NUTRITIONAL EVALUATION OF BROWSE-BASED AND CASSAVA PEELS-BASED PELLETED DRY SEASON SUPPLEMENTS FOR GOATS

BY

EMMANUEL AMPONG

(10491467)

THIS THESIS IS SUBMITTED TO THE UNIVERSITY OF GHANA, LEGON IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF MPHIL IN ANIMAL SCIENCE DEGREE

NOVEMBER, 2020

DECLARATION

I, Emmanuel Ampong, do hereby declare that except for other people's work which have been duly cited and acknowledged, the work herein submitted as a thesis to the School of Graduate Studies, University of Ghana, Legon, for the degree of Master of Philosophy in Animal Science, is the results of my own research work done in the Department of Animal Science, University of Ghana, Legon. This thesis has not been presented for another degree elsewhere, either in part or in whole.

..... 13/09/2021

Emmanuel Ampong — Date

(Student)

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

..... 13/09/2021

Prof. Frederick Yeboah Obese — Date

(Principal Supervisor)

..... 13/09/2021

Dr. Leonard Kofi Adjorlolo — Date

(Co-Supervisor)

DEDICATION

I dedicate this thesis to the Almighty God who has protected and brought me this far. This work is also dedicated to my family for their love and support. Finally, to my supervisors who were very supportive and always available to assist me whenever the need be.

AKNOWLEDGEMENT

My greatest appreciation goes to the Almighty God for the gift of life and his sustaining grace that has brought me this far.

My profound gratitude goes to my supervisors, Prof. Frederick Yeboah Obese and Dr. Leonard Kofi Adjorlolo for their fatherly guidance, help and the many things that they have taught me within this period of study.

To my sweet mother Mrs. Akoma Joyce and siblings; Oforiwaa, Amofa, Dwamina and Naomi, I say thank you for your undying support and guidance. I am most grateful.

I also express my sincerest gratitude to the rest of the teaching and non-teaching staff of the Department of Animal Science, University of Ghana especially Dr. Raphael A. Ayizanga for helping with the statistical analysis.

I thank Dr. Eric Timpong-Jones, the Head of Livestock and Poultry Research Centre, Dr. Felix Sarkwa, Mr. Amos Nyarko, Sir Julius, Mr Solomon Boadu, Madam Princess, Mr Nunoo and Mr. Bashiru Mohammed. Without them, this work would not have been a success.

Finally, to Mr. Mark Nsoh and all friends and loved ones, thank you for helping me in diverse ways. God bless you all.

LIST OF ACRONYMS

AACC	American Association for Clinical Chemistry
ADF	Acid Detergent Fibre
ADFI	Acid Detergent Fibre Intake
ADL	Acid Detergent Lignin
AGD	Average Daily Gain
ALMS	Acacia Leaf Meal-Based Supplement
ANF	Antinutritional factor
ANOVA	Analysis of Variance
BW	Body Weight
CDC	Centres for Disease Control and Prevention
CP	Crude Protein
CPMS	Cassava Peel Meal-Based Supplement
CPI	Crude Protein Intake
DM	Dry Matter
DMI	Dry Matter Intake
EE	Ether Extract
FCR	Feed Conversion Ratio
FLMS	Ficus Leaf Meal-Based Supplement
Hb	Haemoglobin
HCN	Hydrogen Cyanide
IVDMD	*In Vitro* Dry Matter Digestibility
IVDOM	*In Vitro* Digestibility of Organic Matter
K3.EDTA	Tripotassiumethelyne Diamine Tetra Acetic Acid
LIPREC	Livestock and Poultry Research Centre
LSD	Least Significant Difference
MCH	Mean Corpuscular Haemoglobin
MCHC	Mean Corpuscular Haemoglobin Concentration

MCV	Mean Corpuscular Volume
MoFA	Ministry of Food and Agriculture
MS	Mean Square
NDF	Neural Detergent Fibre
NDFI	Neutral Detergent Fibre Intake
NFE	Nitrogen Free Extract
NRC	National Research Council
OM	Organic Matter
PCV	Packed Cell Volume
PPR	Peste des petits ruminants
RBC	Red Blood Cells
SEM	Standard Error of Mean
SLMS	Samanea Leaf Meal-Based Supplement
TC	Total Cholesterol
WADG	West African Dwarf Goat
WBC	White Blood Cells

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Goats grazing natural pasture are challenged with seasonal variation in pasture availability and nutritive value. Therefore, improving the nutrition of goats through supplementary feeding during periods of pasture or nutrient deficit is necessary for improved productivity. This study was undertaken to assess the effects of supplementary feed based on three browses *(Samanea saman, Acacia auriculiformis,* and *Ficus exasperata)* and cassava peels on the performance of West African Dwarf goats, on a basal diet of *Andropogon gayanus* (Gamba grass) hay. An acceptability study revealed that the goats accepted all the four supplements but had a significant ($P<0.05$) preference for cassava peel meal-based and *Samanea saman* leaf meal-based supplements over *Ficus exasperata* leaf meal-based and *Acacia auriculiformis* leaf meal-based supplements. Although there was no marked difference in dry matter intakes across the four supplements ($P>0.05$), intake of crude protein was significantly higher ($P<0.05$) in goats fed ficus leaf meal-based than those fed cassava peel meal-based supplement. All the haematological parameters tested did not show significant ($P>0.05$) differences across experimental diets. Also, all the serum biochemical parameters tested were not affected, except blood urea concentration which was higher ($P<0.05$) in goats fed *Samanea saman* leaf meal-based supplement. The growth and the carcass parameters were also not affected ($P>0.05$) by the dietary treatments. It was therefore concluded that, *Samanea saman, Acacia auriculiformis and Ficus exasperata* leaf meals and cassava peel meal-based pelleted supplements are acceptable to goats and have similar nutrient composition, hence, they could be fed to goats on low quality forages during the dry season with no negative influence on feed intake and utilisation, growth, carcass quality, physiology and health of goats.

Keywords: WAD goats, Supplementation, Blood parameters, Carcass parameters, Dry season

CHAPTER ONE

1.0 INTRODUCTION

1.1 BACKGROUND AND JUSTIFICATION OF THIS STUDY

Small ruminant (sheep and goat) production is carried out mainly by smallholder farmers in the Accra Plains using mainly the indigenous breeds West African Dwarf sheep or goat and occasionally, crossbreds (long-legged Sahelian x West African Dwarf). The animals are grazed extensively on natural pasture with little or no feed supplementation coupled with minimal health care (Baiden and Obese, 2010; Ampong *et al*., 2019). A major limitation in this production system is the scarcity of quality fodder especially during the dry season with reduced levels of essential nutrients especially protein and minerals (Amankwah *et al*., 2012; Adjorlolo *et al*., 2016). The inadequate intake of nutrients relative to metabolic demands contributes to low birth weight, weight losses, lowered resistance to disease and poor reproductive performance causing economic loss to farmers (Annor *et al.,* 2007; Konlan, 2010). This adversely affects the livelihood of the resource poor ruminant livestock farmers. According to Osafo *et al*. (2013), due to the naturally insufficient nutrients in local grasses and cereal crop residues, which are the principal feed materials avaliable in Ghana, such feed resources are not able to sustain effective animal production when animals are fed on such feeds only.

The feeding challenge is worsened by the need to confine animals due to increasing cropping close to human settlements and urbanisation of hitherto rural or peri-urban areas (Adjorlolo *et al*., 2016). Provision of supplementary feedstuffs which are suitable would be a crucial means to enhance ruminant productivity so far as agro-pastoral and smallholder production systems are concerned in Ghana. The need for the development of good supplementation packages, with agro-industrial

by-products and leguminous forages which are cost effective and can supply substantial amounts of livestock energy, protein and mineral needs is therefore key.

In the past, research projects in Ghana aimed at developing feed supplementation packages as means of combating dry season feeding problems yielded minimal results. This was mainly due to lack of involvement of the farmers in the development of the packages at the inception of the research projects and the use of materials which were not readily available in the farmers' localities. Currently, very few farmers practice supplementary feeding which in most cases involves the use of one feed ingredient. For instance, feeding of cassava peels which is not fortified with any other nutrient source is very common. Variations in nutrient values of the local feed resources necessitate the combination of two or more of the feed resources in order to optimize feed quality and utilisation.

This study therefore sought to develop feeding packages based on locally available feed resources (agro-industrial by-products and leguminous fodder plants) that can easily be produced by farmers to improve productivity of small ruminants. With the increase in productivity, it is hoped that the nutrition of the farm family will improve directly through increased consumption of animal produce or indirectly through increased income.

Nsoh (2019) in a recent study identified some common feed resources used as supplements in small ruminants in five districts in the Accra plains in the Coastal Savannah Zone of Ghana. Among these were three browses *Samanea saman*, *Acacia auriculiformis* and *Ficus exasperata* and cassava peels which were used to develop multi-nutrient supplements and tested in sheep. The

effects of the supplements on the growth, physiology and carcass characteristics of goats have not been documented. This study therefore sought to develop multi-nutrient feed supplements based on three browses *(Samanea saman, Acacia auriculiformis* and *Ficus exasperata)* and cassava peels and to evaluate their effect on growth rate, metabolism, physiology and carcass characteristics of the West African Dwarf goat.

1.2 Main objective

The main objective of this study was to assess the effects of supplementary feed meals based on three browses *(Samanea saman, Acacia auriculiformis,* and *Ficus exasperata)* and cassava peels on performance of the West African Dwarf goat in the Accra Plains of Ghana.

1.3 Specific objectives

The specific objectives were to:

i. Determine the acceptability of pelleted supplements based on each of the three browse species and cassava peels by West African Dwarf goats.

ii. Assess the effect of pelleted supplements based on three browse species and cassava peels on voluntary feed intake, digestibility and weight gain in West African Dwarf goats.

iii. Determine the effect of pelleted supplements based on three browse species and cassava peels on some haematological and blood biochemical parameters of the West African Dwarf goat.

iv. Evaluate the effect of pelleted supplements based on three browse species and cassava peels on some carcass parameters of the West African Dwarf goat.

CHAPTER TWO

2. 0 LITERATURE REVIEW

2.1 Small ruminant production in Ghana

Small ruminant (sheep and goat) production in Ghana is carried out mostly by smallholder farmers using indigenous breeds (West African Dwarf) and crossbreds such as the West African Long-Legged and Sahelian types. As a result of their relatively small size, small ruminants have shown to be of great benefit to farmers with limited access to land for production and who often have no refrigerators to keep their meat (Ayizanga *et al*., 2018). Their fast reproductive, fast growth rates and shorter gestation length helps in early return on investment (Oppong-Anane, 2008).

The animals are grazed extensively on natural pasture with little or no feed supplementation coupled with minimal health care (Okantah *et al.*, 2006; Baiden and Obese, 2010; Ampong *et al*., 2019). This leads to low productivity depicted by low birth weight, slow growth rate, delayed puberty, poor conception rates, extended calving and lambing interval (Oppong-Anane, 2013).

2.1.1 Importance and constraints associated with small ruminant production in Ghana

Small ruminants have the ability to convert plant carbohydrates and proteins into available nutrients for human use, making otherwise unusable land productive (Lombardi, 2005; Rinehart, 2006). Sheep and goats provide essential resources such as meat, milk, skin and hide for human use, provide manure for fertilizing crop fields as well as employment opportunities (Oppong-Anane, 2013). They also serve as security and a store of wealth for farmers by providing ready

cash when sold (Karbo and Agyare, 2002; Konlan, 2018). Moreover, small ruminants are also used for socio-cultural purposes including the celebration of festivals, marriage, naming and funeral ceremonies (Karbo and Agyare, 2002; Oppong-Anane, 2008; Konlan, 2018).

Although small ruminants provide numerous products that improves the livelihood of smallholder farmers and the economy of Ghana in general, their production is faced with a number of constraints. The major constraint is the scarcity of quality fodder especially during the dry season with reduced levels of essential nutrients especially protein and mineral (Amankwah *et al*., 2012; Baah *et al*., 2012; Adjorlolo *et al*., 2016). The inadequate intake of nutrients relative to metabolic demands contributes to low birth weight, weight losses, lowered resistance to disease, poor reproductive performance causing economic loss to farmers (Obese, 1994; Annor *et al*., 2007; Konlan, 2010). According to Osafo *et al*. (2013), due to the naturally insufficient nutrients in local grasses and cereal crop residues, which are the principal feed materials avaliable in Ghana, are not able to sustain effective animal production when animals are fed on such feeds only.

Moreover, the difficulty in securing capital from financial institutions and the considerably low government budget allocation for livestock development are constraints that small ruminant production is faced with (Baah, 1994; MoFA, 2010; Oppong-Anane, 2010; Baah *et al*., 2012). This has led to an average importation of 50% livestock and/or its products to satisfy Ghana's domestic requirements since only 30% of Ghana's meat requirements are produced locally (Oppong-Anane, 2011).

According to Sadat (2015), the heavy encroachment on farmlands by people in the neighbouring communities for other human activities such as real estate development among others is also a

major constraint facing ruminant production, as this reduces the size of pasture lands resulting in a decrease in the available feed for use by small ruminants. This consequently leads to decreased productivity in terms of weight loss, delay in the resumption of the ovarian activity and conception in female animals (Sadat, 2015).

In addition to the above challenges are health issues such as annual disease and pest outbreaks with examples being Peste des petits ruminants (PPR) (Baah *et al*., 2012; Mahama, 2012). An estimated annual economic loss of US$50 million in Ghana has been associated with health problems in ruminant production in Ghana (MoFA, 2012 cited by Nsoh, 2019).

Adequate knowledge on the health, feeding behaviours and nutrient needs of small ruminants is vital for managing their overall wellbeing as well as contributing to the livelihoods of people that depend on them (Araújo *et al*., 2010). Therefore, provision of supplementary feedstuffs which are suitable would be a crucial means to enhance ruminant productivity so far as agro-pastoral and smallholder production systems are concerned in ghana.

2.1.2 The West African Dwarf goat

The West African Dwarf (WAD) goat is a predominant local breed found in West and Central Africa (Chiejina and Behnke, 2011; Birteeb *et al*., 2015; Chiejina *et al*., 2015). They are mostly reared extensively (Adedeji *et al*., 2011), or are raised in small herds on mixed farms (Chiejina *et al*., 2015). The WAD goat has an average matured weight of 30 kg and 20 kg for males and females respectively, measures 50 cm in height and the coat colour varies from white, brown, black and

various combinations of these colours (Adedeji *et al*., 2011; Ayizanga *et al*., 2018). They reach sexual maturity within 3 – 6 months (National Research Council, 1991).

The WAD goat provides a broad range of products such as meat, milk, skin, cash income and manure for crop production, as well as plays socio-economic roles in our society (Peacock, 2005; Chiejina and Behnke, 2011; Ampong *et al*., 2019). Their shorter gestation length, fast growth and reproductive rates help in early return on investment (Oppong-Anane, 2008). They are acknowledged for their high fertility, prolificacy, trypanotolerance, hardiness and suitability for year-round breeding (Koney, 2004; Oppong-Anane, 2008; Karnuah *et al*., 2018).

2.2 Supplementation in ruminant nutrition

Tropical grasses and fibrous fodder crops in general are poor sources of fermentable nitrogen as their crude protein is below the level required by rumen microorganisms for microbial activities (Nurfeta, 2010; Anderson, 2017; Anya and Ozung, 2018). These low-quality grasses and fodder crops are also low in readily degradable carbohydrates, minerals and other nutrients required to balance the products of digestion to requirements. All these result in limited intake, poor rumen function, increased methane emission and low animal productivity (Kosgey and Okeyo, 2007; Nurfeta, 2010; Anya and Ozung, 2018).

Nurfeta, (2010) has however reported that, when these tropical grasses are supplemented with concentrates, their intake and digestibility are improved. Nevertheless, such interventions are not often practiced by smallholder livestock farmers because these farmers consider concentrates to

be scarce and expensive to use. To solve these challenges associated with inadequate nutrient intake, there is a need to look for alternative protein sources that farmers can produce on their own farms without incurring much additional cost (Anderson, 2017). The use of alternative nonconventional protein and carbohydrate feed resources to close the feed deficit, reduce feed cost and sufficiently tackles seasonal fluctuations in forage quality and quantity has been well documented in the studies of other authors (Anderson, 2017; Konlan, 2018; Nsoh, 2019; Adjorolo *et al*., 2020).

Supplements are feedstuffs that are used as fillers to a diet deficient in some nutrients in the livestock feed to improve production (Feed Supplements Market Business Opportunities, 2019). The commonly known types of supplements include energy concentrates (grains, cereals and molasses), protein concentrates (soybean meal, cotton seed cake and groundnut cake), non-protein nitrogen and minerals.

Supplementation with high nitrogen feeds help enhance the rumen ecosystem by providing energy and nitrogen to rumen microbes. This enables rumen microbes to break down forages that are low in nitrogen, and high in fibre thereby improving the animal's ability to digest fibrous portions of these forages (Preston and Leng, 1987). The supplementation of low quality feeds with dietary supplements have been reported to enhance the productivity of ruminants (Ondiek *et al*., 2013; Lawa *et al*., 2017; Brown *et al*., 2018; Adjorlolo *et al*., 2020).

2.2.1 The use of pelleted feed as supplements for small ruminants

Pelleted feeds have been used successfully as supplements for small ruminants. The use of pelleted feeds as supplements has numerous benefits, some of which include: Selective feeding is avoided on those ingredients in the formulation which are more palatable and thus more desirable to the animal; segregation of individual constituents in animal feeds due to varying size and density is prevented; provision of higher bulk density, which has advantages both for transporting and handling, resulting in maximum load efficiency and reduced storage requirements; and improvement in nutrient utilization thereby increasing the feed conversion rate (Wanapat *et al*., 2013; Ishaq *et al*., 2019; Song *et al*., 2021). It has also been documented that pelleting improves the acceptability, density and keeping quality of feedstuffs for small ruminants (Trinh and Wanapat, 2012).

Generally, pelleted feeds are produced in an extrusion-type thermoplastic melding operation in which finely divided particles of a feed ration are formed into compact, easily-handled pellets. Binder additives may be used to improve the strength and shelf-life of pellets and to reduce the release of fines during the pelleting process. Preferably, nutritive binder additives are used which also provide essential nutrients such as magnesium, calcium, potassium and/or sulfur to the feed (Wanapat *et al*., 2013).

2.2.2 The use of tree and shrub leaves as supplements to low quality basal diets in small ruminants

The seasonal changes in both quality and quantity of animal feed, particularly native grass and crop residues, is a major challenge to ruminant production in the tropics and calls for exploration

of some varieties of multipurpose trees and shrubs which maintain their quality and are available throughout the year in order to ascertain their suitability for ruminant feeding (Okpara *et al*., 2014; Lawa *et al*., 2017; Brown *et al*., 2018). As a result of the decreased availability of pasture lands, focus is now being given to tree leaves and shrubs for feeding small ruminants in many parts of the world (Okpara *et al*., 2014).

Multipurpose tree and shrub fodder are important feed resources that can be used to solve the seasonal deficit in feed quantity and quality as they increase metabolizable energy and nitrogen intake and improve animal performance (Kaitho, 1997). Rahman *et al*. (2015) observed higher weight gain, digestibility and nitrogen balance in goats supplemented with green trees than goats fed on only grasses.

Leaves of tree legumes contain high protein and minerals and could be used to supplement grass-based diets in order to improve the productivity of ruminants especially during the dry season (Traiyakun *et al*., 2011; Ondiek *et al*., 2013; Muir *et al*., 2014). Lawa *et al*. (2017) indicated that leaves of leguminous species contained 25 to 50% more crude protein than non-leguminous plants because they have the ability to fix atmospheric nitrogen. During the dry season, local goat in Timor Island fed native grass supplemented with acacia had an increase in feed intake, maintained their body weight gain better than goats fed only native grasses (Fuah and Pattie, 2013). The improvement in intake, digestibility and general performance of small ruminants when fodder trees and shrubs were used as supplements to low quality diets have been demonstrated by several researchers (Baah, 1994; Damptey *et al*., 2014; Obese *et al*., 2018; Adjorlolo *et al*., 2020).

2.2.3 Palatability and acceptability of browses by small ruminants

According to Baumont (1996) and Van (2006), palatability or acceptability often indicates those features of a feed that incite a sensory response in small ruminants, and is considered to be the consequence of the animal's appetite for the feed. Daly, (2009) defined palatability as plant characteristics or conditions which invoke a response in herbivorous animals as to whether they select or avoid a plant. Palatability is determined by both plant and animal factors (Osuga *et al*., 2008; Kalio *et al.,* 2012). Factors such as plant age, plant parts, presence of protein, sugar, fat and volatile oils contents, physiological responses from animals, animal memory, an animal's pursuit to maintain and update rumen microflora and fauna, presence of lignin, crude fibre, tannins and nitrate contents tend to influence palatability in small ruminants (Owen-Smith and Cooper, 1987; Rinehart, 2006; Osuga *et al*., 2008; Daly, 2009; Lamidi and Ologbose, 2014). Ruminant livestock are particularly known to consume a wide range of browse foliages and are reported to select those that meet their nutritional needs and avoid those that can be toxic (Osuga *et al*., 2008).

Ruminants seek sweetness in their feed, probably because sweet is an indicator of soluble carbohydrates, the most critical dietary element for animals. On the other hand, ruminants tend to reject plants containing terpenes and tannins which are known to have strong odours and astringent taste (Rinehart, 2006; Daly, 2009; Kalio *et al*., 2012). These reduce voluntary feed intake (Tedeschi *et al*., 2019) and consequently reduce the growth and performance of ruminants (Lamidi and Ologbose, 2014). Also, ruminant livestock generally prefer and accept less matured and fresh succulent grasses and browse foliages, as matured ones have high lignin content (Lamidi and Ologbose, 2014).

2.2.4 Effects of anti-nutritional factors on nutrient digestibility and utilisation in small ruminants

Anti-nutritional factors are chemical substances that are present in ruminant feed materials prominently in tree and shrub foliages. They serve as defence mechanism against herbivores (Rogosic *et al*., 2008). Anti-nutritional factors such as essential oils, alkaloids, tannins, saponins and terpenes, have been extensively documented to limit feed intake, digestion and utilisation of nutrients (Daly, 2009). According to Harborne (1993), the presence of these chemical substances in high quantities in feed can be toxic to animals.

An animal`s performance is significantly influenced by the digestibility and utilisation of the feed it consumes (Lamidi and Ologbose, 2014). Small ruminants however, often encountered the challenge of feeding on forages which contain high levels of anti-nutritional factors such as tannins, saponins and terpenes (Rogosic *et al*., 2008)**.** These anti-nutritional factors tend to hinder the animal`s ability to effectively digest and utilise the nutrients available in these forages to promote optimum performance. Tree fodder intake and utilisation by small ruminants are influenced by the chemical substances present in the plant and the physiological capacity of the animal to manage the nutrients or compounds in the feed.

Cooper and Owen-Smith (1985) reported that plants that contained more than 5% proanthocyaninidins were rejected by goats as feed during the wet season. The presence of tannins has been reported to be associated with lower nutritive value and lower biological availability of macromolecules like proteins and carbohydrates (Sharifi *et al*., 2013). Lawa *et al*. (2017) observed a decrease in intake of nutrients due to the increase of white kabesak leaves level in the concentrate feed and attributed it to the increase of anti-nutritive factors (phenolic compound) and crude fibre.

Abdu *et al*. (2012) stated that the presence of anti-nutritive factors especially condensed tannin in some tree leaves decreased feed intake and livestock performance, mainly when the tree leaves are fed in large quantity.

Digestibility gives a relative measure of the extent to which ingested feed and its nutrients have been digested and absorbed by the animal (Madalla, 2008). The presence of certain chemical and physical substances in forages develop barriers between nutrients and digestive enzymes thereby decreasing digestion. Antinutritional factors such as saponins, tannins and phytates have been shown to form poorly digestible complexes with nutrients (Madalla, 2008). Saponins are capable of inflicting damage on the intestinal mucosa thereby impeding the digestion process (Bureau, 1998).

Tannins are complex polyphenolic substances that bind to proteins within the rumen making the bound protein indigestible (Makkar, 2003). Tannins can reduce the rate of digestion; causing livestock to eat less feed, which can reduce animal production (Makkar 2003; Osuga *et al.*, 2008; Daly, 2009). However, ingesting small amounts of tannins can be beneficial. Small amounts of tannins in livestock diets can increase the efficiency of microbial protein synthesis in the rumen (Makkar 2003; Daly, 2009) and increase the amount of essential amino acids entering the small intestine and consequently absorbed into the blood stream (Rogosic *et al*., 2008; Daly, 2009).

2.2.5 Effects of feed processing on anti-nutritional factor levels

Generally, unprocessed legume leaves and other plant materials are known to contain far higher levels of anti-nutritional factors (ANFs) than their processed forms; therefore, processing is necessary before the addition of them into animal diets (Madalla, 2008; Adebowale and Maliki, 2011; Luo and Xie, 2013). The efforts to improve the use of legumes and other plant materials have led to a wide range of processing techniques including cooking, roasting, soaking, dehulling, autoclaving, fermentation, and recently extrusion cooking (Habiba, 2002; Adebowale and Maliki, 2011; Luo and Xie, 2013; Mondal and Payra, 2015). It has been documented that some ANFs like trypsin inhibitor, α-amylase inhibitor, and lectin were greatly reduced by heat, but soaking and dehulling caused a slight decrease or increase in the levels of these compounds (Habiba, 2002; Wang *et al*., 2009).

