29.*

ILCA. (1986). Annual *report. ILCA.* Addis Ababa, Ethiopia.

International Fund for Agriculture Development (IFAD) (2004). Livestock and Services and the Poor. A Global Initiative Collecting, Coordinating And Disseminating Experiences. Draft Report, Danida, IFAD and The World Bank.

Janzen, D. H. (1983). Seasonal changes in abundance of large nocturnal dung beetles (Scarabaeidae) in a Costa Rican deciduous forest and adjacent horse pasture. *Oikos*, 46, 274-283.

Jayasuriya M. C. N. (2002). Principles of ration formulation for ruminants; Development and field evaluation of animal feed supplementation packages. Proceedings of the final review meeting of IAEA Technical Co-operation Regional Project, Cairo, Egypt, 25–29 November 2000. pp 9 – 14.

Jiménez-Peralta, F. S., Salem, A. Z. M., Mejia-Hernández, P., González-Ronquillo, M., Albarrán-Portillo, B., Rojo-Rubio, R. and Tinoco-Jaramillo, J. L. (2011). Influence of individual and mixed extracts of two tree species on *in vitro* gas production kinetics of a high concentrate diet fed to growing lambs. *Livestock Science*, *136* (2-3), 192-200.

Jones, G. A., McAllister, T. A., Muir, A. D. and Cheng, K. J. (1994). Effects of sainfoin (Onobrychis viciifolia Scop.) condensed tannins on growth and proteolysis by four

strains of ruminal bacteria. *Applied Environmental Microbiology*, *60*(4), 1374-1378.

Juárez F. I., Montero M., Alpirez, F., Contreras, J. and Canudas, E. (2004). Evaluación nutricional de leguminosas tropicales para bovinos de doble propósito. XVII Reunión Científca Tecnológica Forestal Agropecuaria. Veracruz, México.

Kapele, P.M., Japtap, D.G., Badukale, D.M. and Sahatpure, S.K. (2008). Serum total proteins and serum total cholesterol levels in Gaolao cattle. *Veterinary World* 1 (4), 115-116.

Kernick, B. L. (1991). The effect of form of nitrogen on the efficiency of protein synthesis by rumen bacteria in continuous culture. PhD. Thesis. University of Natal, Pietermaritzburg, South Africa.

Kerr, M.G. (2002). Veterinary Laboratory Medicine: Clinical Biochemistry and Haematology, 2nd edition. Blackwell Science Ltd. UK.

Khan, T. A. and Zafar, F. (2005). Haematological study in response to varying doses of estrogen in broiler chicken. *International Journal of Poultry Science, 4(10), 748-751.*

Koney E. B. M. (2004). Livestock Production and Health in Ghana. Advent Press, Accra. pp 1– 49.

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

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

Krueger, W. C., Laycock, W. A. and Price, D. A. (1974). Relationships of taste, smell, sight, and touch to forage selection. *Journal of Rangeland Management Archives, 27*(4), 258-262.

Kuamar, R. and D'Mello, J. P. F. (1995). Anti-nutritiional factors in forage tree legumes. In: Tropical legumes in Animal Nutrition. D'Mello, J. P. F. and Devendra, C. (eds). CAB International pp 95-125.

Kuamar, R. and Singh, M. (1984). Tannins: their adverse role in ruminant nutrition. *Journal of Agriculture and Food Chemistry*, 32, 447-453.

Lakpini, C. A. M., Balogun, B. I., Alawa, J. P., Onifade, O. S. and Otaru, S. M. (1997). Effects of graded levels of sun-dried cassava peels in supplement diets fed to Red Sokoto goats in first trimester of pregnancy. *Animal Feed Science and Technology, 67*(2-3), 197-204.

Larbi, A., Jabbar, M. A., Orok, E. J., Indieng, N. B. and Cobbina, J. (1993). *Alchornea cordifolia*: A promising indigenous browse species adapted to acid soils in south eastern Nigeria for integrated crop –livestock agroforestry production systems. *Agroforestry Systems,* 22, 33-41.

Larsen, R. E. and Amaning-Kwarteng, K. (1976). Cassava peels with urea and molasses as dry season supplementary feed for cattle. Ghana Journal of Agricultural Science 9, 43-47.

Lascano, C. E., Maass, B. L., Argel, P. J. and Viquez, E. (1995). Leucaena in Central and South America. In ACIAR, proceedings, Australian Centre for International Agricultural Research, pp152-158.

Lawal, I. O., Uzokwe, N. E., Ladipo, D. O., Asinwa, I. O. and Igboanugo, A. B. I. (2009). Ethnophytotherapeutic information for the treatment of high blood pressure among the people of Ilugun area of Ogun State, south-west Nigeria. *African Journal of Pharmacy and Pharmacology*, *3*(4), 222-226.

Le Houerou, H. N. (1980). Browse in Northern Africa. In: H. N. Le Houerou(ed), Browse in Africa: The current state of knowledge. Papers presented at the International Symposium on Browse in Africa, Addis Ababa, ILCA (International Livestock Centre for Africa), Addis Ababa, Ethiopia, pp. 55-82.

Lesca, P. (1983). Protective effects of ellagic acid and other plant phenols on benzo pyrene-induced neoplasia in mice. Carcinogenesis, *4*(12), 1651-1653.

Lewington, A. J., Padanilam, B. J., Martin, D. R. and Hammerman, M. R. (2000). Expression of CD44 in kidney after acute ischemic injury in rats. *American Journal of Physiology-Regulatory, Integrative and Comparative Physiology*, *278*(1), R247-R254.