Soaking is a domestic technological treatment that has been widely used to significantly reduce phytate, trypsin inhibitor activity and tannins in diets (Duhan *et al*., 2002; Mubarak, 2005, Vijayakumari *et al*., 2007). It has been observed in previous studies that soaking of leucaena leaf meal in water eliminated all or most of the mimosine, a toxic non–protein amino acid which causes the poor performance of this material (Hassan and Roy, 1994; El-Sayed, 1999; Madalla, 2008). During fermentation, micro flora may produce proteolytic enzymes which may be responsible for the increase in protein digestibility. Also, the elimination of phytic acid contributes to the improvement in protein digestibility of fermented products (Adebowale and Maliki, 2011; Olanipekun *et al*., 2015). Plant material fermentation appreciably reduced the ANFs and fibre content and increased the plant's nutritional values (Bairagi *et al*., 2002; Mondal and Payra, 2015).

Bairagi *et al*. (2002) reported that fermentation of *Lemna* leaf meal resulted in a significant decrease in the levels of crude fibre and the antinutritional factors, tannin and phytic acid, whereas, there was increase in the levels of free amino acids and fatty acids. Mukhopadhyay and Ray (2005) also reported that the anti-nutritional factor (phytic acid from linseed meal) could be decreased by fermentation with lactic acid bacteria. In addition to the processes listed above, the inclusion of activated charcoal, polyethylene glycol, and calcium hydroxide to shrubs (*Quercus ilex, Arbutus unedo*, and *Pistacia lentiscus)* which contained high levels of secondary compounds such as tannins, saponins, and terpenes was seen to positively influence feed intake, ruminal degradation and fermentation, and utilization when they were fed to ruminants (Van, 2006; Rogosic *et al*., 2008).

2.3 *Samanea saman* – general description and nutritional value

Samanea saman commonly called rain tree is native to north Southern America, and now naturalized throughout the tropics (Hagan, 2013). The tree is a naturally tall and fast growing tropical tree that can reach a height of 25 meters with a large trunk of about 1 to 2 meters in diameter (Staples and Elevitch 2006; Barcelo and Barcelo, 2012; Banakar *et al*., 2017). The tree has a wider upper part that is supported by horizontal branches and it has a characteristic dome-shaped canopy in an open environment with feathery leaves (Staples and Elevitch, 2006). The leaves which are 20 to 40 centimetres long and 10 to 34 centimetres in width, are quite sensitive to sunlight and close up in the night (Barcelo and Barcelo, 2012; Delgado *et al*., 2016). Staples and Elevitch (2006) reported that the leaves contain 22 to 27% crude protein.

The *Samanea saman* tree flowers from January to May and culminates in April and May, however, it varies as results of the area where it grows. The flowering peak occurs in April and May. Flowers are of light pink color arranged in umbels The *Samanea saman* tree`s pod is straight, non-shedding, a bit fleshy, measures about between 15 to 20 cm long and 2 cm wide, with ellipsoidal and red seeds (Barcelo and Barcelo, 2012). The bark of the tree is characterized with an uneven, grayish brown with horizontal lines (Staples and Elevitch 2006; Schmidt 2008). A matured tree can produce 550 kg leaves on dry matter basis and 500 to 600 kg pods in a year (Idowu *et al*., 2006; Barcelo and Barcelo, 2012; Banakar, *et al*., 2017).

The effect of replacing corn with *Samanea saman* pod meal on weight gain and general performance of broiler chickens has been reported by Hagan (2013). In his study, weight gain, feed consumption and feed conversion efficiency improved (De la Cruz., 2003 cited by Hagan, 2013). *S. saman* pods are nutritious with 12 to 18% protein, 40% digestibility and are commonly consumed by small ruminants such as sheep and goats (Staples and Elevitch, 2006). *Samanea saman* pods are potential supplement for ruminants as they have beneficial effect of increasing metabolizable energy, nitrogen intake, feed efficiency, and improve animal performance (Osuji *et al*., 1995; Hagan, 2013). A study in Ghana on *Samanea saman* pods showed that it could be used as protein and energy supplement for ruminant livestock during the dry season (Tagoe, 2011). Also, an increase in dry matter digestibility, nitrogen intake and growth performance were observed when Napier grass supplemented with *Samanea saman* pods was fed to Djallonke sheep during the dry season (Addey, 2011; Offoh, 2011).

.

2.3.1 Chemical composition of Samanea saman leaves

The *Samanea saman* foliage has been reported to have a mean crude protein concentration between 20-29 %, calcium and phoshorous levels between 0.2-1.3 % and 0.1-0.3 % respectively (León *et al.*, 2012; Delgado *et al*., 2016; Banakar *et al*., 2017). The leaves have also been documented to contain 46.3 % NDF, 33.2 % ADF and 14.8 % lignin (Ojeda *et al.*, 2012; Delgado *et al*., 2016) and high energy value (Delgado *et al*., 2016).

Aside the above mentioned chemical composition of *Samanea saman* foliage, the foliages also contain secondary compounds (especially saponins, steroids, alkaloids, flavonoids, tannins and resins) that produce substances which serve as defense against herbivores (Jiménez *et al.*, 2003; Delgado *et al*., 2016). Although they are mainly considered harmful, lower concentrations could be beneficial for ruminants (Delgado *et al*., 2016). Some researchers have documented that when saponins are consumed, the population of protozoa in the rumen is reduced and this helps nitrogen utilisation especially in poor quality feeds (Hu *et al.* 2005; Delgado *et al*., 2016). According to Escobar (1972), the seeds and leaf extract of the rain tree are toxic, as a result of the presence of pitecolobina in them, which is a toxic alkaloid with abortion-inducing properties.

2.3.2 Effects of Samanea saman leaf and pod meals on feed intake and digestibility in small ruminants

The primary limitation to ruminant production improvement in the tropics is dry matter intake, especially in the dry season. The supplementation with ground leaves and pods of *Samanea saman* has been reported to increase dry matter intake and digestible energy consumption, without negatively affecting forage intake (Delgado *et al*., 2016). However, Barcelo and Barcelo (2012) reported a low feed intake of goats fed 100% *Samanea saman* pods and attributed it to the presence of ANFs in *Samanea saman sp*ecies. Some *Samanea saman* species contain albuminoid substances and tannins which could lower feed intake and nutrient utilization (Lesseps and Chipanda, 1995 cited by Barcelo and Barcelo, 2012). The leaves of *Samanea saman* have been reported by Pedraza *et al*. (2003) to have low ruminal degradability of DM (44.7 %) and OM (47.4 %). They also reported *in vitro* intestinal digestibility of 34.8 % nitrogen in *Samanea saman* which was less when compared to *Gliricidia* and *Leucaena* which recorded 69.4 and 65.7 % respectively (Pedraza *et al*., 2003).

2.3.3 Ruminant performance on *Samanea saman* leaf and fruit meals

Several researchers have observed and reported that the use of *Samanea saman* leaves and fruits as feed supplements to basal diets influenced animal performance positively. The inclusion of 10 and 20 % of the fruits of *Samanea saman* in the diet of heifers did not affect the development in heifers (Thole *et al.* 1992). *Samanea saman* supplementation up to 15 or 30 % with ground or whole fruits in the diet of beef and dairy cows, under grazing, resulted in a weight increase of 4.1 to 5.1 % and milk production increased between 0.5 to 1.1 L per cow per day (Delgado *et al*., 2016). Roncallo *et al.* (2009) reported that milk of cows supplemented with 30 % of ground fruits

showed higher contents of total solids (1.38 %), butterfat (1.01 %) and protein (0.59 %). Higher pregnancy (16.6 %) was recorded in animals supplemented with raintree fruits compared to the other experimental groups (Roncallo *et al.* 2009).

Navas *et al.* (2001) opined that the good outcome observed in animal performance and the efficiency of nutrient utilisation when different animals are supplemented with rain tree pods may be due to its effect on the balance between the glucogenic and acetogenic short chain fatty acids and the increase between protein and energy in the nutrients absorbed. It is also possible to use *S. saman* foliages for the preparation of silages, pre-dried hays, in multi-nutritional blocks and for the preparation of integral rations for ruminants and other species. Chumpawadee and Pimpa (2009) documented in their study that the inclusion of *Samanea saman* leaf meal increased consumption from 1.9 to 2.6 % liveweight and feeding performance improved as well in beef cattle. The inclusion of 10-30% *Samanea saman* foliages to diets increased weight gain and milk production in dairy cows and other productive species (Roncallo *et al*. 2009 cited by Delgado *et al.*, 2016). Barcelo and Barcelo, 2012 reported that the inclusion of 25 % of *Samanea saman* pods in feeds for goats was the optimum level as the feed conversion efficiency was best in goats fed with 25% *Samanea saman* pods in combination with 75% *Pennisetum purpureum.*

2.4 *Acacia auriculiformis*- distribution and nutritional and health importance

Acacia auriculiformis commonly referred to as Earleaf Acacia or Northern Black Wattle is a leguminous, evergreen, fast growing tree which produces abundant foliage and it is able to reach a height of 30m and belongs to the family Fabaceae (Keir *et al*., 1997; Starr *et al*., 2003; Eunice and Olamiposi, 2019). *A. auriculiformis* is native to Australia, Papua New Guinea and

Indonesia. They are naturally distributed in Asia, Africa, North America, Central America, the Caribbean, South America and Oceania (Boland *et al*., 1990; Gilman and Watson, 2010; PROTA, 2016). The foliage of *Acacia auriculiformis* is composed of 91.30 % DM, 20.16% CP and 4.50% ash (Devendra and McLeroy, 1982). Hassan and El-Dayem (2019) reported that acacia leaf meal contains an adequate percentage of CP and Nitrogen Free Extracts content, which implies that it has potential values to supply protein and readily available carbohydrates for livestock.

A. auriculiformis has the ability to improve rumen microbial activities such as feed degradation and utilisation since its crude protein content (20.16%) surpasses the 7-8% crude protein recommended for rumen microbes of tropical livestock below which there will be a deficiency in performance (Minson, 1990; Norton, 1994).

The leaf, stem, bark and root extracts of *Acacia auriculiformis* plant have shown antioxidant benefit on living organisms (Singh et al., 2007). The bark extract was used to treat rheumatism by the Aborigines of Australia (Girijashankar, 2011). Several researchers have reported that acacia effectively fights against helminths, filariasis and microbial diseases (Mandal *et al.*, 2005; Ghosh *et al.*, 1993; Eunice and Olamiposi, 2019). According to Eunice and Olamiposi (2019), the root extract could be used to treat aches, pains and sore eyes in humans.

2.4.1 Chemical composition of *Acacia auriculiformis* leaves

According to Reddy and Elanchezhian (2008), *Acacia auriculiformis* leaves contains 15.50 % CP, 93.95 % DM, 92.5 % OM, 7.53 % ash, 22.1 % crude fibre, 36.94 % NDF, 30.08 % ADF, 14.13 % lignin, 0.90 % Calcium and 0.52% Phosphorous. *Acacia auriculiformis* contains high levels of galactose, glucuronic acid, rhamnose methylglucuronic acid and arabinose (Anderson *et al.*, 1988).

The phenols and polyphenols found in *Acacia auriculiformis* apply their protective effects through different media such as killing filarial worms and inhibiting the formation of carcinogens from precursor substances by behaving as blocking agents or suppressing agents (Lesca, 1983; Tatsuta *et al.*, 1983; Garai and Mahato, 1997). However, Garai and Mahato (1997) documented that *Acacia auriculiformis* leaf has central nervous system – depressant and spermicidal activities due to the tannins and triterpenoid saponins found in it.

2.4.2 Effects of *Acacia auriculiformis* leaf meals on feed intake and digestibility in animals

Hassan and El-Dayem (2019) observed increase in feed intake when levels of acacia leaf meal was fed to broilers. They also reported that the addition of Acacia leaf meal improved the digestion coefficients of CP, CF and NFE. Giridhar *et al*. (2018) reported an *in vitro* dry matter digestibility (IVDMD) and *in vitro* organic matter digestibility (IVDOM) values of 64.95 and 32.52 % respectively for *A. auriculiformis*

2.5 Ficus exasperata – description, distribution and nutritional importance

Ficus exasperata which is commonly called sandpaper fig tree or white fig tree in English is a terrestrial tropical shrub. It can attain a height of about 20 meters. *Ficus exasperata* has scabrous

and ovate leaves which are about 3-20 by 2-12cm in size (Berg, 1989; Berg and Wiebes, 1992). The leaves have 3 to 5 pairs of lateral veins with the basal pair branched and reaching a margin at or above middle of the lamina (Ahmed *et al*., 2012). The petiole is about 0.5 to 4cm long while the stipules range from 0.2 to 0.5m long. The figs are found either solitary or in pairs in the leaf axils and rarely on older wood. The figs often appear in pairs in the leaf axils. The bark is smooth, grayish cream with brown streats and it exudes gummy sap (Ahmed *et al*., 2012). Ficus is extensively distributed 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 (Ahmed *et al*., 2012). The ficus plant also grows well in the rain forest regions of West Africa (Gbile and Adesina, 1986 cited by Nsoh, 2019).

The leaf extract has been documented to have several medicinal benefits, which include treating haemostative, ophthalmia, hypertensive patients, coughs and haemorrhoids (Ayinde *et al.,* 2007; Odunbaku *et al*., 2008; Ahmed *et al.,* 2012; Nsoh, 2019). Ficus leaves could be used to scratch skin parts affected by ringworm. The grounded leaves could also be used to treat boils (Okoli *et al.,* 2007; Ahmed *et el*., 2012). The leaves are also used in the stabilization of palm oil to enhance keeping qualities through the elimination of saponins and the foaming tendency and enhancement of carotenoid levels in the oils, thereby resulting in reduced free fatty acids, acid value and peroxide value (Ahmed *et el*., 2012). The young leaves are prescribed as a common anti-ulcer remedy (Adebayo *et al.*, 2009; Ahmed *et el*., 2012). Anti-diabetic, lipid lowering and anti-fungal activities have been reported for *Ficus exasperata* (Sonibare *et al.,* 2006; Nsoh, 2019). According to Odunbaku *et al. (*2008), the leaves are used as supplement to basal diets and acts as antimicrobials. In Ghana, the sap is used to stop bleeding (Abbiw, 1990).

The root bark is reported to have been used in the treatment of high blood pressure (Lawal *et al.*, 2009). The boiled bark liquid has been observed to quicken the expulsion of the after birth in cows and hasten childbirth in women (Hallan, 1979; Ahmed *et el*., 2012) The scraped bark is used to embrocate the body in Southern Africa (Burkill, 1985)

2.5.1 Chemical composition of *Ficus exasperata* leaves

Ficus leaves have been reported to contain 89.78 % DM, 83.8% OM, 13.65% CP, 2.9 % nitrogen, 7.12 % EE, 43.9% NDF, 36.5% ADF, 7.4% hemicellulose, 31.1% cellulose, 2.0% ADL, 6.44% ash, 4.4% calcium and 0.19% phophorous (Dike, 2009; Baah *et al*., 2011)**.** According to Ijeh and Ukwemi (2007), antinutritional facors such as alkaloids, tannins, saponins and cyanogenic glycosides are present in *Ficus exasperata*. These ANFs have been reported to negatively affect nutrient utilisation and consequently, the general performance in animals (Ijeh and Ukwemi, 2007).

2.5.2 Effects of *Ficus exasperata* leaf meals on feed intake and digestibility in small ruminants

Annan (1998) in a previous study reported mean daily dry matter and organic matter intake ranges from 51.47 to 88.13 g/kgw°75 and 48.02 to 77.42 g/kg W°75 respectively, when sheep were fed cassava peels supplemented with *ficus exasperata* leaves. He observed that the mean daily dry matter and organic matter intake per unit metabolic body size were significantly influenced by ficus supplementation, and that the values increased with increasing level of supplementation. However, the DM and OM digestibilities decreased with increasing level of supplementation. Baah

et al., (1999) reported that Djallonké lambs fed cassava peels as total diet lost weight, however, ficus leal meal improved weight gain (from 44 to 58 g w0.75/d) and dry matter intake of cassava peels.

When only the ficus supplement was fed to the sheep *ad libitum*, the DM and OM digestibilities were 226.0 and 75.5 g/kg DM respectively**.** Apori *et al*. (1998) reported a range of 71.8 to 83.4 % and 76.3 to 89.9 % for *in vitro* dry matter and protein degradability respectively for *Ficus exasperata* leaves. Baah (1994) reported that ficus leaves had *in sacco* dry matter disappearance of 48 % and 64 % at 24 and 48 h respectively. There was significant increase of the potentially degradable fraction of the dry matter in cassava peels incubated in animals when ficus leaf was used as supplement.

In an earlier study, Ngodigha and Oji (2009) reported that *F. exasperata* had the highest degradable fraction (73.53g/ 100g DM) among the browse plants studied. The other browse plants which included *Dactyledania barteri, Newbouldia laevis, Microdesmis puberula, Manniophyton fulvum* and *Palisota hirsute* had degradable fractions of 38.93, 44.20, 61.56, 41.96 and 20.57 g/ 100g DM respectively. *F. exasperata* also had the highest predicted voluntary dry matter intake (VDMI) and digestible dry matter intake (DDMI) of 6.5 and 3.7 kg/day respectively.

2.5.3 Small ruminant performance on *Ficus exasperata* leaf meal

The leaves have been widely used as feed for ruminants. The leaves of *Ficus exasperata* contain CP levels of 14 % even in the dry season, therefore feeding it as a sole meal or as a supplement would improve the performance of small ruminants (Sarkwa *et al.*, 2011; Adjorlolo *et al.*, 2014; Nsoh, 2019). Baah (1994) observed an increase in live weight gains in sheep fed cassava peel-based diets supplemented with varying levels of ficus leaves.

A feed conversion efficiency range of 0.02 to 0.04 kg gain/kg feed and a predicted growth rate of 0.75 g/day have been reported in previous studies where ficus was used (Annan, 1998; Ngodigha and Oji, 2009). *Ficus exasperata* leaf meal significantly improved the nutritive value of cassava peels fed to sheep (Baah *et al*., 2011). According to Ijeh and Ukwemi (2007), the presence of ANFs in ficus could negatively affect nutrient utilisation and general performance in animals. Antinutritiona factors that have been reported include alkaloids, tannins, saponins and cyanogenic glycosides (Ijeh and Ukwemi, 2007).

2.6 Cassava peel meal as supplement for small ruminants

Cassava peel is the main agro-industrial by-product from the processing of cassava roots to obtain products such as starch and ‘gari’ for human and industrial use (Baah, 1994; Baiden and Obese, 2010; Anya and Ozung, 2018). The peels are important source of energy in ruminant diets and they have been extensively utilised as either the sole meal or as supplement to feed small ruminants (Baiden and Obese, 2010). Cassava peel is rich in metabolizable energy (3.03 Mcal/Kg DM) but low in nitrogen (Anya and Ozung, 2018). In a study in Cameroon, sheep fed increasing levels of cassava peels as replacement for *Pennisetum purpureum*, with cottonseed cake as the protein source, improved weight gain (Okeke and Oji, 1988; Heuzé *et al.*, 2016).

2.6.1 Chemical composition of cassava peels

Cassava peels have been reported to contain 87.4 % DM, 82.4% OM, 5.25 CP, 1.0 % nitrogen, 57.4% NDF, 28.4% ADF, 5.8% ash, 29.0% hemicellulose, 20.8% cellulose, 5.0% ADL, 0.7% calcium and 0.1% phosphorous (Baah, 1994; Heuzé *et al*., 2016). According to Tewe (2004) and Oboh (2006), cassava peels have phytates and high quantities of cyanogenic glycosides, they should therefore be processed to lower the contents of cyanogenic glycosides and phytate, and to maintain its nutrient quality (Oboh, 2006; Heuzé *et al*., 2016). Several processes have been employed by some researchers to effectively reduce the cyanogenic glycoside contents. These processes include ensiling, soaking and sun-drying. These processes have produced acceptable outcomes (Tewe, 1992; Salami and Odunsi, 2003; Heuzé *et al*., 2016).

There are two cyanogenic glycosides present in cassava, these are linamarin (80% of total glycosides) and lotaustralin (20% of total glycosides) (Heuzé *et al*., 2016). Linamarin and lotaustralin are converted to hydrogen cyanide (HCN), that is harmful to animal. The breakage of the cell wall through eating or processing releases HCN. Cassava peels that have been well processed normally have 50 mg/kg levels of HCN or below (Osei and Twumasi, 1989; Nwokoro *et al.,* 2005; Heuzé *et al*., 2016). (Oboh, 2006). a high phytase level of up to 1% DM could be present in cassava peels (Ubalua, 2007), and a reduction of this level to 0.7% could be achieved through fermentation

2.6.2 Effects of cassava peels supplementation on feed intake and digestibility in small ruminants

Cassava peels have high digestibility of 78% DM and 81% OM of total tract digestibility (Baah *et al*., 1999; Heuzé *et al*., 2016). Smith (1992) reported a dry matter degradability value of 70% for cassava peels. According to Fomunyan and Meffeja (1987), DMI, digestibility and growth rate went up linearly with rising cassava peels content in feed. Okeke and Oji, (1988) reported that ensiled mixture of grass-legume (Guinea grass and tropical kudzu *Pueraria phaseoloides*), in 60:20:20 proportions, poultry excreta and cassava peels fed to west african dwarf goats positively influenced intake and digestibility, as well as normal rumen and blood metabolites. Baah (1994) reported that cassava peels had dry matter disappearance of 43% and 53% at 24 and 48 h respectively.

2.6.3 Small ruminant performance on cassava peel meal

In ruminant nutrition, cassava peels can be used as a roughage and as an energy feed source in ruminant diets to achieve optimum performance (Smith, 1992; Heuzé *et al*., 2016). However, the provision of cassava peels as a sole diet is not recommended as the nutrients present in them is not adequate to improve rumen function and productivity (Heuzé *et al*., 2016). Optimal utilization of cassava peels can be achieved through the supplementation of readily fermentable protein and by-pass protein, as well as micronutrients (sulphur, phosphorus, and vitamin B). Cassava peels are important source of feed to ruminants if fed in a balanced diet (Smith, 1992; Heuzé *et al*., 2016).

In Ghana, Larsen and Amaning-Kwarteng (1976) reported weight gains of 0.29 or 0.33 kg/day (*vs.* 0.07 kg/day for the control diet) in crossbred grazing bullocks supplemented with dried or ensiled cassava peels while those without supplementation recorded 0.07 kg/day. According to Azevêdo *et al*. (2011), cassava peels can partly replace about 30% of total DMI of energy concentrates, with no influence on the intake, digestibility, microbial efficiency, and nitrogen retention.

2.7 Some haematological parameters in WAD goats

Haematological values are of importance in diagnosing many haemoparasitic infections in food animals (Anosa and Isoun, 1980; Daramola *et al*., 2005; Onasanya *et al*., 2015) and determining the health status of ruminants (Adedeji *et al*., 2011; Adjorlolo *et al*., 2020). Any haematological changes observed through blood analysis are used to determine the body status or health condition, metabolic profile, production patterns and to assess the impact of environmental, nutritional and pathological stresses on the animal (Hagan, 2013).

Haematological parameters provide valuable information on the immune status of animals (Kral and Suchy, 2000) as well as serve as indicators of physiological state of animals (Chowdhury *et al.*, 2005; Hagan, 2013). Knowledge on haematological parameters could also aid in formulating breeding programmes. According to Hagan (2013), haematological analysis could help determine the normal physiological values under local conditions for improve feeding, breeding, management, prevention and treatment of diseases.

2.7.1 Haemoglobin

Haemoglobin is generally a large complex, biomolecule which constitute four polypeptide chains. Each polypeptide chain is bound by an iron-containing porphyrin known as haem. The function of the haem is to transport oxygen in the body (Baker *et al.*, 1981; Nsoh, 2019). Located in the erythrocytes is a pigment called haemoglobin which transports oxygen from the lungs to the cells and tissues in the body (Frandson, 1986). The normal physiological values of haemoglobin in goats ranged from 8 to 12 g/dL (Merck Manual, 2012). According to Aseme *et al.* (2020), high concentrations of haemoglobin may result from infection or stress whereas low concentration below normal indicates anaemia.

2.7.2 Packed cell volume (PCV)

Packed cell volume (haematocrit counts**)** is a measure of a given unit of blood that is made up of cells. According to Frandson (1986), the levels of erythrocyte counts are associated with PCV. Heat stress increases haematocrit counts which can be explained by an increase in the number of red blood cells (Borges *et al*., 2003; Adedeji *et al*., 2011)**.** Frandson (1986) also reported that high PCV values result in a condition called haemoconcentration, where the proportion of red blood cells to fluid in the blood is higher than normal. This condition is primarily caused by excess loss of water due to diarrhoea or low intake of water.

Factors such as season, sex, breed, and physiological state of small ruminants have been documented to have influence on PCV levels (Turkson and Ganyo, 2015). Frandson (1986) stated that, PCV values are associated with high red blood cell count, which implies that adequate oxygen

is available to tissues for oxidation to supply energy. The normal physiological values of PCV in goats ranged from 22 to 38 % (Merck Manual, 2012). According to Aseme *et al*. (2020), high concentrations of PCV may result from infection or stress whereas low concentration indicates anaemia.