Longland, A. C., Theodorou, M. K., Sanderson, R., Lister, S. J., Powell, C. J. and Morris, P. (1994). Non-starch polysaccharide composition and in vitro fermentability of tropical forage legumes varying in phenolic content. *Animal Feed Science and Technology*, *55*(3-4), 161-177.

Lowry, J. B., Petheram, R. J. and Tangendjaja, B. (1992). Plants Fed to Village Ruminants in Indonesia, ACIAR, Canberra, Australia, pp 54.

Mahama, C. (2012). Farm animals are vital to Ghana's food secure future, Modern Ghana Multimedia Group.

Makeham, J. P. and Malcolm, L. R. (1986). *The economics of tropical farm management*. Cambridge University Press, pp 64-95.

Makkar, H.P. and Becker, K. (1994). Isolation of tannins from leaves of some trees and shrubs and their properties. *Journal of Agricultural and Food Chemistry*, *42*(3), 731-734.

Manh, N. S., Wanapat, M., Uriyapongson, S., Khejornsart, P. and Chanthakhoun, V. (2012). Effect of eucalyptus (Camaldulensis) leaf meal powder on rumen fermentation characteristics in cattle fed on rice straw. *African Journal of Agricultural Research*, *7*(13), 1997-2003.

Manual of Basic Techniques for a Healthy Laboratory, (2003). Handbook of Medical Technology and Radiation Medicine. 2nd edition. World Health Organization, Geneva, pp. 265-266

Marinda, P. A. (2006). Child–mother nutrition and health status in rural Kenya: the role of intra-household resource allocation and education. *International Journal of Consumer Studies*, *30*(4), 327-336.

Marshall, D., Stern, A., Bachand S. and Calsamiglia, A. (2006). New concepts in protein nutrition of ruminants 21st annual southwest nutrition and management conference Canada, pp 45-47.

McDonald, P., Edwads, G. A. and Greenhalgh, J.F.D. (1993). Animal Nutrition (6th ed). Longman, New York, pp 342-345.

Medhi, S. M., Reza, S., Mahnaz, K., Reza, A. M., Abbas, H., Fatemeh, M. and Hassan, V. (2010). Phytochemistry and larvicidal activity of Eucalyptus camaldulensis against malaria vector, Anopheles stephensi. *Asian Pacific Journal of Tropical Medicine*, *3*(11), 841-845.

Mehansho, H., Ann, D. K., Butler, L. G., Rogler, J. and Carlson, D. M. (1987). Induction of proline-rich proteins in hamster salivary glands by isoproterenol treatment and an unusual growth inhibition by tannins. *Journal of Biological Chemistry*, *262*(25), 12344-12350.

Meshkani, F., Rezaei, M. and Andache, M. (2014). Investigation of the catalytic performance of Ni/MgO catalysts in partial oxidation, dry reforming and combined reforming of methane. *Journal of Industrial and Engineering Chemistry*, *20*(4), 1251-1260.

Ministry of Food and Agriculture (MoFA) (2007). Annual Report. Accra, Ghana.

Ministry of Food and Agriculture (MoFA) (2010). Agriculture in Ghana, Facts and Figures. Statistics, Research and Information Directorate (SRID).

Ministry of Food and Agriculture (MoFA) (2011). Facts and figures: Ministry of Food and Agriculture, Statistical Research and Information Directorate. Accra, Ghana. Pp 12 – 34.

Ministry of Food and Agriculture (MoFA) (2012). Agriculture in Ghana: Facts and figures, Accra; Ministry of Food and Agriculture, Statistics, Research and Information Directorate, Accra, Ghana.

Ministry of Food and Agriculture (MoFA) (2015). Facts and Figures, Statistics, Research and Information Directorate, Accra, Ghana.

Minson, D.J. (1990). *Forage in ruminant nutrition. Academic Press, San Diego, 483 pp...*

Misra, A. K., Saraswat, B. L. and Jakhmola, R. C. (2007). Effect of Inclusion of Tree

Misra, A. K., Saraswat, B.L. and Jakhmola, R.C. (2007). Effect of Inclusion of Tree Leaves in Feed on Nutrient Utilization and Rumen Fermentation in Sheep. *Bioresource Technology, 98, 511- 517.*

Morgavi, D. P., Beauchemin, K. A., Nsereko, V. L., Rode, L. M., Iwaasa, A. D., Yang, W. Z. and Wang, Y. (2000a). Synergy between ruminal fibrolytic enzymes and enzymes from *Trichoderma longibrachiatum. Journal of Dairy Science*, *83*(6), *1310-1321.*

Morgavi, D. P., Newbold, C. J., Beever, D. E. and Wallace, R. J. (2000b). Stability and stabilization of potential feed additive enzymes in rumen fluid. *Enzyme and Microbial Technology*, *26(2-4), 171-177.*

Mould, F.L. and Ørskov, E.R. (1984). Manipulation of rumen fluid pH and its influence on cellulolysis in-Sacco, dry matter degradation and the rumen micro flora of sheep offered either hay or concentrate. *Animal Feed Science and Technology 10:1-14.*

Mpairwe, D. R., Sabiiti, E. N. and Mugerwa, J. S. (1998). Effect of dried Gliricidia sepium leaf supplement on feed intake, digestibility and nitrogen retention in sheep fed dried KW4 elephant grass (Pennisetum purpureum) *ad-libitum*. *Agroforestry systems*, *41*(2), 139-150.

Mueller-Harvey, I. (2006). Unravelling the Conundrum of Tannins in Animal Nutrition and Health. *Journal of the Science of Food and Agriculture, 86, 2010-2037.* http://dx.doi.org/10.1002/jsfa.2577.

Navas, A., Restrepo, C. and Jimenez, G. (2001). Ruminal function in sheep supplemented with Pithecellobium saman pods. International Symposium on Silvopastoral Systems and Second Congress on Agroforestry and Livestock Production in Latin America. Available: http//www.fao.org/WAIRDOCS/X6109 E/x6109e00.htm#Contents.

Ndlovu, T., Chimonyo, Okoh, A.I., Muchenje, V., Dzama, K. and Raats, J.G. (2007). Review: Assessing the nutritional status of beef cattle: current practices and future prospects. *African Journal of Biotechnology5, 2727-2734*.

Norton, B.W. (1994). The nutritive value of tree legumes. In: Forage Tree Legumes in Tropical Agriculture, (R.C. Gutteridge and H.M. Shelton, editors). Wallingford, Oxford: CAB International., pp. 177–191.

NRC. (2000). Nutrient Requirements of Beef Cattle. 7th Review. ed. Natitional Academy Press, Washington, DC.

Nurfeta, A. (2010). Digestibility and nitrogen utilization in sheep fed enset (Ensete ventricosum) pseudostem or corm and graded levels of Desmodium intortum hay

to wheat straw-based diets. *Journal of Animal Physiology and Animal Nutrition*, 94(6), pp.773-779.

Obasi, N.L., Egbuonu, A.C.C., Ukoha, P.O and Ejikeme, P.M. (2010). Comparative phytochemical and antimicrobial screening of some solvent extracts of *Samanea saman* (fabaceae or mimosaceae) pods. *African Journal of Pure and Applied Chemistry 4, 206.*

Odedire, J. A., and Oloidi, F. F. (2014). Feeding Wild Sunflower (*Tithonia Diversifolia Hemsl.,* A. Gray) to West African Dwarf Goats as a Dry Season Forage Supplement. *World Journal of Agricultural Research 2 (6), 280-284.*

Odunbaku, O. A., Ilusanya, O. A. and Akasoro, K. S. (2008). Antibacterial activity of ethanolic leaf extract of Ficus exasperata on *Escherichia coli* and *Staphylococcus albus*. *Science Research Essay*, *3*(11), 562-4.

Ojeda, A., Barroso, J.A., Obispo, N., Gil, J.L. and Cegarra, R. (2012). Composición química, producción de gas *in vitro* y astringencia en el follaje de *Samanea saman* (Jacq.) Merrill. Pastos y Forrajes. 35, 205.

Okantah, S.A., Obese, F.Y., Oddoye, E.O.K., Gyanu, P. and Asante, Y. (1996). A survey on the livestock and milk production characteristics of peri-urban agro-pastoral dairing in Ghana. Ghana Journal of Agriculture Science, 32,39-46.

Okoli, R. I., Aigbe, O., Ohaju-Obodo, J. O. and Mensah, J. K. (2007). Medicinal herbs used for managing some common ailments among Esan people of Edo State, Nigeria. *Pakistan Journal of Nutrition, 6*(5), 490-496.

Oldham, J. D. and Alderman, G. (1980). Recent advances in understanding protein-energy interrelationships in intermediary metabolism of ruminants. Protein and energy supply for high production of milk and meat, Pergamon Press, Oxford, pp 728.

Onyeyili, P.A, Egwu, G.O., Jibike, G.I., Pepple, D.J. and Ohaegbulam, J.O. (1992). Seasonal variation in haematological indices in the grey-breasted guinea fowl (*Numida mealagris Gallata pallas*). *Nigeria Journal of Animal Production, 18(2), 108-110.*

Oppong-Anane, K. (2010). Ghana livestock sector review; FAO Presentation in Ghana. Accra, Ghana. pp 124 – 158.

Osei-Amponsah, R. (2010). Phenotypic and genetic characterisation of local chicken (Gallus gallus) ecotypes of Ghana. PhD Thesis. Department of Animal Science. University of Ghana, Legon.

Osman, T. E. A. and Al-Busadah, K. A. (2003). Normal concentrations of twenty serum biochemical parameters of she-camels, cows and ewes in Saudi Arabia. *Pakistan Journal of Animal Science, 6*(14), 1253-1256.

Owen, E. and Jayasuriya, M.C.N. (1989). Research and Development in Agriculture: Report on Prices in Botswana. USAID –Southern Africa. 6,129–138.

Palo, R.T. and Robbins, C.T. (1991). Plant defenses against mammalian herbivory. CRC Press.

Patra, A. K. and Yu, Z. (2012). Effects of essential oils on methane production and fermentation and abundance and diversity of rumen microbial populations. *Applied Environmental Microbiology*, *78*(12), 4271-4280.

Pedraza, R.M., La O. O., Estévez, J., Guevara G. and Martínez. S. (2003). Nota técnica: Degradabilidad ruminal efectiva digestibilidad intestinal *in vitro* del nitrógeno del follaje de leguminosas arbóreas tropicales. Pastos Forrajes 26, 237.

Peters, J. C., Lawson, K. D., Middleton, S. J. and Triebwasser, K. C. (1997). Assessment of the nutritional effects of olestra, a nonabsorbed fat replacement: summary. *The Journal of Nutrition*, *127*(8), 1719S-1728S.

Pham, H.H. and Preston, T.R. (2009). Effect of dried cassava peelings on the rumen environment of cattle fed natural grasses. *Livestock Research for Rural development (21) 9.*

Preston, T. R. and Leng, R. A. (1984). Supplementation of diets based on Fibrous residues and by-products. In: Sundstol, F. and Owen, E. eds. *Straw and other Fibrous by products as Feed*. Elsevier Science Publishers, Amsterdam.