2.7.3 Erythrocytes (red blood cells)

They are cells that are round or oval and biconcave in appearance. RBCs lack nuclei but contain haemoglobin (Nsoh, 2019). During the process of respiration, the haemoglobin in them transport oxygen from the lungs to the tissues whereas carbon dioxide is carried from the tissues to the lungs for expulsion (Etim *et al.*, 2014; Ocheja *et al*., 2016). Transportation of low oxygen or carbon dioxide levels to the tissues or the lungs respectively, is an indication of a decrease in the red blood cell counts (Ugwuene, 2011). The normal physiological range of red blood cells concentration reported for goats is 8 to 18 x 10^{03} µl (Merck Manual, 2012). Normal RBCs levels indicate the transportation of high oxygen levels to tissues and the absence of anaemic condition in animals (Fajemisin *et al*., 2010; Ocheja *et al*., 2016).

2.7.4 Total leucocyte count (WBCs)

White Blood Cells (WBCs) serve as the defense mechanism which mainly fight against diseases and other harmful foreign materials that enter the body. They contain nuclei and consist of two main types (Nsoh, 2019). These are agranulocytes (monocytes and lymphocytes) and granulocytes (neutrophils, eosinophils and basophils). The neutrophils are phagocytic and attack bacteria or any foreign materials that enter the body; normal neutrophils level may suggest the absence of bacterial

infection or inflammatory disease (Naskalski *et al.*, 2007; Konlan *et al.*, 2012). Basophils encompass heparin; the anti-coagulant that is released in inflammatory areas to hinder blood clotting and staticity of blood and lymph (Schalm *et al.*, 1975; Nsoh, 2019). The presence of normal basophil levels implies the absence of hypersensitivity reactions in animals.

The eosinophils detoxify toxic substances that enter the body; normal eosinophils levels may indicate the absence of parasitic infections (AACC, 2011). The monocytes are also phagocytic that engulf bacteria and other foreign matter. The function of lymphocytes is to produce antibodies in the blood in response to antigen to protect the body against infections and diseases (Frandson, 1986). Normal lymphocyte levels in the blood indicate that the immune system is not impaired, whereas normal monocyte levels may mean the absence of infections (AACC, 2011). The normal physiological range of values reported for white blood cells, neutrophils, lymphocytes, monocytes, eosinophils and basophils concentration for goats are 4-13 x 10^9/L, 30-48 %, 50-70 %, 0-4 %, 1-8 %, 0-1 % respectively (Merck Manual, 2012).

2.7.5 Mean corpuscular volume (MCV)

MCV is a laboratory value that measures the mean size and volume of a red blood cell. MCV aid in determining the causes of anaemia (Maner and Moosavi, 2020). MCV is also used for red blood cell distribution width calculation. The MCV is a ratio of the mean red blood cell size to the standard complete blood count. MCV within normal range indicates normocytic anaemia, MCV above normal range indicates macrocytic anaemia whiles MCV below normal range indicates

microcytic anaemia (Maner and Moosavi, 2020). The normal physiological range is 16 to 25 fL for goats (Merck Manual, 2012).

2.7.6 Mean corpuscular haemoglobin (MCH)

MCH quantifies the amount of hemoglobin per red blood cell. The normal values for MCH are 29 ± 2 picograms (pg) per cell (Sarma, 1990). The ratio of the mean mass of haemoglobin to red blood cell in a sample of blood gives the mean corpuscular haemoglobin. Reported normal physiological MCH range for healthy goats is 5.2 to 8 pg (Merck Manual, 2012).

2.7.7 Mean corpuscular haemoglobin concentration (MCHC)

Huang and Hu, (2016) defined MCHC as the average hemoglobin level in a red blood cells. The ratio of haemoglobin concentration to a given volume of packed red blood cells gives the MCHC. Normal physiological range of values of MCHC for goats is 30 to 36 g/dL (Merck Manual, 2012). Decreased production of hemoglobin could lower MCHC (Hill *et al.*, 2009).

2.8 Some blood biochemistry in West African Dwarf goats

Blood metabolite profiles provide key information on the nutritional, physiological and health status of animals and could be used in evaluating the normal nutritional, physiological and health status in animals (Adjorlolo *et al.*, 2019). Variations in the levels of blood components of ruminants have been employed as a medium for studying metabolic disturbance, toxicity and used

as a standard of nutrient status and nutrient value of feeds (Church and Gilbert, 1984; Puoli *et al.*, 1992).

Blood chemistry involves the study of the chemical constituents in the blood. Proteins, glucose, calcium, sodium, potassium, triglycerides, cholesterol, urea, alkaline phosphatase and glutamic oxaloacetic transaminase are some of the chemical constituents in the blood. Factors such as age, breed and sex of animal, seasonal differences, nutrition and physiological status are some of the factors that influence blood biochemical components (Nsoh, 2019).

2.8.1 Serum Proteins

The components of plasma proteins involve globulin, albumen and fibrinogen (Coles, 1967). The intravenous administration of plasma proteins can efficiently provide the required nitrogen needed by fasted animal (Breazile, 1971). According to Ikhimioya and Imasuen, (2007), serum total proteins aid in osmotic and other cellular activities regulation, immunity and transport of several substances (hormones, lipids, enzymes, vitamins and metals) in the animal's body. High serum total protein value is associated with the presence of high quality protein in the body of an animal (Tewe, 1985). According to Obese *et al*. (2018), higher concentrations of total protein in the blood could be attributed to the availability of adequate nitrogen for improved microbial protein synthesis and lower concentrations could be due to low amino acid profile of feeds (Iwuji *et al*., 2017). Serum concentrations of total protein, albumin and globulin could be used to evaluate the protein status in animals (Ndlovu *et al*., 2007; Adjorlolo *et al*., 2020).

Moreover, circulating concentrations of globulin often suggests the immune state of an animal and its ability to defend itself against diseases and infections (Kapale *et al*., 2008). The liver and the immune system are known to secret globulins. Certain globulins are known to form complexes with haemoglobin to enable them transport iron in the blood stream as well as help prevent infections (Rastogi, 2008). Higher globulin values may suggest the presence of infections and energy deficiencies. Circulating concentrations of globulin are often high during parasitic infections (Kapale *et al*., 2008; Adjorlolo *et al*., 2019).

Albumin, which is a component of serum proteins maintains the pressure of plasma and regulates the normal supply of water between tissue and the blood as well as transport materials such as macromolecules (Rastogi, 2008). Albumin also prevents the blood from leaking out of the blood vessels. The protein status of an animal is determined by albumin concentration in the blood; high concentrations of albumin in the blood indicate sufficient nitrogen availability for enhanced microbial protein synthesis whiles a decrease in the levels indicate protein deficiency (Agenäs *et al.*, 2006; Obese *et al.*, 2018). A concentration of albumin below 2g/100ml could results in a condition known as oedema (Rastogi, 2008). The normal physiological range of serum total protein, globulin and albumin values reported for goats are 61 to 75 g/L, 2.7 to 4.4 g/dL and 2.3 to 3.6 g/dL respectively (Merck Manual, 2012).

2.8.2 Glucose

Blood glucose concentration is an important indicator of dietary energy intake as it reflects energy status in animals (Damptey *et al*., 2014). Hassan *et al*. (2015) identified high condensed tannin intake as a cause of low serum glucose concentration in the body of ruminants, as condensed

tannins decreased feed intake and hence reduce available energy to animals. The normal physiological range of glucose values reported for goats is 2.7-4.2 mmol/L (Merck Manual, 2012).

2.8.3 Cholesterol

Cholesterol is an organic molecule which is biosynthesized by all animal cells. It is an essential structural component of animal cell membranes which is predominantly produced in the liver. Cholesterol serves as a precursor for the biosynthesis of steroid hormones, bile acid and vitamin D (Hanukoglu, 1992). It usually occurs as lipoproteins. These lipoproteins are of two types namely, low-density lipoprotein (LDL) and high-density lipoprotein (HDL) (CDC, 2017). LDL, sometimes called "bad" cholesterol, makes up most of the body's cholesterol. High levels of LDL could result in heart disease and stroke. HDL (high-density lipoprotein), or "good" cholesterol, absorbs cholesterol and carries it back to the liver. The liver then flushes it from the body. High levels of HDL cholesterol can lower the risk of contracting heart disease and stroke CDC (2017).

Knowledge on 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 (Nsoh, 2019). Normal range of total levels of cholesterol stated for healthy goats is 64.6 to 136.4 mg/dL (Merck Manual, 2012). According to Damptey *et al*. (2014), lower cholesterol values may imply low energy requirements and lower degree of adipose tissue breakdown in the animals. Lower serum cholesterol level is preferable in the production of lean carcass as fat is undesirable to consumers of meat due to the occurrence of cholesterol-related diseases (Salami and Odunsi, 2017).

2.8.4 Blood urea

Urea is the nitrogenous end product of ammonia metabolism. It is the primary metabolite derived from dietary protein and tissue protein catabolism (Hosten, 1990). High blood urea concentration is associated with impairment of renal functions such as uremia (Coles, 1967; McDonald *et al.*, 2002). Low soluble carbohydrates in feed which prevent proper formation of keto acids and high levels of rumen degradable nitrogen due to increased urease activity have been documented to cause high blood urea concentration (Haliburton and Morgan, 1989). Poor protein quality as well as poor protein utilization in animals could amount to an unusually high urea value (Anya and Ozung, 2018). Normal blood urea value for healthy goats ranges from 4.5 to 9.2 mmol/L (Merck Manual, 2012). According to Hassan *et al*. (2015), low dietary protein level or hepatic chronic disease causes a decline in blood urea nitrogen concentration while renal failure or body dehydration causes an increase in blood urea nitrogen concentration. Urea concentrations in the blood are increased when there is energy deficiency in animals limiting microbial protein synthesis (Belewu and Ogunsola, 2010; Obese *et al*., 2015).

2.8.5 Triglycerides

A triglyceride is an ester that is obtained from glycerol and three fatty acids (Gunasundari, 2018). They are the primary components of body fat in humans and other vertebrates (Lehninger *et al*., 2005) Triglycerides in the blood permit adipose fat and blood glucose transference from the liver (Lampe *et al*., 1983). High levels of triglycerides in the bloodstream have been associated with stroke, atherosclerosis and heart disease (Singh and Afroz, 2017). Normal triglyceride value for a clinically healthy goat ranges from 2.88 to 28.83 mg/dL (Merck Manual, 2012). The age, breed, type of diet fed and physiological state of the animal used may account for the differences.

2.8.6 Minerals (total sodium and potassium)

According to Adedeji *et al*. (2011), electrolytes are chemicals that breakdown into their ionic constituents. They function to maintain the body acid base balance. Sodium and potassium are the essential ions for the maintenance of osmotic prssure and acid-base balance of the body fluids. Potassium is involved in antagonism, nervous conduction, excitement, muscle contraction, synthesis of tissue proteins, and maintenance of intracellular homeostasis, enzymatic reactions, osmotic and acid-base balance. Serum sodium and potassium levels are affected by heat stress. Potassium and sodium concentration decrease as temperature rises (Borges *et al*., 2003). Higher sodium level may be attributed to cellular dehydration characterized by haemo-dilution (Ikhimioya and Imasuen, 2007). The normal physiological serum sodium and potassium range values reported for goats are 140.3-153.9 mmol/L and 3.8-5.7 mmol/L respectively (Merck Manual, 2012).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Location and duration of experiment

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 November, 2019 to February, 2020. LIPREC lies within latitude $05^0$40'N and longitude $00^0$16'W in the Coastal Savannah zone of Ghana. The rainfall pattern is bi-modal (major and minor season). The major rainy season spans between April and July and the minor rainy season occurs from September to November. The average annual rainfall is between 128 – 1709 mm, and an average monthly temperature of 26.9^0c. The vegetation cover of the area consists of natural grassland of medium tussock growth with widely-spaced fire-resistant trees and shrubs (Osei-Amponsah, 2010; GSS, 2014).

3.2 EXPERIMENT ONE: Preference, intake, digestibility and growth response of West African Dwarf goats fed *Andropogon gayanus* hay and supplements comprising of *Acacia auriculiformis* leaves, *Samanea saman* leaves, *Ficus exasperata* leaves and cassava peels

3.2.1 Experimental animals and their management

In this experiment, 18 growing West African Dwarf goats (comprising of 8 males and 10 females) with a mean liveweight of 10.9 ± 2.07 kg, were used. The animals were kept under intensive system of management in separate pens with good ventilation and cemented floors. The housing unit was roofed with corrugated iron sheets. The pens were 3m x 1.5m in dimension. The pens, feed and water troughs were well cleaned and disinfected before the animals were introduced into them.

Individual pens had two plastic troughs, one for water and the other for the supplement and a wooden feeding trough for the basal diet. The feeding trough was made in a form to minimise feed spillage. The animals were externally treated against parasites with pour-on acaricide and dewormed with Albendazole (10%), a broad-spectrum anthelmintic.

3.2.2 Preparation of experimental diets

The leaves of three browse plants namely *Samanea saman, Acacia auriculiformis* and *Ficus exasperata* and cassava peels fed by farmers to their small ruminants in five districts surveyed (Ga East, Ga West, Ga Central, Shai Osu-Doku and Ada West districts) in the Accra Plains were used (Nsoh, 2019). The leaves of the browse plants were harvested from trees around LIPREC. The method of processing the leaves of browse plants and cassava peels to form test diets for feeding the West African Dwarf goat followed that in an earlier study by Nsoh (2019). Briefly, the leaves were shade dried for 9 days under an erected shed and then ground with in a hammer mill (1-mm screen) to form the browse plant leaf meals (Samanea leaf meal, Acacia leaf meal and Ficus leaf meal). 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. Conventional feed ingredients and micro-nutrients were added to the cassava peels and the three leaf meals and pelleted to form four experimental diets, which were used in the acceptability, feed intake and growth, digestibility and haematological and blood biochemistry studies. All experimental diets were isonitrogenous.

Table 3.1: Feeding materials and their ranks by respondents

Forage used	**Rank**	**Frequency**
Ficus exasperate	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
Avocado leaves	14	12
Khaya senegalensis	15	12
Pawpaw leaves	16	21
Palm fronds	17	4
Andropogon gayanus	18	9
Panicum maximun	19	3
Wheat bran	20	11
Maize bran	21	11
Cowpea haulms	22	3
Corn milling wastes	23	9

Source: (Nsoh, 2019)

Table 3.2: Ingredient composition of supplements for the acceptability trial

	Supplements			
Ingredients: (g/kg)	SLMS	ALMS	FLMS	CPMS
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 exasperate	0	0	700	0
Total (kg)	1000	1000	1000	1000
CP (calculated)	160.6	160.1	160.7	160.7

SLMS = Samanea leaf meal-based supplement; ALMS = Acacia leaf meal-based supplement; FLMS = Ficus leaf meal-based supplement; CPMS = Cassava peel meal-based supplement

3.2.3 Acceptability study

The acceptability study was carried out using five (three males and two females) West African Dwarf (WAD) goats with 11.7 ± 2.4 kg average live weight. The animals were housed separately and provided with fresh and clean drinking water *ad libitum*. At 08:00 hours each day, the four supplements were given to each animal and was permitted to select for an hour. At 09:00 hour, the leftover supplements were subtracted from the offer to ascertain the quantity of each supplement

ingested. The basal diet (*Andropogon gayanus* hay) was then given to the animals without restriction. The animals were allowed 14 days to adapt to the supplements and actual data was taken for seven days after the adaptation period. Table 3.2 shows the ingredient composition of supplements used in the acceptability study.

3.2.4 Voluntary feed intake and growth studies

The voluntary feed intake and growth studies were carried out using 18 WAD goats (comprising of 8 males and 10 females) with an initial average liveweight of 10.9 ± 2.07 kg. The WAD goats were allocated randomly to four experimental diets in a completely randomized design with treatments one and three having five replicates (five goats per treatment) and treatments two and four having four replicates (four goats per treatment). The animals were offered *Andropogon gayanus* grass hay as basal diet and either of the three browses or cassava peels supplements (concentrate) as shown below;

TREATMENT	**EXPERIMENTAL DIET**
Treatment 1 (T_1)	Samanea leaf meal-based supplement + grass hay
Treatment 2 (T_2)	Acarcia leaf meal-based supplement + grass hay
Treatment 3 (T3)	Ficus leaf meal-based supplement + grass hay
Treatment 4 (T_4)	Cassava peel meal-based supplement + grass hay

The goats were housed individually and clean drinking water was offered *ad libitum*. At 08:00 hours each day, a measured amount of supplement corresponding to one-third of each animal's body weight (nearly 25% of voluntary intake) was offered and after each goat has consumed all

the supplement provided, the basal diet (grass hay) was then offered *ad libitum*. Daily feed intake of the grass hay was ascertained by deducting refusal from offer. The animals were allowed 14 days to adapt to the diet and actual data was taken for 83 days after the adaptation period. Body weights were taken every two weeks and feed intake was calculated on daily basis during the study.

Feed intake was determined as: Weight offered – Weight of refusal.

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

Feed conversion ratio was calculated as: $\frac{\text{Feed intake (g)}}{\text{Weight gained (g)}}$ (Tadesse *et al.*,2016)

3.2.5 Digestibility study

For the digestibility studies, total collection of faeces was performed using a male goat from each of the four test diets. Faecal collection bags were used to collect faecal samples from four male goats for six consecutive days, starting from 6:30 in the morning and keeping over 24 hours. The faeces were collected after spontaneous defecation, weighed and packed in polyethylene containers. Approximately 10% of the total faeces was sampled for each animal on each day and stored in a refrigerator at -20°C (Sampaio *et al.*, 2011). The faecal nutrient composition was determined by defrosting the faecal samples at room temperature and oven dried at 55℃ for 72 hours. The dried faeces were ground using a laboratory miller of 1mm sieve and were assigned identities with respect to the animals involved. The samples were then subjected to analysis of dry matter (DM), crude protein (CP), ash, neutral detergent fibre (NDF) and acid detergent fiber (ADF) (Silva Inácio *et al.*, 2017).

The apparent digestibility (%) of dry matter, crude protein, neutral detergent fibre, acid detergent fibre, and organic matter were obtained using the following equation:

Apparent digestibility of nutrient (%) = $\frac{Nutrient\ consumption(kg) - Nutrient\ loss\ in\ faeces(kg)}{Nutrient\ consumption(kg)} \times 100$

(Silva Inácio *et al.*, 2017)

3.2.6 Analysis of the chemical constituents in feed and faeces

The AOAC (2004) method for chemical analyses was used to determine the CP, DM and ash for the feed and faecal materials. The difference between the DM and total ash contents gave the organic matter content in the samples (AOAC, 2004). The neutral detergent fibre (NDF), acid detergent fibre (ADF), cellulose, hemicellulose and lignin were determined according to Van Soest *et al.* (1991). ADF was deducted from NDF to determine the hemicellulose component in the samples.

3.3 EXPERIMENT TWO: Effect of dietary supplementation on the haematological and blood biochemical parameters of west african dwarf goats

3.3.1 Blood sampling

10 ml blood samples were taken every two weeks (week 1, 3, 5, 7 and 9) between 7.30 and 8.00 hours from the jugular vein of each goat in Experiment one. First, 5 mls of the 10 ml of blood taken was transferred into a glass vacutainer tube containing the anticoagulant tripotassiumethelyne diamine tetra acetic acid (K3.EDTA). An ice box containing ice cubes was loaded with the tubes and taken instantly to the laboratory for analyses of haematological

parameters (Hb, PCV, total RBC and total WBC and their differentials). The other 5 mls of the blood was also transferred into glass vacutainer tubes containing clot (Gel) activator and immediately sent to the laboratory where it was centrifuged at 3000 rpm for 10 minutes at 4 ^{0}C using the Centaur 2 centrifuge. After centrifugation, the sera acquired were carefully collected into Eppendorf tubes. They were then stored in a refrigerator at -20 ^{0}C until analysed for biochemical indices including glucose, total protein, albumin, total cholesterol, triglycerides, urea, sodium and potassium.

3.3.2 Haematological Parameters

3.3.2.1 Determination of PCV

The Hawksley Micro-haematocrit Reader was used to determine the PCV by following the Microhaematocrit protocol (Samour, 2006). About three-quarters portion of a plain micro-capillary tube was filled with the blood sample of each goat after mixing it well. Plasticine was used to cover one end of each filled tube. Afterwards, the filled micro-capillary tubes with the covered ends directed towards the rim gasket, were arranged in the numbered grooves of the microhaematocrit rotor. The microhaematocrit tubes were spun at 12,000 g for 5 minutes using the micro-capillary centrifuge

In the tubes were seen three different strata after spinning; the plasma stratum, the buffy coat and the red cell stratum. The demarcation between the sealant and the red column was made to be on the zero mark (base line) by properly placing individual tubes in the slider slots. The mark on the top of the plasma column was ensured to be in line with the top line (100 mark) by sliding the tube

holder. The knob was then set up in a way to ensure that the centre line run through the top of the RBC column. The PCV was determined on the scales on the right corresponding to the middle line on the Hawksley Micro-haematocrit reader (Hawksley, London).

3.3.2.2 Haemoglobin determination

Haemoglobin concentration was determined out using the Cyanmethaemoglobin method (Gillet *et al.*, 2009). A chemical solution having a pH 9.6 called Drabkin's solution was used for the determination. A pipette was used to draw five millilitres of the above-mentioned solution and then transferred into an empty test tube with assigned identities. In a dilution ratio of 1:250, a pipette was used to fetch and transfer 20 µL of whole blood into the test tube that was already having Drabkin's solution in it. The resulting content in the test tube were properly mixed and made to stand for about 5 minutes. The spectrophotometer was zeroed out using a blank and the absorbance values were taken on a CECIL1000 Series Spectrophotometer (Cecil Instruments, England) at a wavelength of 540 nm. The haemoglobin was estimated from A standard graduation curve was employed to measure the haemoglobin concentration.

Four Cyanmethaemoglobin standards solutions having values matching blood haemoglobin concentrations 5.0, 10.0, 15.0 and 20.0 g/dL were acquired from Randox Laboratories Limited (Co. Antrim, U.K) and used in making the graduation curve. The absorbance of these standard solutions was read against distilled water at room temperature at a wavelength of 540 nm. The blood haemoglobin concentrations (g/dL) were ascertained by plotting the absorbance values against haemoglobin concentration.

3.3.2.3 Determination of Total blood cell counts (RBC and WBC)

The formol citrate solution and Tuerks solution were utilized in finding the RBC and WBC counts respectively (Baker *et al.*, 1981). Whole blood (20 µl) was suck out with a micropipette and transferred into tubes with the help of a pipette. The chambers of the enhanced Neubauer haemocytometer were gently filled and permitted to stand for five minutes to enable the cells settle down. A light compound microscope at x40 objective magnification was employed to count the cells. The nuclei of the large oval RBCs were 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 calculated using the formula given by Samour (2006): RBC (10^{12} /L) $= \frac{N}{100}$

Where: L= Litre

N = Number of cells counted in 160 small squares

Cells found in the four outer large squares of the haemocytometer was counted and the total WBC counts was determined with the formula given by Campbell, 1995:

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

Where: L= litre

N = number of cells counted in nine small squares

3.3.2.4 Red Blood Cell Indices Determination

The formulas given by Reece and Swenson (2004), were used in determining the RBC indices:

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

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

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

3.3.2.5 White Blood Cell differential counts determination

Microscope slides were properly cleaned with ethanol to ensure there were no dirt or grease on their surfaces. Blood samples were obtained from venipuncture and thin smears of it were made on these cleaned microscope slides. They were air-dried, fixed in absolute methanol and stained with Giemsa stain. An oil immersion objective at 1000X magnification was used to study the stained slides. Neutrophils, basophils, eosinophils lymphocytes and monocytes proportions were estimated based on observation of 200 WBC per film.

3.3.3 Blood Biochemistry Parameters

The Mindray BA -88A Semi-Auto Chemistry Analyser was used in determining the concentrations of the following blood biochemical indices in the sera that were collected into Eppendorf tubes and refrigerated; total cholesterol, urea, total sodium, total potassium, glucose, total proteins, albumin and triglycerides. The concentrations of the serum biochemical indices were determined against the concentration of the standard and the blank set in the Mindray BA -88A Semi-Auto Chemistry Analyser. The difference between total protein and albumin concentrations gave the globulin concentration (Hsu *et al*., 2006).

3.3.3.1 Measurement of cholesterol

A mixture of 10 µl of serum sample with 1000 µl of the reagent were incubated for 10 minutes at 37^0C. The absorbance of the standard (AS) and the sample (AT) were measured against the reagent blank at a wavelength of 505 nm and cholesterol concentration was determined using the formula:

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

Where AT = Absorbance of the sample

AS = Absorbance of the standard.

3.3.3.2 Measurement of total protein

The serum sample (20 µl) was added to 1000 ul of the reagent and incubated for 10 minutes at 20 to 25^0C. The measurement of total protein was done against the standard and the blank at a wavelength of 540 nm and concentration of the protein was ascertained using the equation below:

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

3.3.3.3 Determination of albumin concentration

A mixture comprising of 5 µl of the serum sample and 1000 µl of the reagent were 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 equation below was used in determining the albumin concentration.

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

Where AT = Absorbance of the sample

AS = Absorbance of the standard.

3.3.3.4 Determination of glucose concentration

A mixture of 10 µl of serum sample and 1000 µl of the reagent 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. The concentration of glucose was measured 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.