Provenza, F. D., Burritt, E. A., Clausen, T. P., Bryant, J. P., Reicharadt, P. B. and Distel, R. A. (1990). Conditioned flavour aversion: A mechanism for goats to avoid condensed tannins in black brush. *American Naturalist*; 136, 810-828.

Provenza, F. D., Lynch, J. J., Burritt, E. A. and Scott, C. B. (1994). How goats learn to distinguish between novel foods that differ in postingestive consequences. *Journal of Chemical Ecology*, *20*(3), 609-624.

Puoli, J. R., Reid, R. L. and Belesky, D. P. (1992). Photosensitization in lambs grazing switchgrass. *Agronomy Journal*, *84*(6), 1077-1080.

Quarshie, B. S. (1992). Studies on various treatment conditions affecting urea-ammoniated rice straw in Ghana. MPhil Thesis. Faculty of Agriculture, University of Ghana, Legon.

Quintavalla, J., Kumar, C., Daouti, S., Slosberg, E. and Uziel-Fusi, S. (2005). Chondrocyte cluster formation in agarose cultures as a functional assay to identify genes expressed in osteoarthritis. *Journal of Cellular Physiology*, *204*(2), 560-566.

Raghuvansi, S.K., Prasad, R., Mishra, A.S., Chaturvedi, O.H., Tripathi, M.K., Misra, A.K., Saraswat, B.L. and Jakhmola, R.C. (2007). Effect of inclusion of tree leaves in feed on nutrient utilization and rumen fermentation in sheep. Bioresource Technology, 98, 511- 517.

Rastogi, S. K. (2008). Renal effects of environmental and occupational lead exposure. *Indian Journal of Occupational and Environmental Medicine*, *12*(3), 103.

Roncallo, B., Torres, E. and Sierra, M. (2009). Producción de vacas de doble propósito suplementadas con frutos de Algarrobillo (*Pithecellobium saman*) durante las lluvias.

Rothmans, J. M., Diernfeld, E. S., Molina, D. O., Shaw, A. V., Hintz, H. F. and Pell, A. N. (2006). Nutritional chemistry of foods eaten by gorillas in Bwindi Impenetrable National Park, Uganda. *American Journalof Primatology 66: 75 – 91*.

Sadava, D., Hillis, D. M., Heller, H. C. and Berenbaum, M. (2011). Life: The Science of Biology, Sunderland, MA.

Salem, M. L. and Hossain, M. S. (2000). Protective effect of black seed oil from Nigella sativa against murine cytomegalovirus infection. *International Journal of Immunopharmacology*, *22*(9), 729-740.

Salem, M. Z. M., Ali, H. M. and Basalah, M. O. (2014). Essential oils from wood, bark, and needles of *Pinus roxburghii* Sarg from Alexandria, Egypt: Antibacterial and antioxidant activities. *BioResources*, *9*(4), 7454-7466.

Salem, M. Z. M., El-Adawy, M. M. and Robinson, P. H. (2006). Nutritive evaluations of some browse tree foliages during the dry season: secondary compounds, feed intake and in vivo digestibility in sheep and goats. *Animal Feed Science and Technology*, *127*(3-4), 251-267.

Sallam, S. M. A., Bueno, I. C. D. S., Brigide, P., Godoy, P. B., Vitti, D. M. S. S., and Abdalla, A. L. (2009). Efficacy of eucalyptus oil on *in vitro* ruminal fermentation and methane production. Options Mediterraneannes, *Nutritional and Foraging Ecology of sheep and goats, 85(85), 267-272.*

Sallam, S. M., Bueno, I. C., Nasser, M. E. and Abdalla, A. L. (2010). Effect of eucalyptus (Eucalyptus citriodora) fresh or residue leaves on methane emission in vitro. *Italian Journal of Animal Science*, *9*(3), 58.

Samour, J. (2006). Diagnostic value of haematology. Clinical Avian Medicine, 2,587-610.

Sandoval, C.A., Lizarraga, H.L. and Solorio, F. J. (2005). Assessment of tree fodder preference by cattle using chemical composition, *in vitro* gas production, and *in situ* degradability. *Animal Feed Science Technology, 123, 277.*

Sanson, D. W., Clanton, D. C. and Rush, I. G. (1990). Intake and digestion of low-quality meadow hay by steers and performance of cows on native range when fed protein supplements containing various levels of corn. *Journal of Animal Science, 68*(3), 595-603.

Scalbert, A. (1991). Antimicrobial properties of tannins. *Phytochemistry*, *30*(12), 3875-3883.

Schalm, O. W., Jain, N. C. and Carroll, E. J. (1975). Veterinary haematology. 3rd edition Lea and Febiger Philadelphia, U.S.A. pp13, 123, 136.

Seedtakoses, P., Yothinsirikul, W. and Siri, A. (1988). Utilization of saman pod (*Samanea saman*) as cattle and buffalo feed. Proc. Workshop on the utilization of Local material as Animal Feeds. Department of Animal Husbandry, Faculty of Agricultural, Chiangmai University, Chiangmai, Thailand.

Selvam, V. E. (2007). Trees and shrubs of the Maldives. *RAP Publication*.

Simons, A. J. and Stewart, J. L. (1994). *Gliricidia sepium*-a multipurpose tree legume. In: Guttridge, R. C. and Shelton, H. M. (eds). *Forage tree legumes in tropical Agriculture.* CAB International, 34, 315-322.

Singab, A. N., Ayoub, N., Al-Sayed, E., Martiskainen, O., Sinkkonen, J. and Pihlaja, K. (2011). Phenolic constituents of Eucalyptus camaldulensis, with potential antioxidant and cytotoxic activities. *Records of Natural Products*, *5*(4).