3.3.3.5 Determination of urea concentration

The serum urea 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. The formula below was employed to measure the concentration of urea in the serum.

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

Where AT = Absorbance of the sample

AS = Absorbance of the standard.

3.3.3.6 Determination of triglyceride concentration

A mixture of 10 µl of serum sample with 1000 µl of the reagent were incubated for 5 minutes at 37^0C. The absorbance of the standard (AS) and the sample (AT) were measured against the reagent

blank at a wavelength of 505 nm. The concentration of triglyceride was determined using the formula below:

Triglyceride (mg/dl) = $\frac{AT}{AS}$ x concentration of the standard (Bucolo and David, 1973)

3.3.3.7 Determination of sodium concentration

The serum sodium concentration was determined by incubating a mixture of 10 µl of the serum sample and 1000 µl of the reagent at room temperature for 5 minutes. The absorbance of the standard (AS) and the sample (AT) were measured against the reagent blank at a wavelength of 630 nm. The formula below was employed to measure the concentration of sodium in the serum.

Sodium (mmol/L) = $\frac{AT}{AS}$ x Concentration of the standard (Tietz, 1976)

Where AT = Absorbance of the sample

AS = Absorbance of the standard.

3.3.3.8 Determination of potassium concentration

A mixture of 20 µl of serum sample with 1000 µl of the reagent was incubated for 5 minutes at room temperature. The absorbance of the standard (AS) and the sample (AT) were measured against the reagent blank at a wavelength of 630 nm. The concentration of potassium was determined using the formula below:

Potassium (mg/dl) = $\frac{AT}{AS}$ x concentration of the standard (Hillman *et al.*, 1967)

3.4 EXPERIMENT THREE: Effect of supplements on dressing percentage and organ weights in West African Dwarf goats

At the end of the experimental period two goats were randomly selected from each treatment diet and slaughtered at the LIPREC slaughterhouse. After the animals were slaughtered and skinned, visceral parts of each goat such as kidney, heart, liver, lung and spleen were dressed and measured. Dressing percentage was calculated as proportion of hot carcass weight to slaughter and empty body weights. Dressing percentage based on slaughter weight was calculated as;

Dressing percentage = (Hot carcass weight (kg)) x 100/ (Slaughter weight (kg)) (Hassen and Ali, 2019).

3.5 STATISTICAL ANALYSES

A Completely Randomized Design was used to obtain data from the preference, digestibility, growth, and carcass characteristics studies. The data were subjected to a one-way Analysis of variance procedure (ANOVA) of GenStat Release 12th Edition (VSN International, 2009), whilst that of the feed intake and blood parameters were analysed using repeated measures analysis of variance procedure of GenStat (VSN International, 2009). The Least significant difference procedure of GenStat was used to separate the means at 5% level of significance.

CHAPTER FOUR

4.0 RESULTS

4.1 EXPERIMENT ONE: Preference, intake, digestibility and growth response of West African Dwarf goats fed *Andropogon gayanus* hay and supplements comprising of *Acacia auriculiformis* leaves, *Samanea saman* leaves, *Ficus exasperata* leaves and cassava peels

4.1.1 Chemical composition of Grass hay, Samanea, Acacia and Ficus leaf meals and Cassava peel meal

Table 4.1 shows the chemical composition of the three browses (*Acacia auriculiformis, Samanea saman, Ficus exasperata*), cassava peel meal and *Andropogon gayanus* hay that were used in this study. The *Andropogon gayanus* hay which is the basal diet, cassava peels and the leaves of the three browses had similar dry matter contents (ranged from 88.3 to 91.4%). The contents of crude protein, organic matter, NDF, ADF, lignin and total ash ranged from 5.2 to 22.6%, 81.1 to 85.3%, 46.9 to 72.2%, 28.7 to 47.8%, 3.8 to 7.1% and 5.1 to 11.4% respectively. The leaves of the three browses (*Samanea saman, Acacia auriculiformis* and *Ficus exasperata)* had the highest crude protein contents compared to the grass hay and cassava peels. The NDF content in the grass hay was the highest (72.2%) while that of cassava peels had the lowest (46.95%) in this study. The *Acacia auriculiformis* leaves had the highest ADF content (47.8%) among the ingredients used while cassava peels had the lowest (28.7%). The grass hay and *Acacia auriculiformis* leaves had the same but higher lignin content compared to the other ingredients. The cassava peels recorded the lowest total ash content while the grass hay recorded the highest.

Table 4.1: **Chemical composition of *Andropogon gayanus* grass hay, Samanea, Acacia, Ficus leaves and cassava peels**

Fraction (%)	Feed Ingredients (%)				
	Grass hay	Samanea leaf	Acacia leaf	Ficus leaf	Cassava peel
Dry Matter	91.4	90.9	90.7	89.8	88.3
Crude Protein	6.2	22.6	14.5	14.4	5.2
Organic Matter	81.1	84.6	83.2	85.3	82.9
NDF	72.2	53.8	62.1	54.4	46.9
ADF	43.5	36.6	47.8	42.5	28.7
Lignin	7.1	5.5	7.1	5.8	3.8
Total ash	11.4	6.5	8.5	6.4	5.1

NDF = Neutral detergent fibre; ADF = Acid detergent fibre

4.1.2 Chemical composition of the experimental supplements fed to West African Dwarf goats

The chemical constituents of the dietary supplements are detailed in Table 4.2 In this study, the DM contents of the four dietary treatments were alike (ranged from 89.7 to 90.8%). The contents of CP, OM, NDF, ADF and lignin ranged from 15.9 to 22.3%, 82.4 to 85.2%, 42.9 to 49.1%, 19.4 to 33.8%, 3.9 to 5.3% respectively. Among the three browse leaves, Acacia leaf-based supplement had the highest CP (22.3%) and NDF (49.1%) contents. Cassava peels-based supplement recorded the lowest values in both CP and NDF contents. Ficus leaf-based supplement had the highest lignin content while cassava peels-based supplement had the least. The highest ADF content was recorded in the Acacia leaf-based supplement while the ficus leaf-based supplement recorded the lowest.

Table 4.2: Chemical composition of the dietary supplements

Fraction (%)	Supplement (%)			
	SLMS	ALMS	FLMS	CPMS
Dry Matter	89.9	90.4	90.8	89.7
Crude Protein	19.1	22.3	21.7	15.9
Organic Matter	85.2	84.1	82.4	84.1
Neutral detergent fibre	46.5	49.1	46.3	42.9
Acid detergent fibre	28.5	33.8	19.4	31.8
Lignin	4.1	4.4	5.3	3.9

SLMS = Samanea leaf meal-based supplement; ALMS = Acacia leaf meal-based supplement; FLMS = Ficus leaf meal-based supplement; CPMS = Cassava peel meal-based supplement

4.1.3 Preference of West African Dwarf goats for the pelleted supplements

Table 4.3 shows the details of the preference of goats for the four pelleted supplements. All the pelleted supplements were accepted by the goats however cassava peel meal - based and Samanea leaf meal-based supplements were the most preferred, while the Ficus leaf meal-based supplement was the least preferred.

Table 4.3: **Acceptability of supplements fed to West African Dwarf goats**

Supplements (%)	Means of intake (g)
SLMS	168.80[b]
ALMS	93.96[c]
FLMS	48.26[d]
CPMS	190.36[a]
SEM	*0.928*
P-value	*<0.001*

Means in the same column with different superscript are significantly different (p < 0.05)
SLMS = Samanea leaf meal-based supplement; ALMS = Acacia leaf meal-based supplement; FLMS = Ficus leaf meal-based supplement; CPMS = Cassava peel meal-based supplement

4.1.4 Effect of supplement on voluntary feed intake in West African Dwarf goats

The total intakes of DM, CP, OM, NDF, ADF and lignin are shown in Table 4.4. Crude protein intake of 45.0 to 54.23 g/day were observed among the treatments. The crude protein intake was higher (P<0.05) in goats fed FLMS than those fed CPMS. Acid detergent fibre intake was higher (P<0.05) in goats fed SLMS, ALMS and FLMS than those fed CPMS. The ADF intake ranged from 25.54 to 41.43 g/day. The DM, OM, NDF and lignin intakes were similar (P>0.05) across dietary treatments. The values ranged from 306.25 to 388.68, 281.66 to 353.26, 54.31 to 68.97 and 11.02 to 31.41 g/day for DM, OM, NDF and lignin intakes respectively.

Table 4.4: **Effect of supplements on voluntary feed intake in West African Dwarf goats**

Parameters(g/day)	**Treatments**				***LSD***	***SEM***	***P-value***
	SLMS	**ALMS**	**FLMS**	**CPMS**			
Dry matter intake	321.15	306.25	388.68	361.90	74.16	24.45	0.084
Crude protein intake	47.31^{ab}	50.32^{ab}	54.23^{a}	45.01^{b}	8.63	2.84	0.011
Organic matter intake	297.27	281.66	353.26	334.31	68.15	22.47	0.109
NDF intake	54.31	55.56	68.97	58.54	17.08	5.63	0.212
ADF intake	36.85^{a}	40.01^{a}	41.43^{a}	25.54^{b}	10.92	3.59	< 0.001
Lignin intake	27.85	31.41	30.21	21.04	11.02	3.63	0.119

Means in the same row with different superscript are significantly different ($p < 0.05$); SEM = Standard error of mean; LSD= Least significant difference; NDF = Neutral detergent fibre; ADF =Acid detergent fibre; SLMS = Samanea leaf meal-based supplement; ALMS = Acacia leaf meal-based supplement; FLMS = Ficus leaf meal-based supplement; CPMS = Cassava peel meal-based supplement

4.1.5 Effect of supplements on the digestibility of nutrients by West African Dwarf goats

Digestibility of DM, OM, CP, NDF and ADF were all influenced by the type of supplement fed (Table 4.5). Dry matter digestibility was similar for SLMS, ALMS and FLMS but higher (P<0.05) than CPMS. The dry matter digestibility ranged from 47.72 to 62.67%. CP and NDF digestibilities also followed a similar tend to that of dry matter digestibility. Organic matter digestibility was higher (P<0.05) for goats fed SLMS (52.44%) and FLMS (58.60%) than those fed CPMS (43.14%). The crude protein and neutral detergent fibre digestibility ranged from 38.65 to 47.18% and 30.68 to 40.16% respectively. Also, the acid detergent fibre digestibility in goats fed SLMS (33.40%) or ALMS (34.16%) were higher (P<0.05) than those fed (26.84%)

Table 4.5: **Effect of supplementation on nutrient digestibility in West African Dwarf goats**

Fraction (%)	Treatments				LSD	SEM	*P-value*
	SLMS	ALMS	FLMS	CPMS			
Dry matter digestibility	57.47^{a}	56.79^{a}	62.67^{a}	47.72^{b}	8.417	2.853	<0.012
Organic matter digestibility	52.44^{a}	51.15^{ab}	58.60^{a}	43.14^{b}	9.134	3.096	<0.018
Crude protein digestibility	46.40^{a}	47.18^{a}	46.45^{a}	38.65^{b}	4.018	1.362	<0.001
NDF digestibility	38.44^{a}	40.16^{a}	36.24^{a}	30.68^{b}	3.966	1.344	<0.001
ADF digestibility	33.40^{ab}	34.16^{a}	29.51^{bc}	26.84^{c}	4.049	1.372	<0.004

Means in the same row with different superscripts are significantly different (p < 0.05); SEM = Standard error of mean; LSD = Least significant difference; NDF = Neutral detergent fibre; ADF =Acid detergent fibre; SLMS = Samanea leaf meal-based supplement; ALMS = Acacia leaf meal-based supplement; FLMS = Ficus leaf meal-based supplement; CPMS = Cassava peel meal-based supplement

4.1.6 Effect of pelleted supplements on growth parameters of West African Dwarf goats

In this study, the average daily weight gain and feed conversion ratios of the goats fed the three browse leaf meal-based supplements and the cassava peel meal-based supplements were not significantly (P>0.05) different (Table 4.6). The values ranged from 9.64 to 13.55 g/day and 27.86 to 50.72 for ADG and FCR respectively (Table 4.6).

Table 4.6: **Effect of supplementation on feed intake and growth parameters in West African Dwarf goats**

Parameter	**Treatments**				***LSD***	***SEM***	***P-value***
	SLMS	**ALMS**	**FLMS**	**CPMS**			
Initial weight (kg)	10.90	9.75	12.00	10.75	2.89	1.33	0.436
Final weight (kg)	11.80	10.63	12.80	11.88	2.62	1.23	0.399
ADG (g/day)	10.84	10.54	9.64	13.55	6.34	2.96	0.612
Feed intake (g)	321.15	306.25	388.68	361.90	70.32	32.79	0.084
FCR	33.57	35.12	50.72	27.86	27.26	12.71	0.330

ADG = Average daily gain; FCR = Feed conversion ratio; SEM = Standard error of mean; LSD= Least significant difference; SLMS = Samanea leaf meal-based supplement; ALMS = Acacia leaf meal-based supplement; FLMS = Ficus leaf meal-based supplement; CPMS = Cassava peel meal-based supplement

4.2 EXPERIMENT TWO: Effect of Dietary Supplementation on the Haematological and Blood Biochemical parameters of West African Dwarf goats

4.2.1 Haematological parameters in West African Dwarf goats

Present in Table 4.7, are the effects of the pelleted supplements on haematological parameters observed in this study. There was no significant treatment effect (P>0.05) on all the haematological parameters measured. Ranges of 10.00-10.31g/dL), 23.12 to 26.72 %, 11.62 to 13.63X10^{12}g/L, and 11.47 to 11.98x10^{9}g/L were recorded for haemoglobin and PCV concentrattions, RBC and WBC counts respectively.

Table 4.7: Haematological parameters in serum of West African Dwarf goats fed basal diet of *Andropogon gayanus* hay and supplements

Parameters	Treatments				LSD	SEM	P-value
	SLMS	ALMS	FLMS	CPMS			
Haemoglobin (g/dL)	10.31	10.05	10.00	10.12	0.369	0.122	0.265
PCV (%)	26.72	24.55	23.12	24.90	4.604	1.518	0.350
RBC (x10^{12}g/L)	13.63	12.18	11.62	12.53	2.624	0.865	0.351
WBC(x10^{9}/L)	11.70	11.98	11.94	11.47	0.904	0.639	0.934
Neutrophils (%)	50.84	48.55	45.44	43.95	7.421	2.447	0.189
Lymphocyte (%)	46.88	50.05	51.64	53.00	8.001	2.638	0.360
Eosinophils (%)	0.60	0.90	1.84	1.40	1.129	0.372	0.091
Monocytes (%)	1.68	0.50	1.08	1.15	1.455	0.480	0.372
Basophils (%)	0.00	0.00	0.00	0.00	-	-	-
MCHC (g/dL)	39.21	41.83	44.85	41.27	6.939	2.288	0.317
MCV (fL)	19.96	20.37	20.56	20.10	2.127	0.701	0.910
MCH (pg)	7.85	8.47	9.23	8.30	1.772	0.584	0.344

SEM = Standard error of mean; LSD = Least significant difference; MCV=Mean corpuscular volume; MCH=Mean corpuscular haemoglobin; MCHC=Mean corpuscular haemoglobin concentration; PCV= Packed cell volume, RBC= Red blood cell; WBC=White blood cell; SLMS = Samanea leaf meal-based supplement; ALMS = Acacia leaf meal-based supplement; FLMS = Ficus leaf meal-based supplement; CPMS = Cassava peel meal-based supplement

Generally, the concentrations of most of the haematological parameeers determined remained relatively stable and showed similar trends across dietary treatments during the period of study (Figures 4.1 to 4.3).

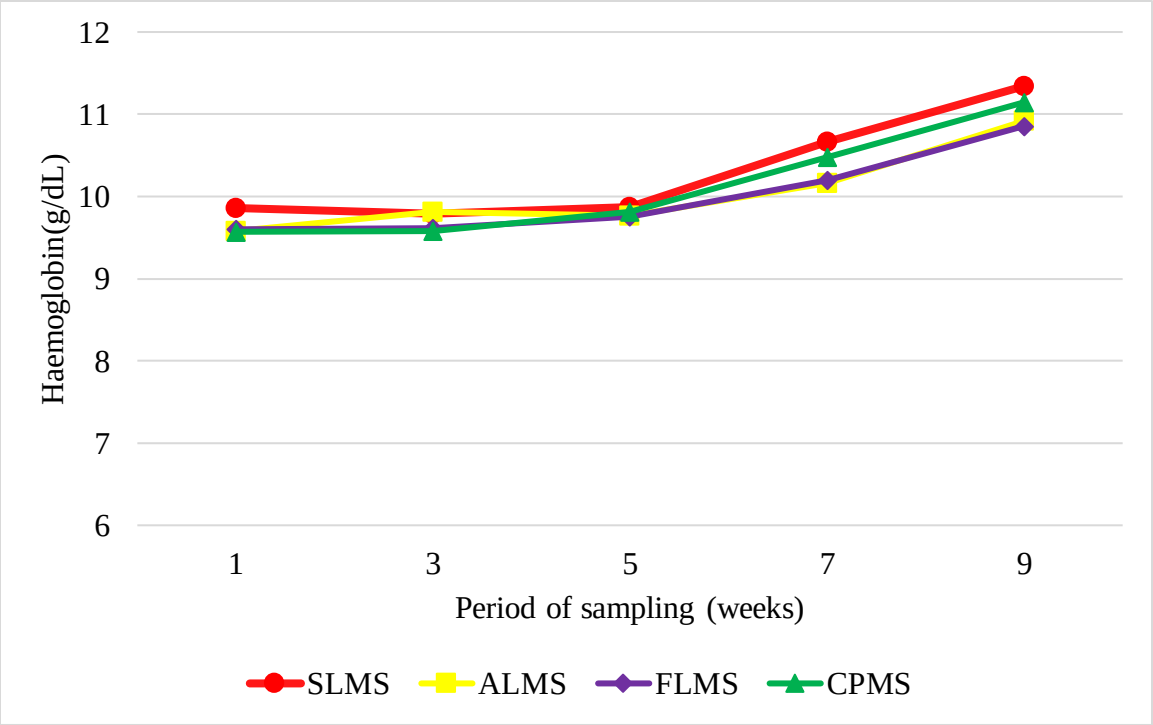

Figure 4.1: Changes in haemoglobin concentrations in West African Dwarf goats

SLMS = Samanea leaf meal-based supplement; ALMS = Acacia leaf meal-based supplement; FLMS = Ficus leaf meal-based supplement; CPMS = Cassava peel meal-based supplement

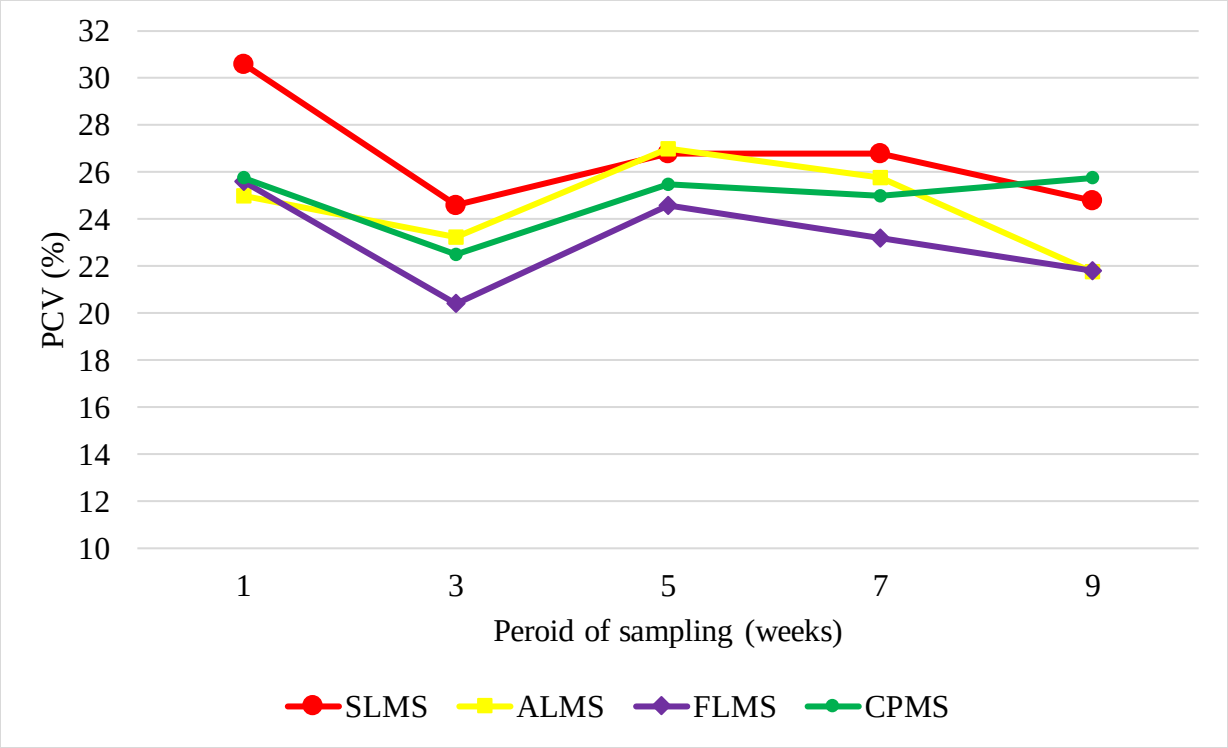

Figure 4.2: Changes in PCV concentrations in West African Dwarf goats
SLMS = Samanea leaf meal-based supplement; ALMS = Acacia leaf meal-based supplement; FLMS = Ficus leaf meal-based supplement; CPMS = Cassava peel meal-based supplement

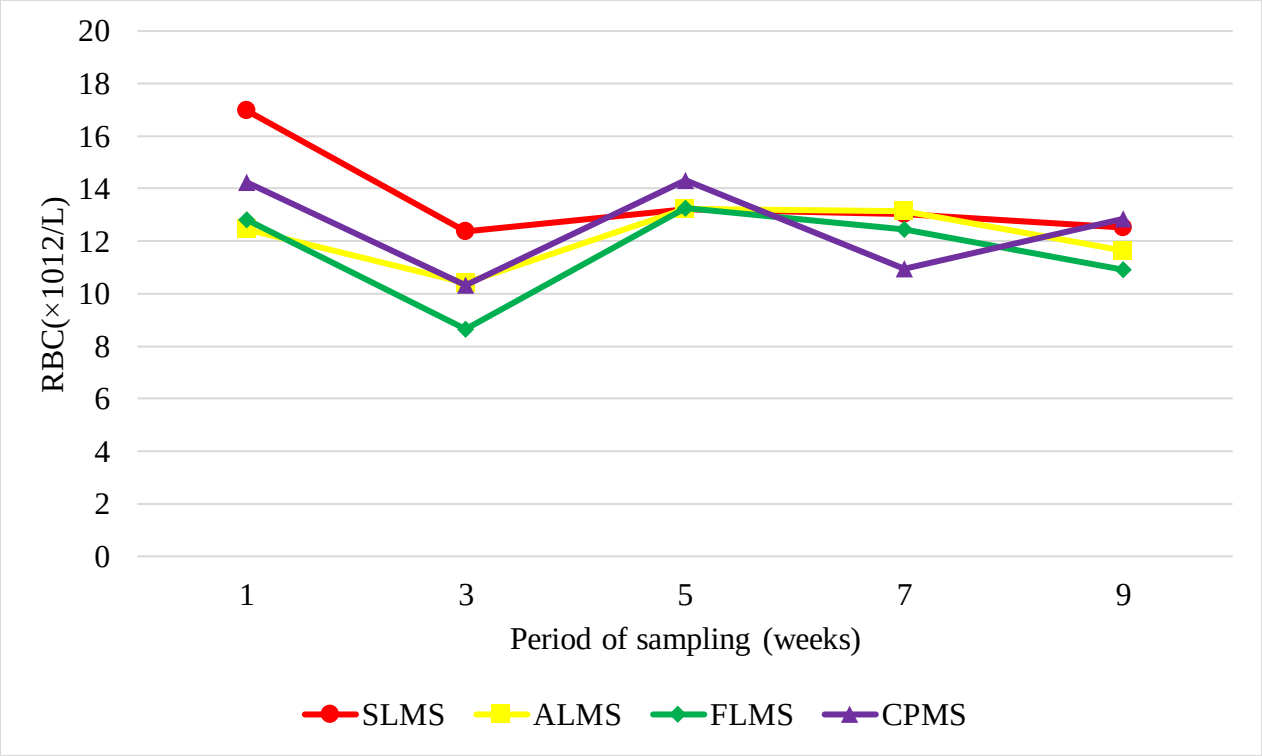

Figure 4.3: Changes in RBC concentrations in West African Dwarf goats
SLMS = Samanea leaf meal-based supplement; ALMS = Acacia leaf meal-based supplement; FLMS = Ficus leaf meal-based supplement; CPMS = Cassava peel meal-based supplement

4.2.2 Serum Biochemical Parameters in West African Dwarf goats

The results showed that dietary treatment did not significantly (P>0.05) influence most of the serum biochemical parameters measured except serum urea concentrations which was higher (P< 0.05) in goats fed SLMS than those fed ALMS, FLMS and CPMS (Table 4.8). Urea concentration ranged from 5.74 to 9.39 mmol/L. Generally, the concentrations of most of the serum biochemical parameers determined remained relatively stable and showed similar trends across dietary treatments during the period of study (Figures 4.4 to 4.6).

Table 4.8: Serum biochemical parameters in West African Dwarf goats fed basal diet of *Andropogon gayanus* hay and supplements

Parameters	Treatments				LSD	SEM	P-value
	SLMS	ALMS	FLMS	CPMS			
Total protein (g/dL)	6.00	5.57	5.56	5.94	0.558	0.26	0.145
Albumen (g/dL)	2.98	2.93	2.87	2.81	0.260	0.09	0.519
Globulin (g/dL)	3.06	2.64	2.69	3.13	0.680	0.22	0.291
TC (mg/dL)	55.32	54.44	64.56	68.99	13.98	4.61	0.097
Sodium (mmol/L)	162.3	154.1	158.6	155.5	14.03	4.62	0.568
Potassium (mmol/L)	5.97	6.18	6.17	6.09	0.879	0.29	0.937
Triglyceride(mg/dL)	26.02	24.15	24.87	26.79	4.546	1.50	0.601
Urea (mmol/L)	9.39[a]	5.74 [b]	6.51[b]	6.17 [b]	2.469	0.81	0.016
Glucose (mmol/L)	1.200	1.375	1.500	1.485	0.378	0.13	0.261

Means in the same row with different superscripts are significantly different ($p < 0.05$); TC = Total cholesterol; SEM = Standard error of mean; LSD = Least significant difference; SLMS = Samanea leaf meal-based supplement; ALMS = Acacia leaf meal-based supplement; FLMS = Ficus leaf meal-based supplement; CPMS = Cassava peel meal-based supplement

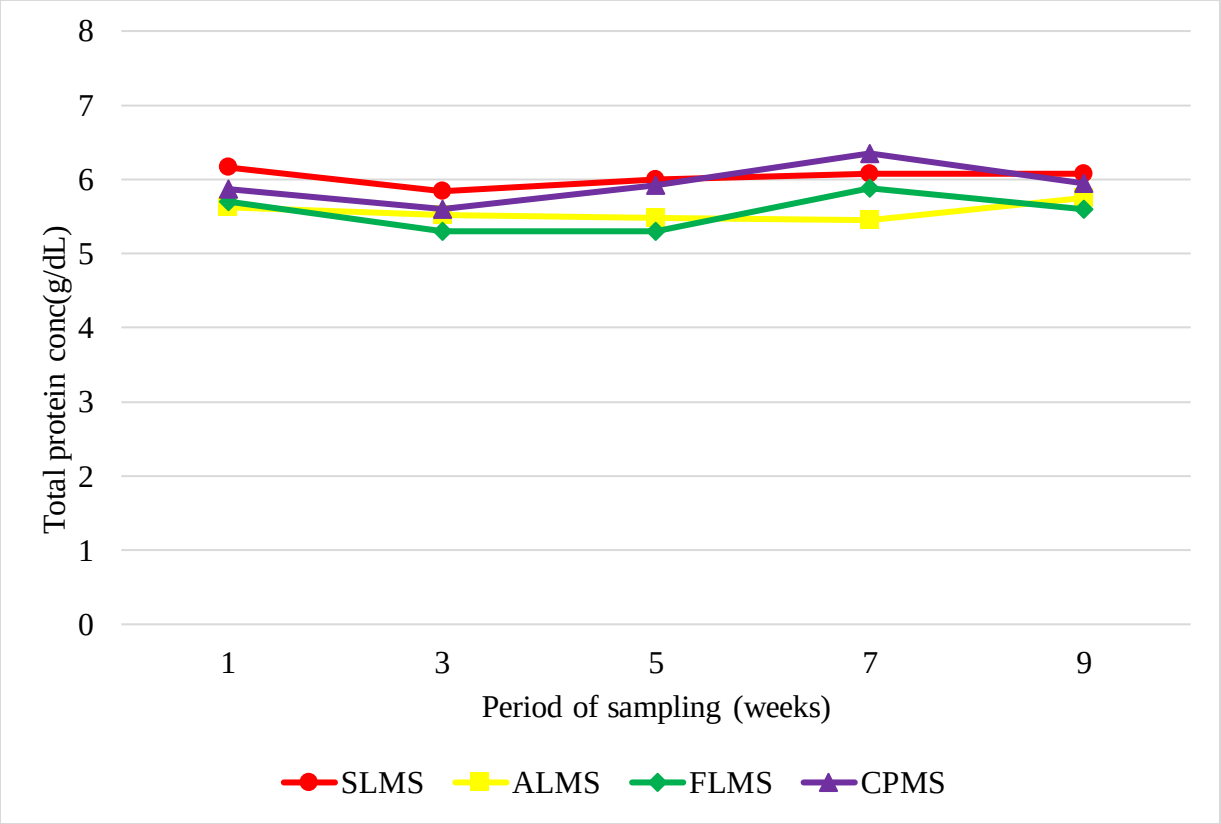

Figure 4.4: Changes in total protein concentrations in West African Dwarf goats
SLMS = Samanea leaf meal-based supplement; ALMS = Acacia leaf meal-based supplement; FLMS = Ficus leaf meal-based supplement; CPMS = Cassava peel meal-based supplement

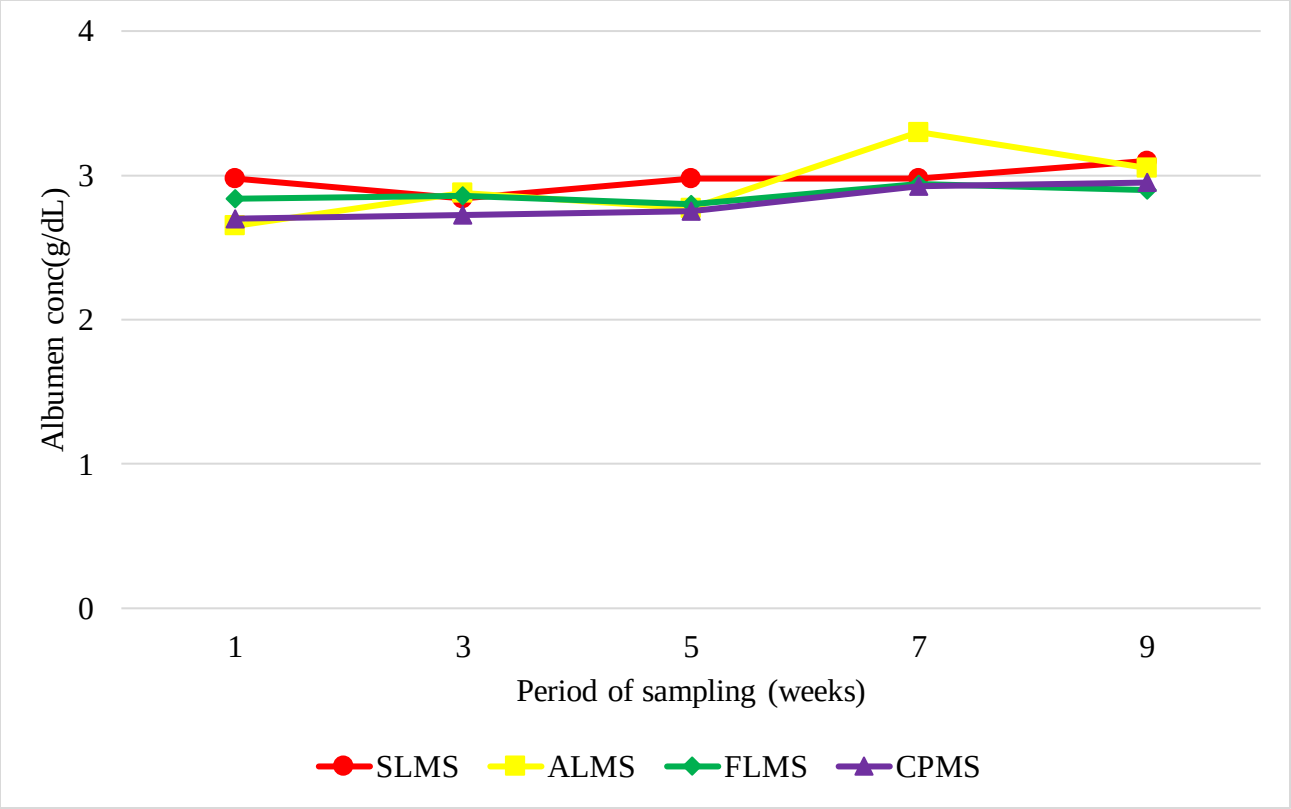

Figure 4.5: Changes in albumen concentrations in West African Dwarf goats
SLMS = Samanea leaf meal-based supplement; ALMS = Acacia leaf meal-based supplement; FLMS = Ficus leaf meal-based supplement; CPMS = Cassava peel meal-based supplement

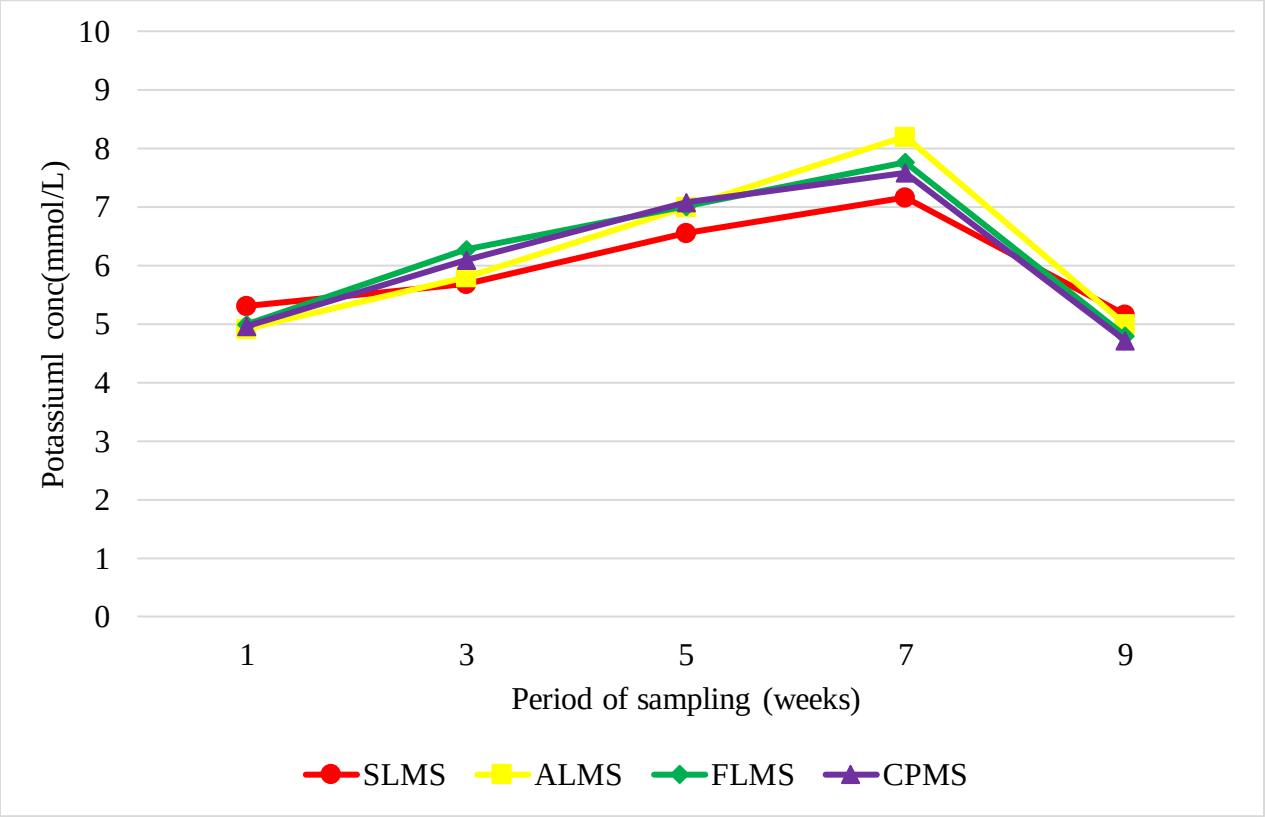

Figure 4.6: Changes in potassium concentrations in West African Dwarf goats
SLMS = Samanea leaf meal-based supplement; ALMS = Acacia leaf meal-based supplement; FLMS = Ficus leaf meal-based supplement; CPMS = Cassava peel meal-based supplement

4.3 EXPERIMENT THREE: Effect of supplements on dressing percentage and organ weights in West African Dwarf goats

There were no significant (P > 0.05) differences in the relative organ weights of goats fed the the three browse leaf meal-based and the cassava peel meal-based supplements in this study. The dressing percentage of the goats on the pelleted supplements were also not significantly (P > 0.05) different (Table 4.9). Numerically, goats on Samanea leaf-based meal (55.30%) had the highest dressing percentage, while those on Acacia leaf-based meal (48.8%) had the lowest.

Table 4.9: Effect of supplements on dressing percentage and organ weights (% of slaughter weight) in West African Dwarf goats

Organs (%)	Treatments				*LSD*	*SEM*	*P-value*
	SLMS	ALMS	FLMS	CPMS			
Heart	0.507	0.544	0.514	0.546	0.34	0.087	0.982
Kidney	0.451	0.542	0.500	0.457	0.38	0.096	0.086
Spleen	0.133	0.168	0.191	0.183	0.23	0.060	0.900
Liver	1.721	1.890	1.627	1.632	0.67	0.170	0.691
Lungs	1.437	1.453	1.287	1.489	0.63	0.161	0.823
Dressing percentage	55.30	48.8	52.2	54.9	12.69	3.23	0.526

SLMS = Samanea leaf meal-based supplement; ALMS = Acacia leaf meal-based supplement; FLMS = Ficus leaf meal-based supplement; CPMS = Cassava peel meal-based supplement

CHAPTER FIVE

5.0 DISCUSSION

5.1 EXPERIMENT ONE: Preference, intake, digestibility and growth response of West African Dwarf goats fed *Andropogon gayanus* hay and supplements comprising of *Acacia auriculiformis* leaves, *Samanea saman* leaves, *Ficus exasperata* leaves and cassava peels

5.1.1 Chemical composition of Grass hay, Samanea, Acacia and Ficus leaf meals, and Cassava peel meal

Apart from cassava peels all the leaf meals of the three browses had higher CP than Gamba grass hay. Also, all the leaf meals of the browses and cassava peel-meal had lower neutral detergent fibre and lignin contents than Gamba grass. This suggests that they could be used as supplements to provide the nutrients that may be deficient in the basal diet of the Gamba grass hay

The dry matter of the feed ingredients in this study ranged from 88.30 - 91.40% and these values favourably compared with the range of values (94.38 - 95.86%) reported by Asaolu *et al. (*2012) for WAD goats fed *Moringa oleifera, Gliricidea sepium* and *Leuceana leucocephala* dried leaves as supplements to Cassava peels. Njidda *et al*. (2018) also reported similar DM values (88.90-92.10%) for red Sokoto goats fed *Daniellia oliveri* foliage.

The crude protein content of the browse species (Samanea, Acacia and Ficus leaves) was observed to be higher than that of the grass hay and cassava peels. This finding is in consonance with the reports of Njidda *et al*. (2018) that browse forage species tend to have higher crude protein content which remains all year round making them suitable supplements for goats. The crude protein content in the present study compares favourably with the values of 21.9%, 16.4% and 15.9% for

Samanea, Acacia and Ficus leaves respectively (Adjorlolo *et al.*, 2020). The level of crude protein in the browse species is higher than the 7-8% crude protein recommended for rumen microbes of tropical livestock below which there will be a deficiency in performance of microbes in the rumen (Minson, 1990; Norton, 1994). This suggest that the inclusion of Samanea, Acacia and Ficus leaf meals in animal feeds will supply adequate protein to rumen microbes and consequently lead to an increase in digestibility of the feed and productivity in animals. The cassava peels recorded the lowest crude protein value (5.2%). This was comparable to the values of 3.93% and 3.22% reported by Baiden and Obese (2010) and Anya and Ozung (2018) but higher than the value of 2.1% (Adjorlolo *et al*., 2020) and 2.63% (Akpabio *et al.*, 2012) obtained for cassava peels. Factors including differences in soil quality where they were grown, varietal differences, stages of harvesting and processing methods may account for the differences.

The mean organic matter content obtained for Samanea leaf meal (84.6%), compared favourably to the values of 92.03% reported for Samanea pods (Hassan *et al*., 2015). The mean NDF and ADF values for the Samanea leaf meal was similar to the values of (59.8% and 39.7%) reported for Samanea leaves (Adjorlolo *et al*., 2020). The mean NDF and ADF values obtained for Acacia leaf were comparable to the values of 60.7% and 49.50% reported for the same species (Adjorlolo *et al*., 2020). The cassava peel meal had the least NDF and ADF mean values. The mean NDF and ADF values for cassava peel meal compared favourably to the NDF and ADF values of (46.30% and 21.6%) reported by Niayale (2017).

The lignin contents obtained for Samanea leaf (5.5%), Acacia leaf (7.1%), Ficus leaf (5.8%) and cassava peel (3.8%) meals compared favourably to the range of 6-14% reported by Juárez *et al.*

(2004) for tree legumes. The total ash values recorded were comparable to the values (6.36, 6.43 and 6.40%) reported for West African Dwarf bucks fed raw and processed cocoa pod husk meal-based diets in the humid high rainforest zone of Nigeria (Anya *et al*., 2018).

5.1.2 Preference for the dietary supplements by West African Dwarf goats

The four dietary supplements were accepted by the goats with CPMS having the highest preference followed by SLMS and ALMS. The FLMS was the least preferred. Other studies (Obour *et al*., 2015; Mamer, 2017; Okoruwa, 2019) have showed that increase or decrease in preference could be due to condensed tannin contents, toxin content, smell, palatability, texture of diets and nutritional needs of the animals. The FLMS being the least preferred dietary supplement in this study is in agreement with what was reported by Adjorlolo *et al*. (2016) in a previous study in sheep. High crude protein content has been observed to increase preference and intake of forages (NRC, 2000), although this observation was not established in this study.

5.1.3 Effect of supplement on voluntary feed intake in West African Dwarf goats

The dry matter intakes were comparable among the dietary treatments and this could have resulted in the similar extents of the basal diet consumption in spite of the varying crude protein levels. These observations were in accordance with the previous finding by Adjorlolo *et al*. (2020).

The significantly higher crude protein intake in goats fed the Ficus leaf meal-based supplement compared to those fed the cassava peel meal-based supplement could be attributed to the higher crude protein content of the Ficus leaf meal-based supplement resulting from the higher crude protein content of the Ficus leaf meal used (14.4%) compared with values as low as 6.9% reported by Bello *et al*. (2014). The lowest crude protein intake observed in goats on the cassava peel meal-

based supplement could be ascribed to the low concentration of crude protein in that supplement fed to the goats.

The similar NDF and lignin intakes in the goats on the dietary treatment could be attributed to their similar levels in the feed and also the similar dry matter intakes. The higher ADF intake in goats fed the three browse-based supplements than those fed the cassava peel-based supplement may be due to the moderate levels of antinutritional factors present in them which could not have negatively affected the rumen environment but helped in ADF digestion hence increasing the intake of ADF (Obasi *et al*., 2010). The lower ADF intake in the cassava peel meal-based supplement could be attributed to the high levels of cyanogenic glycosides in the dried cassava peel meal supplement which might have adversely affected the rumen environment inhibiting ADF digestion thereby reducing the intake of ADF.

5.1.4 Effect of supplement on digestibility in West African Dwarf goat

The lower dry matter digestibility in goats fed Cassava peel meal-based supplement compared to the other treatments could be attributed to lower crude protein intake of this supplement. This suggest that for goats on grass hay nitrogen is the more limiting nutrient for the rumen microbes, compared with starch which is high in the cassava peels. Also, anti-nutritional factors such as cyanogenic glycosides in the cassava peels might have slowed down microbial action and thereby decreased dry matter digestibility. Anti-nutritional factors are known to interfere with normal digestion, metabolism and absorption of nutrients (Gilani *et al.*, 2005). Crude protein and neutral detergent fibre digestibility also followed a similar trend to that of dry matter digestibility.

The higher crude protein intake of goats fed Samea leaf meal, Acacia leaf meal and ficus leaf meal-based supplements over the Cassava peel meal-based supplement could have enhanced the digestibility of crude protein and neutral detergent fibre in these supplements than the Cassava peel meal-based supplement. The leaves of trees and shrubs are high in readily degradable nitrogen 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 dry matter and crude protein digestibility obtained were comparable to the 54.7 to 68% and 44.0 to 59.0% respectively reported when Red Sokoto goats were fed elephant grass (*Pennisetum purpereum*) ensiled with varying proportions of cassava peels (Olorunnisimo, 2011).

The high organic matter digestibility for Acacia leaf meal-based and Ficus leaf meal-based diets than the Cassava peel meal-based diet could be due to the provision of adequate nutrients to the rumen microbes with consequent improvement in organic matter intake whilst higher levels of cyanogenic glycosides in Cassava peel meal-based adversely affected rumen microbial activity resulting in lower organic matter digestibility. Also, the lower crude protein digestibility in goats fed the Cassava peel meal-based diet may account for their lowest organic matter digestibility. The neutral detergent fibre digestibility was higher for Samanea leaf meal-based and Ficus leaf meal-based supplement than Cassava peel meal-based supplement probably due to moderate concentrations of secondary metabolites in the Samanea, Acacia and Ficus leaf meals that might have had positive influence on rumen microbes in accordance with some reports that low or moderate concentrations of secondary metabolites positively impacts rumen fermentation (Salem *et al*., 2006; Jiménez-Peralta, 2011). The low crude protein level in Cassava peel meal-based supplement could have inhibited rumen activity thus decreasing digestibility of neutral detergent fibre of goats fed that diet.

5.1.5 Growth performance of West African Dwarf goats fed dietary supplements

Similarity in weight gain for goats on Cassava peel meal-based supplement to the other treatments, in spite of the differences in digestibility, may suggest similar metabolisable energy intake due to higher level of digestible starch in cassava peels. Daily weight gain ranged from 9.64 to 13.55 g/day and feed conversion ratio ranged from 27.86 to 50.72. The average daily weight gains were comparable to the 10.4 to 18.7 g/day obtained when Philippine native goats were fed concentrates with different inclusion levels of *Samanea Saman* (Morais *et al.*, 2018) but lower than in other studies when goats were fed grass hay basal diets or grass and silage diets supplemented with browse tree leaves or leguminous tree foliage (Okoruwa, 2020; Okoruwa and Ikhimioya, 2020).

The mean FCR values recorded were comparable to the values (21.16-23.34) reported for West African Dwarf goats fed Agro-industrial by-products and *Pennisetum purpureum* hay as dry season feed (Obe and Yusuf, 2017), but were poorer than the 8.0-26.8, 17.0-28.0 and 14.94-19.39 g/day values reported by Mukandiwa *et al*. (2010), Trinh *et al.* (2009) and Asaolu *et al*. (2012) respectively. The variations in the FCR values could be due to differences in breeds used and intake.

5.2 EXPERIMENT TWO: Effect of Dietary Supplementation on the Haematological and Blood Biochemical parameters of West African Dwarf goats

5.2.1 Haematological parameters in West African Dwarf goats

Blood indices serve as useful indicators of nutritional, physiologic, metabolic and health status of farm animals (Mirzadeh *et al.*, 2010; Onasanya *et al.*, 2015) and hence essential in evaluating the suitability of introduced feed resources. The non-significant but similar concentrations of haematological parameters recorded (Table 4.7) suggest similar ability of the dietary treatments in enhancing the production of haemoglobin for efficient transportation of gases, normal synthesis of RBCs and production of enough WBCs to adequately defend the body against infections. The inclusion of the supplement diets not adversely affect the health of the goats indicating that the quality of the supplementary diets were good to help sustain growth of goats during periods when animals rely on poor quality fodder. Most of the levels of the haematological parameters measured were within the normal physiological ranges reported for goats (Merck Manual, 2012) and were also comparable to the values reported by Baiden *et al.* (2007) when West African Dwarf goats were fed varying levels of cassava pulp as a replacement for cassava peels.

The elevated serum MCH values (8.30-9.23 pg) in goats fed Acacia leaf meal-based supplement, Ficus leaf meal based supplement and Cassava leaf meal-based supplement, and MCHC values (39.21 to 41.83) in the three browse-based supplements and cassava peel-based supplement than normal MCH (5-8 pg) and MCHC (30-36 g/dL) may suggest the presence of macrocytic anaemia usually related to vitamin B_{12} and folic acid deficiency (Latimer *et al.*, 2003). However, goats on

these diets were apparently healthy. Goats fed Samanea leaf meal-based supplement had lower lymphocyte level than the normal physiological range due their very high percentage of neutrophils.

5.2.2 Serum biochemical indices in West African Dwarf goats

The higher serum urea concentrations in goats fed Samanea leaf meal-based supplement than those fed Acacia leaf meal-based supplement, Ficus leaf meal-based supplement and Cassava peel meal-based supplement (Table 4.8) might be due to the higher crude protein levels in the Samanea leaf meal than the Acacia and Ficus leaf meals and the cassava peel meal. Also, the slightly higher concentration of urea than the normal range in goats fed SLMS may be due to inefficient utilization of protein leading to increased catabolism of proteins (Oduye and Adadevoh, 1976). Most concentrations of the serum biochemical indices determined were, however within the normal physiological range reported for goats (Merck Manual, 2012) suggesting that feeding the supplements did not have adverse effects on the physiology of the West African Dwarf goats. The concentration of the biochemical parameters recorded compared favourably to the values obtained by Hassan *et al.* (2015) when they fed some forage shrubs made up of Acacia, Leucaena and Moringa to goats during the dry season.