Smith, J.F. (1988). Influence of Nutrition on Ovulation Rate in the Ewe. *Australian Journal of Biological Sciences, 41, 27-36.*

Smith, O. B. (1992). Fodder trees and shrubs in range and farming systems in tropical humid Africa. In: Speedy, A. and Pugliese, P. (Eds). Legume trees and other fodder trees as protein sources for livestock. Proceedings, Food and Agriculture Organisation expert consultation, Malaysian Agricultural Research and Development Institute (MARDI), Kuala Lumpur, Malaysia.

Smith, A.H., Odenyo, A.A., Osuji, P.O., Wallig, M.A., Kandil, F.E., Seigler, D.S. and Mackie, R.I. (2001). Evaluation of toxicity of Acacia angustissima in a rat bioassay. *Animal feed science and technology*, *91*(1-2), 41-57.

Sonibare, O. O. and Effiong, I. (2008). Antibacterial activity and cytotoxicity of essential oil of Lantana camara L. leaves from Nigeria. *African Journal of Biotechnology*, *7*(15).

Sottie, E. T., Agyei Henaku, A. A. O., Amaning-Kwarteng, K. and Fleischer, J. E. (1998). Effect of season on the chemical composition and *in vitro* digestibility of some browse and shrubs in Ghana. *Ghana Journal of Agricultural Science*, 31, 99-105.

Staples, G. W. and Elevitch, C. R. (2006). *Samanea saman* (rain tree). Species profile for Pacific Island agroforestry. Availablea at www.traditionaltree.org.

Tanner, E. V. J., Kapos, V., Freskos, S., Healey, J. R. and Theobald, A. M. (1990). Nitrogen and phosphorus fertilization of Jamaican montane forest trees. *Journal of Tropical Ecology*, *6*(2), 231-238.

Tatsuta, K., Takahashi, H., Amemiya, Y. and Kinoshita, M. (1983). Stereo-selective total synthesis of pyrrolizidine alkaloid bases, rosmarinecine and isoretronecanol. *Journal of the American Chemical Society*, *105*(12), 4096-4097.

Tewe, O. O. (1985). Protein metabolism in growing pigs fed corn or cassava peel based diets containing graded protein levels. *Research in Veterinary Science*, *38*(3), 259-263.

Thapa, B., Walker, D. H. and Sinclair, F. L. (1997). Indigenous knowledge of the feeding value of tree fodder. *Animal Feed Science and Technology*, *68*(1-2), 37-54.

The Merck Veterinary Manual, (2010). A Handbook of Diagnosis, Therapy, and Disease Prevention and Control for the Veterinarian. Editions: Kahn, C. M., and Line, S., Merck and Company Incorporated. New Jersey, USA 905-908.

Thole, N. S., Joshi, A.L. and Rangnekar, D.V. (1992). Nutritive evaluation of rain tree (*Samaneas aman*) pods. *Indian Journal of Animal Sciences 62, 270.*

Togum, V.A., Oseni, B.S.A Ogundipe, J.A. Arewa, T.R., Hammed, A.A., Ajonijebu, D.C. and Mustapha, F. (2007). Effects of chronic lead administration on the haematological parameters of rabbits – preliminary study. Proceedings of the 41st Conference of the Agricultural Society of Nigeria. pp 341.

Turkson, P. K. and Naandam, J. (2006). Constraints to ruminant production in East Mamprusi District of Ghana. *Ghana Journal of Agricultural Science*, *39*(2), 155-164.

Ugwuene, M. C. (2011). Effect of dietary palm kernel meal for maize on the haematological and serum chemistry of broiler turkey. *Nigerian Journal of Animal Science*, *13*, 93-103.

Ukoha, P.O., Cemaluk, E. A. C, Nnamdi, O.L. and Mad, P.E. (2011). Tannins and other phytochemical of the *Samanaea saman* pods and their antimicrobial activities. *African Journal of Pure and Applied Chemistry 5, 237.*

Van Soest, P. J. (1982). Nutritional ecology of the ruminant. O and B Books. Inc., Corvallis, OR, 374.

Van Soest, P. J. (1994). Function of the ruminant forestomach. *Nutritional Ecology of the ruminant*, pp 230-252.

Van Soest, P. V., Robertson, J. B. and Lewis, B. A. (1991). Methods for dietary fibre, neutral detergent fibre, and nonstarch polysaccharides in relation to animal nutrition. *Journal of Dairy Science*, *74*(10), 3583-3597.

VSN International (2012). GenStat 12th Edition. UK. Version 12.1.0.3338.

Waghorn, G. C., Shelton, I. D., McNabb, W. C. and McCutcheon, S. N. (1994). Effects of condensed tannins in *Lotus pedunculatus* on its nutritive value for sheep. 2. Nitrogenous aspects. *The Journal of Agricultural Science*, *123*(1), 109-119.

Wattenberg, L.W. and Lam, L.K.T. (1983). Phenolic antioxidants as protective agents in chemical carcinogenesis. In: *Radioprotectors and anticarcinogens*, Academic Press New York, pp 461.

Woodward, A. and Coppock, D. L. (1995). Role of plant defense in the utilisation of native browse in southern Ethiopia. *Agroforestry Systems*, *32*(2), 147-161.