The low feed intake of the goats on the various diets may account for their lower glucose and protein concentrations than the normal physiological ranges. It is reported that higher cholesterol concentrations of goats may suggest hepatic disease (Özsoy *et al.*, 2013; Salami and Odunsi, 2017). The cholesterol levels in goats fed Samanea leaf meal-based supplement, Ficus leaf-meal based supplement and Cassava peel meal-based supplement were higher than the normal ranges. However, goats on these diets were normal and did not display any symptoms of liver disease. The

serum cholesterol values obtained were comparable to the reported values (58.0-60.67 mg/dL) for goats (Özsoy *et al.*, 2013) but lower than the values (87.03-108.47 mg/dL) reported for West African Dwarf goats fed some browse species supplemented with a concentrate diet (Amina *et al.*, 2020) The higher serum sodium concentrations than the normal physiological range in goats fed Samanea leaf meal-based supplement and Ficus leaf meal-based supplement may be due to kidney disease or dehydration however the goats on these treatments were apparently normal. Generally higher sodium level may be attributed to cellular dehydration characterized by haemo-dilution (Ikhimioya and Imasuen, 2007).

5.3 EXPERIMENT THREE: Effect of supplements on dressing percentage and organ weights in West African Dwarf goats

The dressing percentages and organ weights obtained in this study were not significantly different across the dietary treatments. This is an indication that the dietary supplements were well utilized by the goats without any adverse effects on their organ development (Tadesse *et al*., 2016; Omachi *et al*., 2019; Gboshe and Ukorebi, 2020). The internal organs such as the liver and heart would vary by enlargement if the diets contained poisonous substances. The non-significance in the values for kidney which is an excretory organ across the test diets indicate that the kidney was not overburdened, thus the excretory functions of the goats were not negatively affected (Ocheja *et al*., 2016).

An increase in metabolic activities is usually associated with an increase in the size of the liver during detoxification and it is a common practice in feeding trials to use weights of liver and kidney as indicators of toxicity in feed (Akinmutimi, 2007; Anya and Ozung, 2018). The use of feed

samples containing toxic elements in feeding trials results in abnormalities in the weight of organs and these abnormalities arise due to increased metabolic rate of the organs in an attempt to reduce these toxic elements to nontoxic elements (Bone 1979; Anya and Ozung, 2018).

The simiar dressing percentages and organ weights obtained in this study confirm earlier findings by Anya and Ozung (2018) who observed no significat difference in organ weights for the same breed fed cassava peel meal-based diets supplemented with African Yam Bean concentrate. Studies by Devendra and McLeroy (1982) and Gboshe and Ukorebi (2020) indicated that most small ruminants in the tropics on balanced diets dress out at 40-50%. The values for dressing percentage obtained in this study were within the general range of 45 - 52% reported by Nuru (1985) for West African Dwarf goats.

CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

Based on this study, it can be concluded that:

i. The pelleted cassava peel meal-based and Samanea leaf meal -based supplements were preferred by the West African Dwarf goats relative to the Acacia and Ficus leaf meal-based supplements.

ii. Feeding the three (*Samanea saman, Acacia auriculiformis* and *Ficus exasperata*) pelleted browse leaf meal-based supplements and Cassava peel meal-based supplement influenced feed intake and growth performance to similar extents.

iii. The four pelleted supplements did not adversely affect the physiology and health of the goats since the concentration of the haematological and serum biochemical indices were within acceptable physiological ranges reported for goats.

iv. Inclusion of the three pelleted browse leaf meal-based supplements and Cassava peel meal -based supplement in the diet of West Afrrican Dwarf goats did not adversely influence their carcass parameters.

v. All the four dietary supplements could be fed to confined goats on roughage especially in the dry season to overcome the adverse effects of seasonal fluctuation in feed quality on growth and health of goats.

6.2 Recommendations

i. Further studies should be conducted to determine the concentrations of anti-nutritional factors in *Samanea saman*, *Acacia auriculiformis* and *Ficus exasperata* leaf meals and cassava peel meal in order to ascertain their optimum level of inclusion in goat`s diets without any adverse effect on their feed intake, digestion, growth, physiology and health.

ii. Further research should be conducted to determine the effect of *Samanea saman, Acacia auriculiformis* and *Ficus exasperata* leaf meal-based supplements and cassava peel meal-based supplements on rumen environment and function in goats. This will provide knowledge on how the supplements influence rumen microbial population and function with respect to feed degradation and fermentation, rumen pH, production of volatile fatty acids and ammonia which may provide a key to improving animal production.

iii. Studies to determine the above supplements on meat quality and reproductive performance of goats should be undertaken. This is necessary because meat consumers turn to reject meat that is poor in quality as it is associated with human health risks. This will also provide knowledge on how these supplements influence early attainment of puberty (thus earlier onset of puberty, thereby enabling early reproductive life), ovulation rate or incidence of multiple ovulation and embryo mortality in goats.

REFERENCES

AACC (American Association for Clinical Chemistry), (2011). White blood cell differential count. Lab tests online. http://labtestsonline.org/understanding/analytes/differential/tab/test.

Abbiw, T. (1990). Study of tropical shrubs and plant. J. Biogeorge, 23: 591-602.

Abdu, S.B., Hasan, M.R., Adamu, H.Y., Yashimi, S.M. and Abdullahi, M.J. (2012). Intake, nutrient digestibility and nitrogen balance of Acacia auriculate, Gmelina arborea, Albizia lebbeck and Butryospermum parkii by Yankasa Bucks. Iranian Journal of Applied Animal Science, 2(2): 121-125.

Addey, E. (2011). Feed intake and nutrient digestibility of sheep fed Pennisetum purpureum supplemented with Moringa oleifera leaves and Samanea saman pods. BSc. Agriculture Dissertation, Department of Animal Science, K.N.U.S.T., 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.

Adebowale, O.J. and Maliki, K. (2011). Effect of fermentation period on the chemical composition and functional properties of Pigeon pea (Cajanus cajan) seed flour. International Food Research Journal, 18(4): 1329-1333.

Adedeji, T.A., Ozoje, M.O., Peters, S.O., Sanusi, A.O., Ojedapo, L.O. and Ige, A.O. (2011). Coat pigmentation and Wattle genes effect on some haematological characteristics of heat stressed and extensively reared West African Dwarf goats. World J. Life Sci. Med. Res, 3: 48-55.

Adjorlolo, L.K., Adogla-Bessa, T., Amaning-Kwarteng, K. and Ahunu, B.K. (2014). Effect of season on the quality of forages selected by sheep in citrus plantations in Ghana. Tropical Grasslands-Forrajes Tropicales, 2(3): 271-277.

Adjorlolo, L.K., Timpong-Jones, E.C., Boadu, S. and Adogla-Bessa, T. (2016). Potential contribution of neem (Azadirachta indica) leaves to dry season feeding of ruminants in West Africa. Livestock Research for Rural Development, 28: Article #75.

Adjorlolo, L., Nsoh, M., Mensah-Bonsu, A. and Obese, F. (2020). Effect of pelleted browse-based feed with a basal diet of Andropogon gayanus for sheep on intake, nutrient digestibility and some haematological and blood biochemical parameters. Online Journal of Animal and Feed Research, 10(3): 76-84. https://dx.doi.org/10.36380/scil.2020.ojafr11

Adjorlolo, L., Obese, F.Y. and Tecku, P. (2019). Blood metabolite concentration, milk yield, resumption of ovarian activity and conception in grazing dual purpose cows supplemented with concentrate during the post-partum period. Veterinary Medicine and Science, 5(2): 103-111.

Agenäs, S., Heath, M.F., Nixon, R.M., Wilkinson, J.M. and Phillips, C.J.C. (2006). Indicators of undernutrition in cattle. Animal Welfare, 15(2): 149-160.

Ahmed, F., Ahmed, K.M., Abedin, M. and Karim, A. (2012). Traditional uses and pharmacological potential of Ficus exasperata vahl. Systematic Reviews in Pharmacy, 3(1): 15.

Akinmutimi, A.H. (2007). Effect of cooking period on the nutrient composition of velvet beans (Mucuna pruriens). Proceedings of 32nd Annual Conference of the Nigerian Society for Animal Production. March 18-21st, 2007, University of Calabar, Calabar, pp. 223-226.

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.

Amankwah, K., Klerkx, L., Oosting, S.J., Sakyi-Dawson, O., Van der Zijpp, A.J. and Millar, D. (2012). Diagnosing constraints to market participation of small ruminant producers in

northern Ghana: An innovation systems analysis. NJAS-Wageningen Journal of Life Sciences, 60: 37-47.

Amina, O., Jude, E., Ibrahim, S., Yaro, U.A., Hassanatu, A.S., Theophilus, E.A. and Tsobaza, A.A. (2020). Serum Biochemistry of West African Dwarf Goats Fed some Browse Species supplemented with a Concentrate Diet. Animal and Veterinary Sciences, 8(2): 41.

Ampong, E., Obese, F.Y. and Ayizanga, R.A. (2019). Growth and reproductive performance of West African Dwarf Sheep (Djallonké) at the Livestock and Poultry Research Centre, University of Ghana. Livestock Research for Rural Development, 31: Article #8. http://www.lrrd.org/lrrd31/1/fyobe31008.html

Anderson, P. (2017). Intake, digestibility, and nitrogen balance of sheep fed bambara groundnut haulm as supplement to a maize stover basal diet. MPhil Thesis, Department of Animal Science, K.N.U.S.T., Ghana.

Anderson, S.J., Klopfenstein, T.J. and Wilkerson, V.A. (1988). Escape protein supplementation of yearling steers grazing smooth brome pastures. Journal of animal science, 66(1): 237-242.

Annan, P. (1998). Cassava peels supplemented with Ficus exasperata as feed for small ruminants. MSc Thesis, Department of Animal Science, K.N.U.S.T., Ghana. http://hdl.handle.net/123456789/2903

Annor, S.Y., Djang-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 (Ghana), 27(3): 23-38.

Anosa, V.O. and Isoun, T.T. (1980). Haematological studies on Trypanosoma vivax infection of goats and intact and splenectomized sheep. Journal of Comparative Pathology, 90(1): 155-168.

Anya, M.I. and Ozung, P.O. (2018). Performance and carcass characteristics of West African Dwarf (wad) goats fed cassava peel meal-based diets supplemented with African yam bean concentrate. International Journal of Advances in Agricultural Science and Technology, 5(7): 95-108.

Anya, M.I., Ozung, P.O. and Igwe, P.A. (2018). Blood profile of West African Dwarf (WAD) bucks fed raw and processed cocoa pod husk meal based–diets in the humid high rainforest zone of Nigeria. Global Journal of Pure and Applied Sciences, 24(2): 125-135.

AOAC, (2004). Official Methods of Analysis. 18th Ed, Association of Official Analytical Chemists, Washington, D.C.

Apori, S.O., Castro, F.B., Shand, W.J. and Ørskov, E.R. (1998). Chemical composition, in sacco degradation and in vitro gas production of some Ghanaian browse plants. Animal Feed Science and Technology, 76(1-2): 129-137.

Araújo, G.G.L.D., Voltolini, T.V., Chizzotti, M.L., Turco, S.H.N. and Carvalho, F.F.R.D. (2010). Water and small ruminant production. Revista Brasileira de Zootecnia, 39: 326-336.

Asaolu, V., Binuomote, R., Akinlade, J., Aderinola, O. and Oyelami, O. (2012). Intake and growth performance of West African dwarf goats fed Moringa oleifera, Gliricidia sepium and Leucaena leucocephala dried leaves as supplements to cassava peels. Journal of Biology, Agriculture and Healthcare, 2(10): 76-88.

Aseme, T., Robert, B., Amuzie, C.C. and Akani, G.C. (2020. Haematological Parameters and Haemoparasites of West African Dwarf Goats sold at Trans-Amadi and Rumuokoro Abattoirs, Port Harcourt, Nigeria. Current Trends in Veterinary and Dairy Research, 1(1): 14-19.

Ayinde, B.A., Omogbai, E.K. and Amaechina, F.C. (2007). Pharmacognosy and hypotensive evaluation of Ficus exasperata Vahl (Moraceae) leaf. Acta Poloniae Pharmaceutica, 64(6): 543-546.

Ayizanga, R.A., Tecku, P.K.M. and Obese, F.Y. (2018). Growth and reproductive performance of West African dwarf goats at the Animal Research Institute, Katamanso Station. Ghana Journal of Agricultural Science, 52(1): 43-53.

Azevêdo, J.A.G., Valadares Filho, S.C., Pina, D.S., Valadares, R.F.D., Detmann, E., Paulino, M.F., Diniz, L.L. and Fernandes, H.J. (2011). Intake, total digestibility, microbial protein production, and the nitrogen balance in ruminant diets based on agricultural and agro-industrial by-products. Arquivo Brasileiro de Medicina Veterinária e Zootecnia, 63(1): 114-123.

Baah, J. (1994). Selection and evaluation of feedstuffs for urban and peri-urban small ruminant production systems in Ghana: a systems approach. PhD Thesis, University of British Columbia, Vancouver, BC, CA. http://hdl.handle.net/2429/8773

Baah, J., Tait, R.M. and Tuah, A.K. (1999). The effect of supplementation with ficus leaves on the utilization of cassava peels by sheep. Bioresource Technology, 67(1): 47-51.

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(1): 36-40.

Baah, J., Tuah, A., Addah, W. and Tait, R. (2012). Small ruminant production characteristics in urban households in Ghana. Livestock Research for Rural Development, 24(5): Article #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, 1(5): 60-65. http://197.255.68.203/handle/123456789/1590.

Baiden, R.Y., Rhule, S.W.A., Otsyina, H.R., Sottie, E.T. and Ameleke, G. (2007). Performance of West African dwarf sheep and goats fed varying levels of cassava pulp as a replacement for cassava peels. Livestock Research for Rural Development, 19(3): 118-124.

Bairagi, A., Ghosh, K.S., Sen, S.K. and Ray, A.K. (2002). Duckweed (Lemna polyrhiza) leaf meal as a source of feedstuff in formulated diets for rohu (Labeo rohita Ham.) fingerlings after fermentation with a fish intestinal bacterium. Bioresource Technology, 85(1): 17-24.

Baker, P.J., Amsbaugh, D.F., Stashak, P.W., Caldes, G. and Prescott, B. (1981). Regulation of the antibody response to pneumococcal polysaccharide by thymus-derived cells. Reviews of Infectious Diseases, 3(2): 332-341.

Banakar, P.S., Ally, K., Lokesh, E., Saseendran, A., Jaafar, J. and Dominic, G. (2017). In vitro assessment of nutritive value of unconventional feed resource as livestock feed. International Journal of Livestock Research, 7(6): 159-169. http://dx.doi.org/10.5455/ijlr.20170423030200

Barcelo, P.M., and Barcelo, J.R. (2012). The potential of Samanea saman (Jack) Merr pods as feed for goat. International Journal of Zoology Research, 2(1): 40-43.

Baumont, R. (1996). Palatability and feeding behaviour in ruminants. A review. Annals of Zootechnics, INRA / EDP Sciences, 45 (5): 385-400. https://hal.archives-ouvertes.fr/hal-00889572

Belewu, M.A. and Ogunsola, F.O. (2010). Haematological and serum indices of goat fed fungi treated Jatropha curcas kernel cake in a mixed ration. Journal of Agricultural Biotechnology and Sustainable Development, 2(3): 35-38.

Bello, M.O., Abdul-Hammed, M. and Ogunbeku, P. (2014). Nutrient and anti-nutrient phytochemicals in Ficus exasperata Vahl leaves. International Journal of Scientific and Engineering Research (IJSER), 5(1): 2177-2181.

Berg, C.C. (1989). Classification and distribution of Ficus exasperata, 45(7): 605-611.

Berg, C.C. and Wiebes, J.T. (1992). African fig trees and fig wasps. 298 pp. Amsterdam. Koninklijke Nederlandse Akademie van Wetenschappen, Verhandelingen Afdeling Natuurkunde, Tweede Reeks, Deel, 89.

Birteeb, P.T., Danquah, B.A. and Salifu, A.S. (2015). Growth performance of West African Dwarf Goats reared in the transitional zone of Ghana. Asian Journal of Animal Sciences, 9(6): 370-378.

Boland, D., Pinyopusarerk, K., McDonald, M., Jovanovic, T. and Booth, T. (1990). The habitat of Acacia auriculiformis and probable factors associated with its distribution. Journal of Tropical Forest Science, 3(2): 159-180. http://www.jstor.org/stable/43594382.

Bone, J.F. (1979). Animal Anatomy and Physiology, 4th edition, Reston Publishing Company.

Inc., Reston. Virginia.

Borges, S.A., Da Silva, A.F., Ariki, J., Hooge, D.M. and Cummings, K.R. (2003). Dietary electrolyte balance for broiler chickens exposed to thermoneutral or heat-stress environments. Poultry Science, 82(3): 428-435.

Breazile, J.E. (1971). Textbook of Veterinary Physiology (No. SF 768. T492 1971).

Brown, D., Ng'ambi, J.W. and Norris, D. (2018). Effect of tanniniferous Acacia karroo leaf meal inclusion level on feed intake, digestibility and live weight gain of goats fed a Setaria verticillata grass hay-based diet. Journal of Applied Animal Research, 46(1): 248-253.

Bucolo, G. and David, H. (1973). Quantitative determination of serum triglycerides by the use of enzymes. Clinical Chemistry, 19(5): 476-482.

Bureau, C.V. (1998). Veevoedertalel (Feeding value of feed ingredients). Centraal Veevoeder Bureau, Runderweg, 6.

Burkill, H.M. (1985). The useful plants of tropical West Africa. Richmond, UK, Kew Royal Botanical Garden, London, 1: 252-253.

Campbell, T.W. (1995). Avian Hematology and Cytology. 2nd Edn., Iowa State University Press, Ames, Iowa, USA.

CDC (2017). LDL and HDL Cholesterol: "Bad" and "Good" Cholesterol. https://www.cdc.gov/cholesterol/ldl_hdl.htm

Chiejina, S.N. and Behnke, J.M. (2011). The unique resistance and resilience of the Nigerian West African Dwarf goat to gastrointestinal nematode infections. Parasites and Vectors, 4(1): 12.

Chiejina, S. N., Behnke, J. M. and Fakae, B. B. (2015). Haemonchotolerance in West African Dwarf goats: contribution to sustainable, anthelmintics-free helminth control in traditionally managed Nigerian dwarf goats. Parasite, 22(7). https://doi.org/10.1051/parasite/2015006

Chowdhury, S.R., Sarker, D.K., Chowdhury, S.D., Smith, T.K., Roy, P.K. and Wahid, M.A. (2005). Effects of dietary tamarind on cholesterol metabolism in laying hens. Poultry Science, 84(1): 56-60.

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(7): 1279-1284.

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

Coles, E.H. (1967). Veterinary clinical pathology. Veterinary Clinical Pathology. https://www.cabdirect.org/cabdirect/search/?q=pb%3a%22Philadelphia+(%26+London)%3a+W.+B.+Saunders%22

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.

Daly, F.F.M. (2009). The effect of diet on the nutrition and production of merino ewes in the arid shrublands of Western Australia. PhD Thesis, Curtin University of Technology, Australia. https://espace.curtin.edu.au/handle/20.500.11937/570

Damptey, J.K., Obese, F.Y., Aboagye, G.S., Ayim-Akonor, M. and Ayizanga, R.A. (2014). Blood metabolite concentrations and postpartum resumption of ovarian cyclicity in Sanga cows. South African Journal of Animal Science, 44(1): 10-17.

Daramola, J.O., Adeloye A.A., Fatoba, T.A and Soladoye, A.O. (2005). Haematological and biochemical parameters for West African Dwarf goats. Livestock Research for Rural Development, 17: Article #95. http://www.lrrd.org/lrrd17/8/dara17095.htm

De la Cruz, R. (2003). Acacia pods to feed chickens, Research and Development Digest., Bureau of Agricultural Research, 5(2): 19.

Delgado, D.C., Hera, R., Cairo, J. and Orta, Y. (2016). Samanea saman, a multi-purpose tree with potentialities as alternative feed for animals of productive interest. Cuban Journal of

Agricultural Science, 48(3): 205-212. http://cjascience.com/index.php/CJAS/article/view/573

Devendra, C. and McLeroy, G.B. (1982). Goat and sheep production in the tropics. Longman, London.

Dike, M.C. (2009). Proximate and phytochemical compositions of some browse plant species of southeastern Nigeria. Global Journal of Agricultural Sciences, 8(1): 87-93. https://www.ajol.info/index.php/gjass/article/view/48528

Duhan, A., Khetarpaul, N. and Bishnoi, S. (2002). Content of phytic acid and HCl-extractability of calcium, phosphorus and iron as affected by various domestic processing and cooking methods. Food Chemistry, 78(1): 9-14. https://doi.org/10.1016/S0308-8146(01)00144-3

El-Sayed, A.F.M. (1999). Alternative dietary protein sources for farmed tilapia, Oreochromis spp. Aquaculture, 179(1-4): 149-168. https://doi.org/10.1016/S0044-8486(99)00159-3

Escobar, N. (1972). Flora Tóxica de Panamá. EUPAN.

Etim, N.N., Williams, M.E., Akpabio, U. and Offiong, E.E. (2014). Haematological parameters and factors affecting their values. Agricultural Science, 2(1): 37-47.

Eunice, A.O. and Olamiposi, O.O. (2019). Growth and feed utilization in Clarias gariepinus fingerlings fed on Acacia auriculiformis leaf supplemented diets. International Journal of Fisheries and Aquaculture, 11(3): 55-61.

Fajemisin, A.N., Fadiyimu, A.A. and Alokan, J.A. (2010). Nitrogen retention and haematological indices of West African dwarf rams fed sun dried and fermented rumen digesta and cage hen dropping diets. In Proceedings of the 35th Conference of Nigerian Society for Animal Production (NSAP), 14th–17th March, University of Ibadan, Nigeria, pp. 604-607.

Feed Supplements Market Business Opportunities, (2019). Size, Value Share, Emerging Trend, Global Analysis, Leading Players Strategy and Forecast to 2023. The Free Library. https://www.thefreelibrary.com/Feed+Supplements+Market+Business+Opportunities+2019+%2f+Size%2c+Value...-a0595801876.

Fomunyam, R.T. and Meffeja, F. (1987). Cassava by-products in rabbit and sheep diets. Utilisation of Agricultural by-products as livestock feeds in Africa, ILCA, Addis Ababa, pp.103-107.

Frandson, R.D. (1986). Anatomy and Physiology of Farm Animals, 4th Edn., Lea and Febiger, Philadelphia, USA.

Fuah, A.M. and Pattie, W.A. (2013). Productivity of local goats supplemented with acacia villosa and coripha gebanga. Media Peternakan, 36(1): 40.

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

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), p.19.

Gboshe, P.N. and Ukorebi, B.A. (2020). Performance and carcass characteristics of West frican Dwarf goats fed cassava peel meal partially replaced with sugarcane peel meal. Animal and Veterinary Sciences, 8(1): 36.

Ghana Statistical Service, (2014). 2010 Population and Housing Census Report: Disability in Ghana. Ghana Statistical Service.

Ghosh, M., Babu, S.P., Sukul, N.C. and Mahato, S.B. (1993). Antifilarial effect of two triterpenoid saponins isolated from Acacia auriculiformis. Indian Journal of Experimental Biology, 31(7): 604-606.

Gilani, G.S., Cockell, K.A. and Sepehr, E. (2005). Effects of antinutritional factors on protein digestibility and amino acid availability in foods. Journal of AOAC International, 88(3): 967-987.

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

Gilman, E.F. and Watson, D.G. (2010). Acacia auriculiformis: Earleaf Acacia. Fact Sheet ST-4. University of Florida. https://www.doc-developpement-durable.org/file/Arbres-Bois-de-RapportReforestation/FICHES_ARBRES/Acacia%20auriculiformis/Acacia%20auriculiformis%20-%20EDIS%20-%20University%20of%20Florida.pdf

Giridhar, K.S., Prabhu, T.M., Singh, K.C., Nagabhushan, V., Thirumalesh, T., Rajeshwari, Y.B. and Umashankar, B.C. (2018). Nutritional potentialities of some tree leaves based on polyphenols and rumen in vitro gas production. Veterinary World, 11(10): 1479.

Girijashankar, V. (2011). Micropropagation of multipurpose medicinal tree Acacia auriculiformis. Journal of Medicinal Plants Research, 5(3): 462-466.

Gunasundari, C. (2018). Evaluation of serum uric acid and lipid profile in type 2 diabetes mellitus. Masters Thesis, Department of Biochemistry, Kilpauk Medical College, Chennai. http://repository-tnmgrmu.ac.in/id/eprint/9015

Habiba, R.A. (2002). Changes in anti-nutrients, protein solubility, digestibility, and HCl-extractability of ash and phosphorus in vegetable peas as affected by cooking methods. Food Chemistry, 77(2): 187-192.

Hagan, M.A.S. (2013). Nutritive value of Samanea saman seed and whole pod meals as feed ingredients for broiler chickens. Masters Thesis, Department of Animal Science, K.N.U.S.T., Ghana. http://dspace.knust.edu.gh/handle/123456789/5324

Haliburton, J.C. and Morgan, S.E. (1989). Nonprotein nitrogen-induced ammonia toxicosis and ammoniated feed toxicity syndrome. The Veterinary Clinics of North America. Food Animal Practice, 5(2): 237-249. https://doi.org/10.1016/s0749-0720(15)30974-9

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

Hanukoglu, I. (1992). Steroidogenic enzymes: structure, function, and role in regulation of steroid hormone biosynthesis. The Journal of Steroid Biochemistry and Molecular Biology, 43(8): 779-804.

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

Hassan, M.R. and Roy, P.K. (1994). Evaluation of water hyacinth meal as a dietary protein source for Indian major carp (Labeo rohita) fingerlings. Aquaculture, 124(1-4): 63.

Hassan, A.A., Abu Hafsa, S., Yacout, M.H., Khalel, M.S., Ibrahim, M.A.R. and Mocuta, D. (2015). Effect of feeding some forage shrubs on goats performance and rumen fermentation in dry season. Egyptian Journal of Sheep and Goats Sciences, 10(2): 1-16.

Hassan, M.M. and El-Dayem, A. (2019). Improving utilization of acacia leaves meal and its effects on broilers performance. Egyptian Poultry Science Journal, 39(3): 657-672.

Hassen, A.S. and Ali, M.Y. (2019). Effect of different level of molasses inclusion on feed intake, body weight gain and carcass parameters of Afar sheep in Ethiopia. Asian Journal of Medical and Biological Research, 5(1): 20-30.

Heuzé, V., Tran, G., Archimede, H., Regnier, C., Bastianelli, D. and Lebas, F. (2016). Cassava peels, cassava pomace and other cassava by-products. https://agritrop.cirad.fr/582525/1/ID582525.pdf

Hill, V.L., Simpson, V.Z., Higgins, J.M., Hu, Z., Stevens, R.A., Metcalf, J.A. and Baseler, M. (2009). Evaluation of the performance of the Sysmex XT-2000i Hematology Analyzer with whole blood specimens stored at room temperature. Laboratory Medicine, 40(12): 709-718.

Hillman, G., Beyer, G. and Klin, Z. (1967). Determination of potassium concentration. Chem Clinic Biochemist, 5: 93.

Hosten, A.O. (1990). BUN and creatinine. In Clinical Methods: The History, Physical, and Laboratory Examinations. 3rd edition., Boston: Butterworths, 193. https://www.ncbi.nlm.nih.gov/books/NBK305/

Hsu, A.K., Kerr, B.M., Jones, K.L., Lock, R.B., Hart, D.N. and Rice, A.M. (2006). RNA Loading of Leukemic Antigens into Cord Blood–Derived Dendritic Cells for Immunotherapy. Biology of Blood and Marrow Transplantation, 12(8): 855-867.

Hu, W.L., Liu, J.X., Ye, J.A., Wu, Y.M. and Guo, Y.Q. (2005). Effect of tea saponin on rumen fermentation in vitro. Animal Feed Science and Technology, 120(3-4): 333-339.

Huang, Y.L. and Hu, Z.D. (2016). Lower mean corpuscular hemoglobin concentration is associated with poorer outcomes in intensive care unit admitted patients with acute myocardial infarction. Annals of Translational Medicine, 4(10): 190. https://doi.org/10.21037/atm.2016.03.42

Idowu, A.B., Babalola, O.D. and Ademolu, K.O. (2006). The physiological impact on the consumption of Albizia saman pods by albino rats. Journal of Animal and Veterinary Advances, 5(7): 585-589.

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 Plants Research, 1(2): 27 – 29. https://doi.org/10.5897/JMPR.9000040

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

Ishaq, S. L., Lachman, M. M., Wenner, B. A., Baeza, A., Butler, M., Gates, E. and Yeoman, C. J. (2019). Pelleted-hay alfalfa feed increases sheep wether weight gain and rumen bacterial richness over loose-hay alfalfa feed. PloS one, 14(6), e0215797.

Iwuji, T.C., Nwapi, D.O., Ogbuewu, I.P., Kadurumba, E.O., Egenuka, F.C. and Okere, P.C. (2017). Management, blood and reproductive parameters of rabbits reared in Imo State. Nigerian Journal of Animal Production, 44(2): 230-247.

Jiménez, G.S., Ducoing, H.P. and Sosa, M.R. (2003). The participation of secondary metabolites in the defense of plants. Mexican Journal of Phytopathology, 21 (3): 355-363.

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.

Juárez, FI, Montero, M., Alpirez, F., Contreras, J. and Canudas, E. (2004). Nutritional evaluation of tropical legumes for dual-purpose cattle. XVII Forest and Agricultural Scientific Technological Meeting. Veracruz, Mexico.

Kaitho, R.J. (1997). Nutritive value of browses as protein supplement (s) to poor quality roughages. PhD Thesis, Department of Animal Nutrition, Wageningen Agricultural University, Netherlands. https://library.wur.nl/WebQuery/wurpubs/37642

Kalio, G.A., Ayuk, A.A. and Etela, I. (2012). Preference and acceptability as quality indicators of crop by-products used in feeding west african dwarf goats. Animal Production Research Advances, 8(1): 1-6.

Kapale, P.M., Jagtap, 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.

Karbo, N. and Agyare, W. (2002). Crop–livestock systems in northern Ghana. Improving Crop–Livestock Systems in the Dry Savannas of West and Central Africa, IITA, Ibadan, Nigeria, pp.112-126.

Karnuah, A.B., Osei-Amponsah, R., Dunga, G., Wennah, A., Wiles, W.T. and Boettcher, P. (2018). Phenotypic characterization of the West Africa dwarf goats and the production system in Liberia. International Journal of Livestock Production, 9(9): 221-231.

Keir, B., Van Lai, N., Preston, T.R. and Orskov, E.R. (1997). Nutritive value of leaves from tropical trees and shrubs: 1 In vitro gas production and in sacco rumen degradability. Livestock Research for Rural Development, 9(4): 24-30.

Koney, E.B.M. (2004). Livestock Production and Health in Ghana. Second Edition AHPD, Accra. pp. 94 – 110.

Konlan, S.P. (2010). Shea Nut cake in supplemental concentrate for growing djallonke rams fed a basal diet of rice straw and groundnut haulms in the dry season. Masters Thesis in Animal Science, Department of Animal Science, K.N.U.S.T., Ghana. http://ir.knust.edu.gh/handle/123456789/430

Konlan, S.P. (2018). Availability and utilization of feed resources in small ruminant production among smallholder farmers in northern Ghana. PhD thesis, Department of Animal Science, University for Development Studies, Ghana. http://41.66.217.101/handle/123456789/2064

Konlan, S.P., Karikari, P.K. and Ansah, T. (2012). Productive and blood indices of dwarf rams fed a mixture of rice straw and groundnut haulms alone or supplemented with concentrates containing different levels of shea nut cake. Pakistan Journal of Nutrition, 11(6): 566-571. http://udsspace.uds.edu.gh/handle/123456789/559

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

Kral, I. and Suchý, P. (2000). Haematological studies in adolescent breeding cocks. Acta Veterinaria Brno, 69(3):189-194. https://actavet.vfu.cz/media/pdf/avb_2000069030189.pdf

Lamidi, A.A. and Ologbose, F.I. (2014). Dry season feeds and feeding: a threat to sustainable ruminant animal production in Nigeria. Journal of Agriculture and Social Research (JASR), 14(1): 17-30.

Lampe, M.A., Burlingame, A.L., Whitney, J., Williams, M.L., Brown, B.E., Roitman, E. and Elias, P.M. (1983). Human stratum corneum lipids: characterization and regional variations. Journal of Lipid Research, 24(2): 120-130.

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(1): 43-47.

Latimer, K.S., Mahaffey, E.A. and Prasse, K.W. (2003). Veterinary laboratory medicine. Clinical Pathology, 4: 149-156.

Lawa, E.D.W., Marjuki, M., Hartutik, H. and Chuzaemi, S. (2017). Effect of white kabesak (Acacia leucophloea Roxb) leaves level in the diet on feed intake and body weight gain of Kacang goat. Journal of Indonesian Tropical Animal Agriculture, 42(4): 255-262.

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, Ilugun area of Ogun State, south-west Nigeria. African Journal of Pharmacy and Pharmacology, 3(4): 222-226.

Lehninger, A.L., Nelson, D.L. and Cox, M.M. (2005). Lehninger Principles of Biochemistry. Macmillan.

León, M., Martínez S.J., Pedraza, R.M. and González, C.E. (2012). Indicators of chemical composition and in vitro digestibility of 14 tropical forages. Rev. Prod. Anim., 24(1): 1-5.

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

Lesseps, R. and Chipanda T. (1995). International Workshop on "Nitrogen Fixing Trees for Fodder production.

Lombardi, G. (2005). Optimum management and quality pastures for sheep and goat in mountain areas. Options Méditerranéennes, 67: 19-29. http://om.ciheam.org/om/pdf/a67/06600015.pdf

Luo, Y.W. and Xie, W.H. (2013). Effect of different processing methods on certain antinutritional factors and protein digestibility in green and white faba bean (Vicia faba L.). CyTA-Journal of Food, 11(1): 43-49.

Madalla, N. (2008). Novel feed ingredients for Nile tilapia (Oreochromis niloticus L.). PhD Thesis, Institute of Aquaculture, University of Stirling, Scotland, United Kingdom. http://hdl.handle.net/1893/795

Mahama, C. (2012). Farm animals are vital to Ghana's food secure future, Modern Ghana Multimedia Group. Modern Ghana. Accessed October 2020.

http://www.modernghana.com/news/404595/1/**farm-animals**-are-**vital**-to-ghanas-**food-secure**-futur.html

Makkar, H.P.S. (2003). Effects of fate of tannins in ruminant animals, adaptation to tannins, and strategies to overcome detrimental effects of feeding tannin-rich feeds. Small Rumin. Res., 49: 241-256.

Mamer, J.T.D. (2017). Evaluation of the nutritive value of selected South Sudan rangeland browses fed to crossbred growing goats. Masters Thesis, Faculty of Agriculture, Egerton University, Kenya. http://41.89.96.81:8080/xmlui/handle/123456789/1478

Mandal, P., Babu, S.S. and Mandal, N.C. (2005). Antimicrobial activity of saponins from Acacia auriculiformis. Fitoterapia, 76(5): 462-465.

Maner, B.S. and Moosavi, L. (2020). Mean corpuscular volume (MCV). In: StatPearls. Treasure Island (FL), StatPearls Publishing. Available from: https://www.ncbi.nlm.nih.gov/books/NBK545275/

Mc Donald, P., Edward, R.A., Green Halgh, J.F.D. and Morgan, G.A. (2002). Animal Nutrition 6th Edn., Pearson Educational limited. Edinburgh, Great Britain. Pp. 544.

Merck Manual, (2012). Hematologic and serum biochemical reference ranges. Merck Veterinary manual. Merck Manuals.com. https://www.msdvetmanual.com/

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

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

Minson, D.J. (1990). Forage in Ruminant Nutrition, Academic Press Inc., San Diego, U S A. Pp. 483 – 484.

Mirzadeh, K., Tabatabaei, S., Bojarpour, M. and Mamoei, M. (2010). Comparative study of haematological parameters according to strain, age, sex, physiological status and season in Iranian cattle. Journal of Animal and Veterinary Advances, 9(16): 2123-2127.

Mondal, K. and Payra, P. (2015). A review on use of plant protein sources in diets for fish feed formulation. Journal of International Academic Research for Multidisciplinary, 3(5): 257-264.

Morais, M.J., Sevilla, C.C., Dizon, J.T., Manulat, G.L., Abes, E.E.C. and Angeles, A.A. (2018). Growth performance and ruminal metabolic variables of goats fed rain tree (Samanea saman) pods. Tropical Animal Science Journal, 41(1): 22-28.

Mubarak, A.E. (2005). Nutritional composition and antinutritional factors of mung bean seeds (Phaseolus aureus) as affected by some home traditional processes. Food Chemistry, 89(4): 489-495.

Muir, J.P., Pitman, W.D., Dubeux Jr, J.C. and Foster, J.L. (2014). The future of warm-season, tropical and subtropical forage legumes in sustainable pastures and rangelands. African Journal of Range and Forage Science, 31(3): 187-198.

Mukandiwa, L., Mugabe, P.H., Halimani, T.E. and Hamudikuwanda, H. (2010). A note on the effect of supplementing rangeland grazing with Acacia angustissima mixed with pearl millet on growth performance of goats in a smallholder farming area in Zimbabwe. Livestock Research for Rural Development, 22: Article #9. http://www.lrrd.org/lrrd22/1/muka22009.htm

Mukhopadhyay, N. and Ray, A.K. (2005). Effect of fermentation on apparent total and and nutrient digestibility of linseed, Linum usitatissimum, meal in rohu, Labeo rohita, fingerlings. Acta Ichthyologica et Piscatoria, 2(35). https://www.infona.pl/resource/bwmeta1.element.agro-article-f3c73e1d-0f61-4563-89bd-c371b9afff26

National Research Council, (1991). Microlivestock: Little-known small animals with a promising economic future. National Academy Press, Washington, DC. 33 – 45.

Naskalski, J.W., Kusnierz-Cabala, B., Kędra, B., Dumnicka, P., Panek, J. and Maziarz, B. (2007). Correlation of peripheral blood monocyte and neutrophil direct counts with plasma inflammatory cytokines and TNF-α soluble receptors in the initial phase of acute pancreatitis. Advances in Medical Sciences (De Gruyter Open), 52, p129-134.

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, Latin America.

Ndlovu, T., Chimonyo, M., Okoh, A.I., Muchenje, V., Dzama, K. and Raats, J.G. (2007). Assessing the nutritional status of beef cattle: current practices and future prospects. African Journal of Biotechnology, 6(24): 2727-2734. https://www.ajol.info/index.php/ajb/article/download/58187/46550

Ngodigha, E.M. and Oji, U.I. (2009). Evaluation of fodder potential of some tropical browse plants using fistulated Ndama cattle. African Journal of Agricultural Research, 4(3): 241-246.

Niayale, R. (2017). Effects of ensiling cassava peels on some fermentation characteristics and the growth performance of djallonke sheep on-farm. MPhil Thesis, Department of Animal Science, University for Development Studies, Tamale, Ghana. http://hdl.handle.net/123456789/1236

Njidda, A.A., Olafadehan, A.A., Japhet, N., Omole, O.A. and Ofem, B.B. (2018). The effect of substituting cowpea husk with Daniellia oliveri foliage on the performance of red Sokoto goat. Nigeria Agricultural Journal, 49(1): 1-10.

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 (National Research Council), (2000). Nutrient Requirements of Beef Cattle (7th Ed.). National Academy Press, Washington, DC. 248.

Nsoh, M.A. (2019). Nutritional evaluation of three browse species commonly fed to small ruminants by farmers in the Accra Plains of Ghana. MPhil Thesis, Department of animal Science, University of Ghana, Ghana.

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): 773-779.

Nuru, S. (1985). Trends in small animal production. Proceedings of Small Ruminant Production, 6(10): 35-40.

Nwokoro, S.O., Adegunloye, H.D. and Ikhinmwin, A.F. (2005). Nutritional composition of garri sievates collected from some locations in Southern Nigeria. Pakistan J. Nutr., 4 (4): 257-261.

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 pods. African Journal of Pure and Applied Chemistry, 4(9): 206-212.

Obe, A.A. and Yusuf, K.O. (2017). Performance of West African dwarf goats fed Agro-industrial by-products and Pennisetum purpureum hay as dry season feed. Nigerian Journal of Animal Production, 44(2): 152-160.

Obese, F.Y. (1994). A study on the effects of diets containing varying levels of cocoa pod husk (CPH) and 5% NaOH-treated corn cob on the growth and reproductive performance of confined djallonke sheep. Masters Thesis, Department of Animal Science, K.N.U.S.T., Ghana. http://hdl.handle.net/123456789/3483

Obese, F.Y., Dwumah, K., Adjorlolo, L.K. and Ayizanga, R.A. (2018). Effects of feed supplementation on growth, blood parameters and reproductive performance in Sanga and Friesian-Sanga cows grazing natural pasture. Tropical Animal Health and Production, 50(8): 1739-1746.

Obese, F.Y., MacCarthy, C., Osei-Amponsah, R., Ayizanga, R.A. and Damptey, J.K. (2015). Blood Metabolite Profiles in Cycling and Non-cycling Friesian–Sanga Cross-bred Cows Grazing Natural Pasture During the Post-partum Period. Reproduction in Domestic Animals, 50(2): 304-311.

Oboh, G. (2006). Nutrient enrichment of cassava peels using a mixed culture of Saccharomyces cerevisae and Lactobacillus spp. solid media fermentation. Electronic Journal of Biotechnology, 9 (1): 46-49.

Obour, R., Oppong, S.K. and Abebrese, I.K. (2015). Forage palatability of Broussonetia papyrifera an invasive species in Ghana: Relative preference and palatability by sheep and goats. Journal of Energy and Natural Resource Management, 2: 63 – 70.

Ocheja, J., Ayoade, J.A., Attah, S., Okwori, A.I., Ocheni, J. and Oyibo, A. (2016). Blood Parameters and Organ Weights of Growing West African Dwarf Goats Fed Diets Containing

Graded Levels of Steam Treated Cashew Nut Shell. American Journal of Food Science and Health, 2(4): 60-64. http://files.aiscience.org/journal/article/pdf/70160038.pdf

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. Sci. Res. Essay, 3(11): 562-4.

Oduye, O.O. and Adadevoh, B.K. (1976). Biochemical values of apparently normal Nigerian Sheep. Nigerian Veterinary Journal, 5(1): 43-50.

Offoh, I.A. (2011). The effect of supplementing Samanea saman pods and Moringa Oleifera leaves in the diet of sheep under semi-intensive system of management. BSc. Agriculture Dissertation, Department of Animal Science, K.N.U.S.T., Ghana.

Ojeda, A., Barroso, J.A., Obispo, N., Gil, J.L. and Cegarra, R. (2012). Chemical composition, in vitro gas production and astringency in the foliage of Samanea saman (Jacq.) Merrill. Pastures and Forages, 35(2): 205-218.

Okantah, S., Aboe, P., Boa-Amponsem, K., Dorward, P. and Bryant, M. (2006). Small-scale poultry production in peri-urban areas in Ghana. Pp.11. In: Small stock in development: Proceedings of a workshop on enhancing the contribution of small livestock to the livelihoods of resource-poor communities, Natural Resources International, 15-19 November, 2004, Hotel Brovad, Masaka, Uganda.

Okeke, G.C. and Oji, U. (1988). The nutritive value of grass ensiled with cassava peel and poultry excreta for goats. In Smith, O.B., Bosman, H.G. Proceedings of Workshop on Goat Production in the Humid Tropics (pp. 101-106). Obafemi Awolowo University, Ile-Ife, Nigeria.

Okoli, C.O., Akah, P.A. and Okoli, A.S. (2007). Potentials of leaves of Aspilia africana (Compositae) in wound care: an experimental evaluation. BMC Complementary and Alternative Medicine, 7(1) :24.

Okoruwa, M.I. (2019). Feed intake, relative preference index, rumen digestion kinetics, nutrient digestibility and lve weight change of goats fed selected browse plants. Livestock Research for Rural Development, 31: Article #52. http://www.lrrd.org/lrrd31/4/odion31052.html

Okoruwa, M.I. (2020). The effect of feeding leguminous tree foliages on performance of goats fed basal diets of grass and crop residues. Livestock Research for Rural Development, 32: Article #119. http://www.lrrd.org/lrrd32/7/odion32119.html

Okoruwa, M.I. and Ikhimioya, I. (2020). Influence of browse-tree leaves supplementation on digestibility, rumen fermentation and performance of goats fed mixed grass hay. Livestock Research for Rural Development, 32: Article #93. http://www.lrrd.org/lrrd32/6/odion32093.html

Okpara, O., Akporhuarho, P.O. and Okagbare, G.O. (2014). Determination of browse intake and nutrient digestibility of grazing West African dwarf (WAD) goats fed varying levels of Gmelina arborea leaves as supplements in Delta State Nigeria. International Journal of Animal and Veterinary Advances, 6(2): 52-57.

Olanipekun, B.F., Otunola, E.T. and Oyelade, O.J. (2015). Effect of fermentation on antinutritional factors and in vitro protein digestibility of Bambara nut (Voandzeia subterranean L.). Food Sci. Qual. Manag., 39, pp. 98-112.

Olanipekun, O.T., Omenna, E.C., Olapade, O.A., Suleiman, P. and Omodara, O.G. (2015). Effect of boiling and roasting on the nutrient composition of kidney beans seed flour. Sky J. Food Scis, 4(2): 24-29.

Olorunnisomo, O.A. (2011). Elephant grass silage as dry season feed for goats: effect of cassava peel inclusion on performance and digestibility of the mixture. Tropical Animal Production Investigation, 14(1): 36-39.

Omachi, O.J., Babawuro, Y., Adewale, B.O. and Noah, G.P. (2019). Evaluation of Bye-Products of Carcass of West African Dwarf Goats Fed Diets Containing Graded Levels of Steam-Treated Cashew Nut Shell. Technology, 3(4): 48-51.

Onasanya, G.O., Oke, F.O., Sanni, T.M. and Muhammad, A.I. (2015). Parameters influencing haematological, serum and bio-chemical references in livestock animals under different management systems. Open Journal of Veterinary Medicine, 5(08): 181.

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

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

Oppong-Anane, K. (2011). Ghana livestock review report. Food and Agriculture Organisation (FAO), Rome, Italy.

Oppong-Anane, K. (2013). Cassava as animal feed in Ghana: Past, present and future. In: Berhanu B., Cheikh L. Y., Harinder, P. and Makkar, S. (Eds.) FAO, Accra, Ghana. Pp. 05–10.

Oppong–Annane, K. (2008). Report submitted to the Ministry of Food and Agriculture (MoFA) on Livestock growth trends.

Osafo, E.L.K., Antwi, C., Donkoh, A. and Adu-Dapaah, H. (2013). Feeding graded levels of an improved cultivar of cowpea haulm as supplement for rams fed maize stover diet. International Journal of Agricultural Research, 8(2): 87-93.

Osei, S. A. and Twumasi, I. K. (1989). Effects of oven-dried cassava peel meal on the performance and carcass characteristics of broiler chickens. Anim. Feed Sci. Technol., 24(3-4): 247–252.

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, Ghana.

Osuga, I.M., Wambui, C.C., Abdulrazak, S.A., Ichinohe, T. and Fujihara, T. (2008). Evaluation of nutritive value and palatability by goats and sheep of selected browse foliages from semiarid area of Kenya. Animal Science Journal, 79(5): 582-589.

Osuji, P.O., Fernandez-Rivera, S. and Odenyo, A. (1995). Improving fibre utilization and protein supply in animals fed poor quality roughages: ILRI nutrition research and plans. In: Wallace, R. J. and Lahlou-Kassi, A. (ed.). Rumen Ecology/Research Planning. Proceedings of a Workshop Held at ILRI. Addis Ababa, Ethiopia. Pp. 1 – 22.

Owen-Smith, N. and Cooper, S.M. (1987). Palatability of woody plants to browsing ruminants in a South African savanna. Ecology, 68(2): 319-331.

Özsoy, B., Yalçın, S., Erdoğan, Z., Cantekin, Z. and Aksu, T. (2013). Effects of dietary live yeast culture on fattening performance on some blood and rumen fluid parameters in goats. Revue Méd. Vét, 164(5): 263-271.

Peacock, C. (2005). Goats - A pathway out of poverty. Small Ruminant Research, 60(1-2): 179-186.

Pedraza, RM, La, O., Estévez, J., Guevara, G. and Martínez, S. (2003). Effective ruminal degradability and in vitro intestinal digestibility of nitrogen from the foliage of tropical tree legumes. Pastures and Forages, 26 (3): 237.

Preston, T.R. and Leng, R.A. (1987). Matching ruminant production systems with available resources in the tropics and sub-tropics. Penambul Books, Armidale, Australia. Pp. 265.

PROTA, (2016). PROTA4U web database. Wageningen, Netherlands: Plant Resources of Tropical Africa. http://www.prota4u.org/search.asp

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

Rahman, M.Z., Akbar, M.A., Hossain, M.A. and Ali, M.Y. (2015). Effect of tree forage supplementation on growth performance of goats. Asian Journal of Medical and Biological Research, 1(2): 209-215.

Rastogi, S.K. (2008). Renal effects of environmental and occupational lead exposure. Indian Journal of Occupational and Environmental Medicine, 12(3): 103–106. https://doi.org/10.4103/0019-5278.44689

Reddy, D.V. and Elanchezhian, N. (2008). Evaluation of tropical tree leaves as ruminant feedstuff based on cell contents, cell wall fractions and polyphenolic compounds. Cellulose (ADF-ADL), 14(21-58): 17-52.

Reece, W.O. and Swenson, M.J. (2004). The composition and functions of blood. In: Reece, W.O. (ed). Duke's Physiology of Domestic Animals, 12th ed., Comstock Publishing Associates, Cornell University Press. Ithaca and London. Pp. 26-51.

Rinehart, L. (2006). Switchgrass as a bioenergy crop. National Center for Appropriate Technology, Available online at: http://attra. ncat. org/attra-pub/PDF/switchgrass. pdf.