APPENDICES

Appendix 1: Analysis of variance for acceptability data

Source of variation	d.f	s.s	m.s.	v.r.	F. pr.
Diet	3	489337	163112.	19.96	<.001
Residual	108	882671.	8173.		
Total	**111**	**1372008.**			

Appendix 2: Analysis of variance for total dry matter intake

Source of variation	d.f.	s.s.	m.s.	v.r.	F. pr.
Trt	3	20381.	6794.	1.83	0.143
Residual	220	817498.	3716.		
Total	**223**	**837879.**			

Appendix 3: Analysis of variance for total crude protein intake

Source of variation	d.f	s.s	m.s.	v.r.	F. pr.
Trt	3	1879.62	626.54	13.73	<.001
Residual	220	10042.80	45.65		
Total	**223**	**11922.42**			

Appendix 4: Analysis of variance for total organic matter intake

Source of variation	d.f.	s.s.	m.s.	v.r.	F. pr.
TRT	3	4611.0	1537.0	0.36	0.785
Residual	4	16975.0	4244.0		
Total	7	21586.0			

Appendix 5: Analysis of variance for total neutral detergent fibre intake

Source of variation	d.f.	s.s.	m.s.	v.r.	F. pr.
Trt	3	5751.1	1917.0	16.42	<.001
Residual	220	25691.4	116.8		
Total	**116.8**	**31442.5**			

Appendix 6: Analysis of variance for total acid detergent fibre intake

Source of variation	d.f	s.s	m.s.	v.r.	F. pr.
Trt	3	32553.51	10851.17	288.77	<.001
Residual	220	8266.98	37.58		
Total	**223**	**40820.50**			

Appendix 7: Analysis of variance for total lignin intake

Source of variation	d.f.	s.s.	m.s.	v.r.	F. pr.
Trt	3	190.17	63.39	5.73	<.001
Residual	220	2434.56	11.07		
Total	**223**	**2624.72**			

Appendix 8: Analysis of variance for dry matter digestibility

Source of variation	d.f.	s.s.	m.s.	v.r.	F. pr.
Trt	3	213.938	71.313	23.77	<.001
Residual	52	155.995	3.000		
Total	**55**	**369.933**			

Appendix 9: Analysis of variance for crude protein digestibility

Source of variation	d.f.	s.s.	m.s.	v.r.	F. pr.
Trt	3	273.437	87.313	19.76	<.001
Residual	52	215.995	4.154		
Total	**55**	**489.432**			

Appendix 10: Analysis of variance for organic matter digestibility

Source of variation	d.f.	s.s.	m.s.	v.r.	F. pr.
Trt	3	293.886	97.962	17.58	<.001
Residual	52	289.686	5.571		
Total	**55**	**583.572**			

Appendix 11: Analysis of variance for neutral detergent fibre digestibility

Source of variation	d.f.	s.s.	m.s.	v.r.	F. pr.
Trt	3	443.864	147.955	21.42	<.001
Residual	52	359.219	6.908		
Total	**55**	**803.083**			

Appendix12: Analysis of variance for acid detergent fibre digestibility

Source of variation	d.f.	s.s.	m.s.	v.r.	F. pr.
Trt	3	1266.362	422.121	56.35	<.001
Residual	52	389.543	7.491		
Total	**55**	**1655.906**			

Appendix13: Analysis of variance for initial weight

Source of variation	d.f.	s.s.	m.s.	v.r.	F. pr.
Trt	3	10.000	3.333	1.82	0.318
Rep	1	12.500	12.500	6.82	0.080
Residual	3	5.500	1.833		
Total	**7**	**28.000**			

Appendix 14: Analysis of variance for final weight

Source of variation	d.f.	s.s.	m.s.	v.r.	F. pr.
Trt	3	8.594	2.865	0.81	0.566
Rep	1	0.781	0.781	0.22	0.670
Residual	3	10.594	3.531		
Total	**7**	**19.969**			

Appendix 15: Analysis of variance for ADG

Source of variation	d.f.	s.s.	m.s.	v.r.	F. pr.
Trt	3	5495.6	1831.9	10.58	0.042
Rep	1	1284.0	1284.0	7.42	0.072
Residual	3	519.3	173.1		
Total	**7**	**7298.9**			

Appendix 16: Analysis of variance for FCE

Source of variation	d.f.	s.s.	m.s.	v.r.	F. pr.
Trt	3	0.04638	0.01546	0.98	0.484
Residual	4	0.06281	0.01570		
Total	**7**	**0.10919**			

Appendix 17: Analysis of variance for haemoglobin

Source of variation	d.f.	s.s	m.s.	v.r.	F. pr
Subject stratum					
Trt	3	32.668	10.889	3.57	0.162
Rep	1	1.312	1.312	0.43	0.559
Residual	3	9.155	3.052	0.45	
Subject.Time stratum d.f. correction factor 0.5900					
Time	4	196.592	49.148	7.25	0.017
Time. Trt	12	89.858	7.488	1.10	0.449
Time. Rep	4	9.541	2.385	0.35	0.747
Residual	12	81.337	6.778		
Total	**39**	**420.462**			

Appendix 18: Analysis of variance for packed cell volume

Source of variation	d.f.	s.s	m.s.	v.r.	F. pr
Subject stratum					
Trt	3	214.40	71.47	2.01	0.291
Rep	1	3.60	3.60	0.10	0.771
Residual	3	106.80	35.60	1.62	
Subject.Time stratum d.f. correction factor 0.4511					
Time	4	301.40	75.35	3.44	0.111
Time. Trt	12	652.60	54.38	2.48	0.160
Time. Rep	4	48.40	12.10	0.55	0.589
Residual	12	263.20	21.93		
Total	**39**	**1590.40**			

Appendix 19: Analysis of variance for red blood cells

Source of variation	d.f.	s.s	m.s.	v.r.	F. pr
Subject stratum					
Trt	3	10.685	3.562	3.60	0.160
Rep	1	0.108	0.108	0.11	0.763
Residual	3	2.965	0.988	0.32	
Subject.Time stratum d.f. correction factor 0.5970					
Time	4	14.189	3.547	1.17	0.375
Time. Trt	12	50.301	4.192	1.38	0.340
Time. Rep	4	3.966	0.991	0.33	0.766
Residual	12	36.499	3.042		
Total	**39**	**118.712**			

Appendix 20: Analysis of variance for Neutrophils

Source of variation	d.f.	s.s	m.s.	v.r.	F. pr
Subject stratum					
Trt	3	282.60	94.20	11.53	0.037
Rep	1	562.50	562.50	68.88	0.004
Residual	3	24.50	8.17	0.11	
Subject.Time stratum d.f. correction factor 0.3923					
Time	4	141.35	35.34	0.46	0.613
Time. Trt	12	315.65	26.30	0.34	0.859
Time. Rep	4	407.75	101.94	1.33	0.334
Residual	12	917.25	76.44		
Total	**39**	**2651.60**			

Appendix 21: Analysis of variance for WBC

Source of variation	d.f.	s.s	m.s.	v.r.	F. pr
Subject stratum					
Trt	3	3.1810	1.0603	0.63	0.641
Rep	1	1.6000	1.6000	0.96	0.400
Residual	3	5.0180	1.6727	3.19	
Subject.Time stratum d.f. correction factor 0.2874					
Time	4	9.3660	2.3415	4.47	0.113
Time. Trt	12	14.6240	1.2187	2.33	0.236
Time. Rep	4	2.6150	0.6537	1.25	0.348
Residual	12	6.2870	0.5239		
Total	**39**	**42.6910**			

Appendix 22: Analysis of variance for total protein

Source of variation	d.f.	s.s	m.s.	v.r.	F. pr
Subject stratum					
Trt	3	84.88	28.29	13.48	0.030
Rep	1	40.60	40.60	19.34	0.022
Residual	3	6.30	2.10	0.09	
Subject.Time stratum d.f. correction factor 0.3507					
Time	4	195.04	48.76	2.05	0.232
Time. Trt	12	548.10	45.67	1.92	0.265
Time. Rep	4	95.44	23.86	1.01	0.406
Residual	12	284.88	23.74		
Total	**39**	**1255.24**			

Appendix 23: Analysis of variance for Albumen

Source of variation	d.f.	s.s	m.s.	v.r.	F. pr
Subject stratum					
Trt	3	13.51	4.50	1.50	0.374
Rep	1	4.03	4.03	1.34	0.331
Residual	3	9.03	3.01	0.12	
Subject.Time stratum d.f. correction factor 0.4653					
Time	4	388.12	97.03	3.89	0.89
Time. Trt	12	242.22	20.18	0.81	0.594
Time. Rep	4	72.67	18.17	0.73	0.514
Residual	12	298.99	24.92		
Total	**39**	**1028.56**			

Appendix 24: Analysis of variance for Cholesterol

Source of variation	d.f.	s.s	m.s.	v.r.	F. pr
Subject stratum					
Trt	3	124.6	41.5	1.01	0.497
Rep	1	328.4	328.4	7.99	0.066
Residual	3	123.3	41.1	0.23	
Subject.Time stratum d.f. correction factor 0.4393					
Time	4	6370.3	1592.6	8.89	0.022
Time. Trt	12	957.8	79.8	0.45	0.809
Time. Rep	4	65.2	16.3	0.09	0.894
Residual	12	2150.1	179.2		
Total	**39**	**10119.8**			

Appendix 25: Analysis of variance for Glucose

Source of variation	d.f.	s.s	m.s.	v.r.	F. pr
Subject stratum					
Trt	3	3.0270	1.0090	5.04	0.108
Rep	1	0.0640	0.0640	0.32	0.611
Residual	3	0.6000	0.2000	0.50	
Subject.Time stratum d.f. correction factor 0.4442					
Time	4	4.2200	1.0550	2.63	0.162
Time. Trt	12	1.9680	0.1640	0.41	0.834
Time. Rep	4	0.6760	0.1690	0.42	0.655
Residual	12	4.82000.4017			
Total	**39**	**15.3750**			

Appendix 26: Analysis of variance for Urea

Source of variation	d.f.	s.s	m.s.	v.r.	F. pr
Subject stratum					
Trt	3	18652	6217	1.03	0.492
Rep	1	5885	5885	0.97	0.397
Residual	3	18195	6065	0.99	
Subject.Time stratum d.f. correction factor 0.2500					
Time	4	25490	6373	1.04	0.383
Time. Trt	12	73991	6166	1.01	0.498
Time. Rep	4	24597	6149	1.00	0.390
Residual	12	73511	6126		
Total	**39**	**240322**			

Appendix 27: Questionnaire used for the survey

NUTRITIONAL EVALUATION OF THREE BROWSE SPECIES COMMONLY FED TO SMALL RUMINANTS BY FARMERS IN THE ACCRA PLAINS OF GHANA

District: …… Community: …….. ……

GPS Reading: ….....