Rogosic, J., Estell, R.E., Ivankovic, S., Kezic, J. and Razov, J. (2008). Potential mechanisms to increase shrub intake and performance of small ruminants in Mediterranean shrubby ecosystems. Small Ruminant Research, 74(1-3): 1-15.

Roncallo, B., Torres, E. and Sierra, M. (2009). Production of dual-purpose cows supplemented with locust beans (Pithecellobium saman) during the rains. In: FAO Electronic Conference on Agroforestry for Animal Production, Latin America (Agrofor), Rome (Italy) (Aug 2000 - Mar 2001). Pp. 257-269.

Sadat, S. (2015). Reproductive performance of Djallonké sheep in the Northern Region of Ghana. MPhil Thesis, Department of Animal Science, K.N.U.S.T., Ghana.

Salami, R. I., Odunsi, A. A. (2003). Evaluation of processed cassava peel meals as substitutes for maize in the diets of layers. Int. J. Poult. Sci., 2(2): 112-116.

Salami, R.I. and Odunsi, A.A. (2017). Blood profile of broiler chickens fed varying levels of crude fibre and energy in multi-fibre source-based diets without enzyme supplementation. Nigerian Journal of Animal Production, 44(2): 86-95.

Salem, A.Z.M., 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.

Samour, J. (2006). Diagnostic value of hematology. Clinical Avian Medicine, 2, pp.587-609.

Sampaio, C.B., Detmann, E., Valente, T.N.P., Souza, M.A.D., Valadares Filho, S.D.C. and Paulino, M.F. (2011). Evaluation of fecal recovering and long-term bias of internal and external markers in a digestion assay with cattle. Revista Brasileira de Zootecnia, 40(1): 174-182.

Sarkwa, F.O., Adogla-Bessa, T., Timpong-Jones, E.C. and Adjorlolo, L.K. (2011), July. Preliminary assessment of the nutritional value of eight browse species in the Coastal Savanna. In Proceedings of the XVII Biennial Conference of the Ghana Society of Animal Production, University of Ghana, Ghana.

Sarma, P.R. (1990). Red Cell Indices. In: Walker HK, Hall WD, Hurst JW, editors. Clinical Methods: The History, Physical, and Laboratory Examinations. 3rd edition. Boston: Butterworths; 152. Available from: https://www.ncbi.nlm.nih.gov/books/NBK260/

Schalm, O.W., Jain, N.C. and Carroll, E.J. (1975). Veterinary haematology 3rd ed. Lea and Febiger Philadelphia, pp.324-335.

Schmidt, L.H. (2008). Samanea saman (Jacquin) Merrill. Seed Leaflet, (143).

Sharifi, M., Naserian, A.A. and Khorasani, H. (2013). Effect of tannin extract from pistachio by product on in vitro gas production. Iranian Journal of Applied Animal Science, 3(4): 667-671. https://www.sid.ir/en/journal/ViewPaper.aspx?ID=364012

Silva Inácio, D.F., de Rezende, A.S.C., Saliba, E.D.O.S., Silva, R.H.P., Maruch, S., Lana, Â.M.Q. and Ralston, S.L. (2017). Dry matter intake and apparent digestibility of nutrients in the ration of Mangalarga Marchador weanling horses fed sorghum silage versus grass hay. Journal of Equine Veterinary Science, 49, pp. 87-91.

Singh, R., Singh, S., Kumar, S. and Arora, S. (2007). Evaluation of antioxidant potential of ethyl acetate extract/fractions of Acacia auriculiformis A. Cunn. Food and Chemical Toxicology, 45(7): 1216-1223.

Singh, S.K. and Afroz, N. (2017). Examining the effect of an aerobic exercise program on stress and triglycerides level in sedentary students. International Journal of Occupational Safety and Health, 7(2): 17-21.

Smith, O.B. (1992), November. A review of ruminant responses to cassava-based diets. In Proceedings of IITA/ILCA/UI workshop on potential utilization of cassava as a livestock feed in Africa, Ibadan, Nigeria.

Sonibare, M.O., Isiaka, A.O., Taruka, M.W., Williams, N.S., Soladoye, M. and Emmanuel, O. (2006). Constituents of Ficus exasperata leaves. Natural Product Communications, pp. 23-26.

Song, B., Wu, T., You, P., Wang, H., Burke, J. L., Kang, K. and Sun, X. (2021). Dietary Supplementation of Yeast Culture into Pelleted Total Mixed Rations Improves the Growth Performance of Fattening Lambs. Frontiers in veterinary science, 8, 387.

Staples, G.W. and Elevitch, C.R. (2006). Samanea saman (rain tree). Species Profile for Pacific Island agroforestry. http://www.traditionaltree.org/

Starr, F., Starr, K. and Loope, L. (2003). Acacia auriculiformis. Plants of Hawaii Reports. http://www.citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.608.2853&rep=rep1&type=pdf

Tadesse, D., Urge, M., Animut, G. and Mekasha, Y. (2016). Growth and carcass characteristics of three Ethiopian indigenous goats fed concentrate at different supplementation levels. SpringerPlus, 5(1): 414.

Tagoe, F. (2011). Evaluation of the chemical composition of Moringa leaves, Samanea saman pods and Napier grass. BSc. Agriculture Dissertation, Department of Animal Science, K.N.U.S.T., Ghana.

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

Tedeschi, L.O., Molle, G., Menendez, H.M., Cannas, A. and Fonseca, M.A. (2019). The assessment of supplementation requirements of grazing ruminants using nutrition models. Translational Animal Science, 3(2): 811-828.

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.

Tewe, O.O. (2004). The global cassava development strategy: Cassava for livestock feed in Sub-Saharan Africa. IFAD and FAO, Rome, Italy.

Tewe, O.O. (1992). Detoxification of cassava products and effects of residual toxins on consuming animals. In: Machin, D., Nyvold, S. (1992). Roots, tubers, plantains and bananas in animal feeding. Proceedings of the FAO Expert Consultation held in CIAT, Cali, Colombia, 21–25 January 1991; FAO Animal Production and Health. Pp. 95.

Thole, N.S., Joshi, A.L. and Rangnekar, D.V. (1992). Nutritive evaluation of rain tree (Samanea saman) pods. Indian Journal of Animal Sciences, 62(3): 270-272.

Tietz, N.W. (1976). Fundamentals of Chemistry. W.B. Saunders Co.: Philadelphia. 496– 498.

Traiyakun, S., Harakord, W., Yuangklang, C. and Paengkoum, P. (2011). Leucaena leucocephala meal as replacement to soybean meal in growing goat diets. J. Agric. Sci. Technol., 1: 1150-1154.

Trinh Phuc Hao, Ho Quang Do, Preston, T.R. and Leng, RA. (2009). Nitrate as a fermentable nitrogen supplement for goats fed forage based diets low in true protein. Livestock Research for Rural Development. 21, Article #10. Retrieved October 25, 2020, from http://www.lrrd.org/lrrd21/1/trin21010.htm

Trinh, T. H. N. and Wanapat, M. (2012). Effect of mangosteen peel, garlic and urea pellet supplementation on rumen fermentation and microbial protein synthesis of beef cattle. Agricultural Journal, 7(2): 95-100.

Turkson, P.K. and Ganyo, E.Y. (2015). Relationship between haemoglobin concentration and packed cell volume in cattle blood samples. Onderstepoort Journal of Veterinary Research, 82(1): Article #863, pp. 1-5. http:// dx.doi.org/10.4102/ojvr. v82i1.863

Ubalua, A. O. (2007). Cassava wastes: treatment options and value addition alternatives. Afr. J. Biotech., 6 (18): 2065-2073.

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.

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

Van, D.T.T. (2006). Some animal and feed factors affecting feed intake, behaviour and performance of small ruminants. PhD Thesis, Department of Animal Nutrition and Management, Swedish University of Agricultural Sciences, Uppsala. http://urn.kb.se/resolve?urn=urn:nbn:se:slu:epsilon-1027

Vijayakumari, K., Pugalenthi, M. and Vadivel, V. (2007). Effect of soaking and hydrothermal processing methods on the levels of antinutrients and in vitro protein digestibility of Bauhinia purpurea L. seeds. Food Chemistry, 103(3): 968-975.

VSN International, (2009). GenStat for Windows, 12th Edition. VSN International, Hemel Hempstead, UK. Web page: GenStat.co.uk.

Wanapat, M., Kang, S. and Polyorach, S. (2013). Development of feeding systems and strategies of supplementation to enhance rumen fermentation and ruminant production in the tropics. Journal of Animal Science and Biotechnology, 4(1): 1-11.

Wang, N., Hatcher, D.W., Toews, R. and Gawalko, E.J. (2009). Influence of cooking and dehulling on nutritional composition of several varieties of lentils (Lens culinaris). LWT-Food Science and Technology, 42(4): 842-848.

APPENDICES

Appendix 1: Analysis of variance for acceptability studies

Source of variation	d.f	s.s	m.s.	v.r.	F. pr.
Treatment	3	912968.19	304322.73	10102.29	<0.001
Residual	276	8314.26	30.12		
Total	279	921282.45			

Appendix 2: Analysis of variance for dry matter intake

Source of variation	d.f.	s.s	m.s.	v.r.	F. pr
Subject stratum					
Treatment	3	1620603.9	540201.3	2.72	0.084
Residual	14	2778809.1	198486.4	248.91	
Subject. Time stratum d.f. correction factor 0.0683					
Time	82	2948801.3	35961.0	45.10	<.001
Time. Treatment	246	417175.2	1695.8	2.13	0.014
Residual	1148	915424.1	797.4		
Total	1493	8680813.6			

Appendix 3: Analysis of variance for organic matter intake

Source of variation	d.f.	s.s	m.s.	v.r.	F. pr
Subject stratum					
Treatment	3	1220744.6	406914.9	2.43	0.109
Residual	14	2346544.9	167610.3	247.58	
Subject. Time stratum d.f. correction factor 0.0683					
Time	82	2503467.4	30530.1	45.10	<.001
Time. Treatment	246	354172.5	1439.7	2.13	0.014
Residual	1148	777174.9	677.0		
Total	1493	7202104.3			

Appendix 4: Analysis of variance for crude protein intake

Source of variation	d.f.	s.s	m.s.	v.r.	F. pr
Subject stratum					
Treatment	3	43807.787	14602.596	5.44	0.011
Residual	14	37594.502	2685.322	876.06	
Subject. Time stratum d.f. correction factor 0.0683					
Time	82	11335.192	138.234	45.10	<.001
Time. Treatment	246	1603.621	6.519	2.13	0.014
Residual	1148	3518.890	3.065		
Total	1493	97859.992			

Appendix 5: Analysis of variance for neutral detergent fibre intake

Source of variation	d.f.	s.s	m.s.	v.r.	F. pr
Subject stratum					
Treatment	3	53800	17930	1.70	0.212
Residual	14	147300	10520	253300	
Subject. Time stratum d.f. correction factor 0.0683					
Time	82	153.6	1.874	45.10	<.001
Time.Treatment	246	21.73	0.08835	2.13	0.014
Residual	1148	47.69	0.04154		
Total	1493	201300			

Appendix 6: Analysis of variance for acid detergent fibre intake

Source of variation	d.f.	s.s	m.s.	v.r.	F. pr
Subject stratum					
Treatment	3	177600	59180	13.76	<.001
Residual	14	60200	4300	284800	
Subject. Time stratum d.f. correction factor 0.0683					
Time	82	55.82	0.06808	45.10	<.001
Time. Treatment	246	7.898	0.03210	2.13	0.014
Residual	1148	17.33	0.01510		
Total	1493	237800			

Appendix 7: Analysis of variance for lignin intake

Source of variation	d.f.	s.s	m.s.	v.r.	F. pr
Subject stratum					
Treatment	3	30590	10200	2.33	0.119
Residual	14	61390	4385	290500	
Subject. Time stratum d.f. correction factor 0.0683					
Time	82	55.82	0.6808	45.10	<.001
Time. Treatment	246	7.898	0.03210	2.13	0.014
Residual	1148	17.33	0.01510		
Total	1493	92060			

Appendix 8: Analysis of variance for dry matter digestibility

Source of variation	d.f.	s.s	m.s	v.r.	F. pr.
Treatment	3	693.66	231.22	4.73	0.012
Residual	20	977.01	48.85		
Total	23	1670.67			

Appendix 9: Analysis of variance for organic matter digestibility

Source of variation	d.f.	s.s	m.s	v.r.	F. pr.
Treatment	3	726.91	242.30	4.21	0.018
Residual	20	1150.47	57.52		
Total	23	1877.38			

Appendix 10: Analysis of variance for crude protein digestibility

Source of variation	d.f.	s.s	m.s	v.r.	F. pr.
Treatment	3	288.74	96.25	8.65	<0.001
Residual	20	222.66	11.13		
Total	23	511.41			

Appendix 11: Analysis of variance for neutral detergent fibre digestibility

Source of variation	d.f.	s.s	m.s	v.r.	F. pr.
Treatment	3	264.40	88.13	8.13	<0.001
Residual	20	216.90	10.85		
Total	23	481.30			

Appendix 12: Analysis of variance for acid detergent fibre digestibility

Source of variation	d.f.	s.s	m.s	v.r.	F. pr.
Treatment	3	213.15	71.05	6.29	<0.004
Residual	20	226.03	11.30		
Total	23	439.18			

Appendix 13: Analysis of variance for initial body weight

Source of variation	d.f.	s.s	m.s	v.r.	F. pr.
Treatment	3	11.425	3.808	0.97	0.436
Residual	14	55.200	3.943		
Total	17	66.625			

Appendix 14: Analysis of variance for final body weight

Source of variation	d.f.	s.s	m.s	v.r.	F. pr.
Treatment	3	10.525	3.508	1.06	0.399
Residual	14	46.475	3.320		
Total	17	57.000			

Appendix 15: Analysis of variance for average daily gain

Source of variation	d.f.	s.s	m.s	v.r.	F. pr.
Treatment	3	36.29	12.10	0.62	0.612
Residual	14	272.17	19.44		
Total	17	308.46			

Appendix 16: Analysis of variance for feed conversion ratio

Source of variation	d.f.	s.s	m.s	v.r.	F. pr.
Treatment	3	1345.1	448.4	1.25	0.330
Residual	14	5031.3	359.4		
Total	17	6376.4			

Appendix 17: Analysis of variance for dressing percentage

Source of variation	d.f.	s.s	m.s	v.r.	F. pr.
Treatment	3	54.59	18.20	0.87	0.526
Residual	4	83.57	20.89		
Total	7	138.16			

Appendix 18: Analysis of variance for Spleen

Source of variation	d.f.	s.s	m.s	v.r.	F. pr.
Treatment	3	0.0040	0.0013	0.19	0.900
Residual	4	0.029	0.0071		
Total	7	0.033			

Appendix 19: Analysis of variance for Lungs

Source of variation	d.f.	s.s	m.s	v.r.	F. pr.
Treatment	3	0.047	0.016	0.30	0.823
Residual	4	0.209	0.052		
Total	7	0.256			

Appendix 20: Analysis of variance for Liver

Source of variation	d.f.	s.s	m.s	v.r.	F. pr.
Treatment	3	0.091	0.030	0.52	0.691
Residual	4	0.232	0.058		
Total	7	0.323			

Appendix 21: Analysis of variance Kidney

Source of variation	d.f.	s.s	m.s	v.r.	F. pr.
Treatment	3	0.0137	0.0046	0.25	0.860
Residual	4	0.0741	0.0185		
Total	7	0.0878			

Appendix 22: Analysis of variance for Heart

Source of variation	d.f.	s.s	m.s	v.r.	F. pr.
Treatment	3	0.002	0.001	0.05	0.982
Residual	4	0.061	0.015		
Total	7	0.064			

Appendix 23: Analysis of variance for haemoglobin

Source of variation	d.f.	s.s	m.s.	v.r.	F. pr
Subject stratum					
Treatment	3	1.304	0.435	1.47	0.265
Residual	14	4.132	0.295	8.82	
Subject. Time stratum d.f. correction factor 0.6559					
Time	4	26.262	6.566	196.19	<0.001
Time. Treatment	12	0.700	0.058	1.74	0.122
Residual	56	1.874	0.033		
Total	89	34.273			

Appendix 24: Analysis of variance for PCV

Source of variation	d.f.	s.s	m.s.	v.r.	F. pr
Subject stratum					
Treatment	3	164.070	54.690	1.19	0.350
Residual	14	645.230	46.088	6.51	
Subject. Time stratum d.f. correction factor 0.6773					
Time	4	216.778	54.194	7.65	<0.001
Time. Treatment	12	85.902	7.159	1.01	0.455

Residual	56	396.520	7.081		
Total	89	1508.500			

Appendix 25: Analysis of variance for RBC

Source of variation	d.f.	s.s	m.s.	v.r.	F. pr
Subject stratum					
Treatment	3	53.220	17.740	1.19	0.351
Residual	14	209.578	14.970	5.15	
Subject. Time stratum d.f. correction factor 0.7382					
Time	4	150.602	37.650	12.96	<0.001
Time. Treatment	12	68.301	5.692	1.96	0.071
Residual	56	162.648	2.904		
Total	89	644.347			

Appendix 26: Analysis of variance for WBC

Source of variation	d.f.	s.s	m.s.	v.r.	F. pr
Subject stratum					
Treatment	3	3.429	1.143	0.14	0.934
Residual	14	114.451	8.175	2.03	
Subject. Time stratum d.f. correction factor 0.7355					
Time	4	659.677	164.919	40.95	<0.001
Time. Treatment	12	67.288	5.607	1.39	0.224
Residual	56	225.543	4.028		
Total	89	1070.389			

Appendix 27: Analysis of variance for Neutrophils

Source of variation	d.f.	s.s	m.s.	v.r.	F. pr
Subject stratum					
Treatment	3	655.48	218.49	1.82	0.189
Residual	14	1676.22	119.73	2.05	
Subject. Time stratum d.f. correction factor 0.4705					
Time	4	587.40	146.85	2.52	0.103
Time. Treatment	12	443.32	36.94	0.63	0.693
Residual	56	3264.48	58.29		
Total	89	6626.90			

Appendix 28: Analysis of variance for Lymphocytes

Source of variation	d.f.	s.s	m.s.	v.r.	F. pr
Subject stratum					
Treatment	3	484.25	161.42	1.16	0.360
Residual	14	1948.15	139.15	2.54	
Subject. Time stratum d.f. correction factor 0.4815					
Time	4	247.49	61.87	1.13	0.336
Time. Treatment	12	355.71	29.64	0.54	0.767
Residual	56	3070.00	54.82		
Total	89	6105.60			

Appendix 29: Analysis of variance for Eosinophil

Source of variation	d.f.	s.s	m.s.	v.r.	F. pr
Subject stratum					
Treatment	3	21.829	7.276	2.63	0.091
Residual	14	38.760	2.769	1.68	
Subject. Time stratum d.f. correction factor 0.5655					
Time	4	39.622	9.906	5.99	0.005
Time. Treatment	12	23.038	1.920	1.16	0.352
Residual	56	92.540	1.653		
Total	89	215.789			

Appendix 30: Analysis of variance for Monocytes

Source of variation	d.f.	s.s	m.s.	v.r.	F. pr
Subject stratum					
Treatment	3	15.570	5.190	1.13	0.372
Residual	14	64.430	4.602	1.52	
Subject. Time stratum d.f. correction factor 0.5940					
Time	4	6.511	1.628	0.54	0.618
Time. Treatment	12	14.769	1.231	0.41	0.893
Residual	56	169.120	3.020		
Total	89	270.400			

Appendix 31: Analysis of variance for MCHC

Source of variation	d.f.	s.s	m.s.	v.r.	F. pr
Subject stratum					
Treatment	3	405.04	135.01	1.29	0.317
Residual	14	1465.47	104.68	5.71	
Subject. Time stratum d.f. correction factor 0.7112					
Time	4	1396.82	349.20	19.04	<0.001
Time. Treatment	12	260.94	21.75	1.19	0.331
Residual	56	1026.91	18.34		
Total	89	4555.19			

Appendix 32: Analysis of variance for MCV

Source of variation	d.f.	s.s	m.s.	v.r.	F. pr
Subject stratum					
Treatment	3	5.217	1.739	0.18	0.910
Residual	14	137.727	9.838	1.48	
Subject. Time stratum d.f. correction factor 0.6285					
Time	4	91.606	22.901	3.45	0.033
Time. Treatment	12	125.081	10.423	1.57	0.172
Residual	56	371.436	6.633		
Total	89	731.068			

Appendix 33: Analysis of variance for MCH

Source of variation	d.f.	s.s	m.s.	v.r.	F. pr
Subject stratum					
Treatment	3	24.694	8.231	1.21	0.344
Residual	14	95.535	6.824	3.96	
Subject. Time stratum d.f. correction factor 0.6457					
Time	4	101.226	25.306	14.69	<0.001
Time. Treatment	12	35.915	2.993	1.74	0.125
Residual	56	96.461	1.723		
Total	89	353.830			

Appendix 34: Analysis of variance for Total protein

Source of variation	d.f.	s.s	m.s.	v.r.	F. pr
Subject stratum					
Treatment	3	4.2767	1.4256	2.11	0.145
Residual	14	9.4655	0.6761	4.12	
Subject. Time stratum d.f. correction factor 0.7328					
Time	4	1.6762	0.4191	2.56	0.070
Time. Treatment	12	1.3078	0.1090	0.66	0.732
Residual	56	9.1800	0.1639		
Total	89	25.9062			

Appendix 35: Analysis of variance for Albumin

Source of variation	d.f.	s.s	m.s.	v.r.	F. pr
Subject stratum					
Treatment	3	0.350	0.117	0.79	0.519
Residual	14	2.064	0.147	7.80	
Subject. Time stratum d.f. correction factor 0.7791					
Time	4	0.808	0.202	10.69	<0.001
Time. Treatment	12	0.670	0.056	2.95	0.007
Residual	56	1.058	0.019		
Total	89	4.950			

Appendix 36: Analysis of variance for Globulin

Source of variation	d.f.	s.s	m.s.	v.r.	F. pr
Subject stratum					
Treatment	3	4.145	1.382	1.37	0.291
Residual	14	14.072	1.005	5.82	
Subject. Time stratum d.f. correction factor 0.7561					
Time	4	0.922	0.230	1.33	0.276
Time. Treatment	12	2.296	0.191	1.11	0.378
Residual	56	9.666	0.173		
Total	89	31.101			

Appendix 37: Analysis of variance for Cholesterol

Source of variation	d.f.	s.s	m.s.	v.r.	F. pr
Subject stratum					
Treatment	3	3254.29	1084.76	2.55	0.097
Residual	14	5944.09	424.58	8.42	
Subject. Time stratum d.f. correction factor 0.7714					
Time	4	804.02	201.01	3.99	0.013
Time. Treatment	12	686.73	57.23	1.13	0.360
Residual	56	2824.67	50.44		
Total	89	13513.81			

Appendix 38: Analysis of variance for Sodium

Source of variation	d.f.	s.s	m.s.	v.r.	F. pr
Subject stratum					
Treatment	3	897.2	299.1	0.70	0.568
Residual	14	5987.1	427.7	2.40	
Subject. Time stratum d.f. correction factor 0.6315					
Time	4	42985.5	10746.4	60.36	<0.001
Time. Treatment	12	1798.0	149.8	0.84	0.568
Residual	56	9970.6	178.0		
Total	89	61638.3			

Appendix 39: Analysis of variance for Potassium

Source of variation	d.f.	s.s	m.s.	v.r.	F. pr
Subject stratum					
Treatment	3	0.686	0.229	0.14	0.937
Residual	14	23.492	1.678	1.47	
Subject. Time stratum d.f. correction factor 0.4701					
Time	4	99.246	24.811	21.70	<0.001
Time. Treatment	12	4.649	0.387	0.34	0.902
Residual	56	64.037	1.144		
Total	89	192.110			

Appendix 40: Analysis of variance for Triglyceride

Source of variation	d.f.	s.s	m.s.	v.r.	F. pr
Subject stratum					
Treatment	3	86.30	28.77	0.64	0.601
Residual	14	628.86	44.92	2.76	
Subject. Time stratum d.f. correction factor 0.5887					
Time	4	1296.23	324.06	19.91	<.001
Time. Treatment	12	412.73	34.39	2.11	0.069
Residual	56	911.50	16.28		
Total	89	3335.62			

Appendix 41: Analysis of variance for Urea

Source of variation	d.f.	s.s	m.s.	v.r.	F. pr
Subject stratum					
Treatment	3	193.797	64.599	4.87	0.016
Residual	14	185.551	13.254	8.55	
Subject. Time stratum d.f. correction factor 0.5736					
Time	4	87.962	21.990	14.19	<0.001
Time. Treatment	12	35.332	2.944	1.90	0.103
Residual	56	86.790	1.550		
Total	89	589.432			

Appendix 42: Analysis of variance for Glucose

Source of variation	d.f.	s.s	m.s.	v.r.	F. pr
Subject stratum					
Treatment	3	1.388	0.463	1.49	0.261
Residual	14	4.351	0.311	0.47	
Subject. Time stratum d.f. correction factor 0.5960					
Time	4	8.394	2.099	3.18	0.046
Time. Treatment	12	8.486	0.707	1.07	0.403
Residual	56	36.952	0.660		
Total	89	59.571			