Respondent details

Respondent ID: …..…… Farmer ID: ……

Sex M [ ] F [ ]

1. Age: ……..
2. Marital status: Single [ ] Married [ ] Divorced [ ] Separated [ ]
3. Please indicate your household size …….
4. Primary occupation: Farming [ ] Salaried work [ ] Trading [ ] Artisan [ ] Retiree [ ]
5. Level of education: None [ ] Basic [ ] Secondary [ ] Vocational [ ] Technical [ ] Tertiary [ ] Non-Formal [ ]
6. Religion: Christian [ ] Moslem [ ] Traditional [ ] Other .....
7. How long (in years) have you been keeping small ruminants? ……
8. Which do you prefer to keep; sheep or goat? Sheep [ ] Goats [ ]
9. Please indicate the reasons for your preference.
   a. Easier to manage [ ] b. Easier to sell [ ] c. I prefer the meat d. more profitable [ ] e. Others ……
10. How long (in years) have you been growing crops? ……

Resource Endowment

11. Estimate your total land holding …. ……acres or ……hectares

12. Crop holding

Type of crop	Acreage	Production purpose	
		Commercial	Subsistent

13. Livestock holding

Type of livestock	Breed	Number			Main production purpose	
		Adult Male	Adult Female	Young	Commercial	Subsistent
Sheep						
Goats						

14. Other animals kept by farmer

a. Cattle Yes [ ] No [ ] b. Guinea fowl Yes [ ] No [ ]

c. Local ducks Yes [ ] No [ ] d. Rabbit Yes [ ] No [ ]

e. Grasscutter Yes [ ] No [ ] f. Pigs Yes [ ] No [ ]

g. Local chicken Yes [ ] No [ ] i. Exotic chicken Yes [ ] No [ ] Others: .....

Small ruminant management

15. What system of management do you practice? Intensive [ ] Semi-intensive [ ] Extensive [ ]
16. List four major constraints you face in small ruminant business (Rank)
    a. (Most important) ....
    b. ……..... .....
    c. ....
    d. (Least important) .....
17. Do you house your animals? Yes [ ] No [ ]
18. Do you confine your animals? Yes [ ] No [ ]
19. If yes to Q18, to what extent are they confined?
    a. Always [ ] b. Part of the day [ ] c. Part of the year [ ] d. Occasionally [ ]
20. How do you manage breeding of your animals? (*More than one answer allowed*)
    a. No control [ ] b. Separate males [ ] c. Borrow male [ ]
    d. Castrate undesirable males [ ] Others: .....

Feeding practices

21. Do you allow your animals to graze? Yes [ ] No [ ]
22. If yes to Q21, are the animals herded (followed) during grazing? Yes [ ] No [ ]
23. Do you think your animals are usually well fed? Yes [ ] No [ ]
24. If yes to Q23, what is your indicator that they are usually well fed? ……
25. If no to Q23, how can their feeding be improved? ……
26. Do you feed you animals besides grazing (supplementation)? Yes [ ] No [ ]
27. If you feed, please give names of what you feed. (Multiple responses allowed)
    a. Cassava peels [ ] b. plantain peels [ ] c. cut forage [ ] d. crop residues [ ]
    e. Wheat bran (feed) [ ] f. rice bran [ ] g. maize bran (dusa) [ ] h. spent malt [ ]
    i. Pito mash [ ] j. sugar cane bagasse [ ] j. Others: .....

Do you buy any of the things you feed to your animals? Yes [ ] No [ ]

28. If yes to Q28, which feeds do you buy? (Multiple responses allowed)

a. Cassava peels [ ] b. plantain peels [ ] c. cut forage [ ] d. crop residues [ ]

e. Wheat bran (feed) [ ] f. rice bran [ ] g. maize bran (dusa) [ ] h. spent malt [ ]

i. Pito mash [ ] j. sugar cane bagasse [ ] j. Others: .....

29. How many types of forage species do you cut for your animals?

a. Browses: [ ][ ] (tree leaves)

b. Grasses & [ ][ ] Forbs:

30. Please name the forage species you cut for your animals? (Local names acceptable)

a. ..... b. .....

c. ..... d. .....

31. Do you know about **crop residues** as feed for small ruminants a. Yes [ ] b. No [ ]

32. Have you ever used **crop residues** in feeding your animals? a. Yes [ ] b. No [ ]

If yes, Please name them;

a. maize stover [ ] b. rice straw [ ] c. sorghum stover [ ] d. cassava leaves [ ] e. Others: ……

33. If you do not feed crop residues, indicate what you do with them

a. Nothing [ ] b. Burn [ ] c. Harvest [ ] d. Other people harvest [ ]

Others: ……

34. How do you treat the crop residue before feeding to animals?

Crop residue	Treatment
Maize Stover	
Rice Straw	
Sorghum Stover	
Cassava Leaves	

35. Do you know forages can be conserved for dry season feeding? Yes [ ]No [ ]
36. If yes to 36, which method of forage conservation do you know? Ensiling [ ] Hay making [ ]
37. Which method of forage conservation have you ever used? Ensiling [ ] Hay making [ ]
38. If **yes** to 38, how often do you ensile feed for your animals?
    a. Once [ ] b. Occasionally [ ] c. Seasonally [ ] d. Always [ ]
39. If **yes** to 38, how often do you make hay for your animals?
    a. Once [ ] b. Occasionally [ ] c. Seasonally [ ] d. Always [ ]

40. If **no** to 38, what are your reasons for not conserving feed?

a. Time consuming [ ] b. High cost [ ] c. Not our tradition [ ] Others: …….

<u>Training Needs Assessment</u>

41. Have ever received any training in how to keep ruminants? a. Yes [ ] b. No [ ]

42. If yes to 42, indicate the type of training? ……
43. Which institution offered the training? ……
44. Was the training useful to your animal production activities? a. Yes [ ] b. No [ ] Explain ……..
45. Do you think you need more training in ruminant production? a. Yes [ ] b. No [ ]
46. What aspects of animal production do you think you need training in? ……

End of Questions