PERFORMANCE OF RED SOKOTO GOATS FED INCLUSION LEVELS OF MIXED GMELINA (*Gmelina arborea*) AND MORINGA (*Moringa oleifera*) LEAF MEAL in *Digitaria smutsii* HAY BASED DIETS

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A THESIS SUBMITED TO THE POSTGRADUATE SCHOOL, AHMADU BELLO UNIVERSITY, ZARIA IN PARTIAL FULFILLMENT OF REQUIREMENTS FOR THE AWARD OF DOCTOR OF PHILOSOPHY IN ANIMAL SCIENCE

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DECLARATION

I declare that the work in this thesis entitled "PERFORMANCE OF RED SOKOTO GOATS FED INCLUSION LEVELS OF MIXED GMELINA (*Gmelina arborea*) AND MORINGA (*Moringa oleifera*) LEAF MEAL IN *Digitaria smutsii* HAY BASED DIETS" has been carried out by me in the Department of Animal Science under the supervision of Prof. C.A.M. Lakpini, Dr. S.B Abdu and Prof. O.S. Lamidi. The information derived from literature has been duly acknowledged in the text and a list of references provided. No part of this thesis was previously presented for another degree or diploma at this or any other Institution.

OKAFOR, Emilia Chibuzor ....

Signature Date

CERTIFICATION

This thesis entitled **“**PERFORMANCE OF RED SOKOTO GOATS FED INCLUSION LEVELS OF MIXED GMELINA (*Gmelina arborea*) AND MORINGA (*Moringa oleifera*) LEAF MEAL IN *Digitaria smutsii* HAY BASED DIETS” by OKAFOR, Emilia Chibuzor, meets the regulations governing the Award of the Degree of Doctor of Philosophy (Animal Science) of Ahmadu Bello University, Zaria, and is approved for its contribution to knowledge and literary presentation.

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Signature Date

DEDICATION

I dedicate this Thesis to the memories of my lovely late mother, Mrs. Rebecca Okafor and my late sister, Mrs. Nonyelum Nyam for their love and care.

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ABSTRACT

Studies were conducted to investigate the effect of mixed *Gmelina arborea* and *Moringa oleifera* leaf meal inclusion on the performance of Red Sokoto goats fed *Digitaria smutsii* hay based complete diets. *Gmelina arborea* and *Moringa oleifera* leaf meals were mixed at the ratio of 3:1 and included at 0, 10, 20 and 30% in a 40 % *D. smutsii* hay base. In the first growth trial, 20 intact Red Sokoto bucks between 4 and 5 months of age with a mean weight of 12.00±0.20kg were used to ascertain the effect of mixed *Gmelina arborea* and *Moringa oleifera* (GMMO) leaf meal inclusion on dry matter intake, live weight, cost-benefit, haematological and serum biochemical parameters of Red Sokoto does fed *D. smutsii* hay based complete diets. The bucks (20) balanced by weight, were randomly assigned to four treatments of five bucks per treatment in a Completely Randomized Design. The experimental diets were offered at 4% body weight and the trial lasted for 90 days. A metabolism trial was conducted at the end of the feeding trial to investigate the effect of inclusion levels of GMMO leaf meal on nitrogen intake, digestibility and nitrogen balance. The second experiment on growth trial was carried out to investigate the effect of GMMO leaf meal inclusion on dry matter intake, live weight, total weight gain, cost benefit, haematological and serum biochemical parameters of Red Sokoto does fed *D. smutsii* hay based complete diets. Twenty-eight (28) growing Red Sokoto does aged between 6 and 7 months weighing 14.71±0.09 kg balanced by weight, were randomly assigned to four treatments of seven does per treatment in a Completely Randomized Design. The third study investigated the effect of GMMO leaf meal inclusion on dry matter intake, live weight, pregnancy, birth weight, haematological and serum biochemical parameters and milk composition of Red Sokoto does fed *D. smutsii* hay based complete diets. Twenty-four pregnant Red Sokoto does aged between 13 and 14 months, weighing

22.50 ±0.12 kg balanced by weight, were randomly assigned to four treatments of six does (in their last trimester of pregnancy) per treatment in a Completely Randomized Design. Animals were fed 4% of their body weight in all the studies. Results showed that daily feed intake was significantly ($P<0.05$) higher in animals on GMMO leaf meal than 0% and this ranged from 237.79g/d to 330.17g/d. Total weight gain varied from 2.86 to 4.20 kg, while average daily weight gain ranged from 31.78 to 46.67 g/d in animals fed diets with 0% and 20% leaf meal, respectively. The optimal level of inclusion of GMMO in the diets of growing Red Sokoto bucks was 25%. Dry matter and organic matter digestibility were significantly ($P<0.05$) higher in animals fed 10% (75.86%, 84.97%) and 20% (73.16%, 84.98%) respectively, compared to other treatments. Crude protein digestibility was similar and ranged from 72.60% in animals fed 30% to 77.62% in those fed 20%. Crude fibre digestibility was significantly ($P<0.05$) different across the treatments with highest value in animals fed 20% GMMO leaf meal (76.15%). The results of N intake was statistically similar ($P>0.05$) in bucks fed 10% and 20% inclusion level. Nitrogen retention was significantly ($P>0.05$) similar in animals fed 0%, 10% and 20% GMMO leaf meal. Animals fed 0%, 10% and 20% GMMO leaf meal had significantly ($P>0.05$) similar total weight gain (2.80kg, 3.30 kg and 3.38 kg), respectively. Trend analysis showed 15% inclusion as the optimum level of GMMO leaf meal in the diets of growing Red Sokoto does. The net profit and reduction in feed cost/kg gain at 20% GMMO leaf meal inclusion were highest in the first and second experiment. The inclusion of GMMO leaf meal increased dry matter intake, birth weight of kids and milk protein of the Red Sokoto does. Dry matter intake was significantly ($P>0.05$) similar in does fed 10%, 20% and 30% GMMO leaf meal. Birth weight was significantly higher ($P<0.05$) in does fed 20% and 30% GMMO leaf meal (1.58 kg and 1.68 kg) respectively. The values of haematological and serum biochemical

parameters recorded were within the normal range for healthy goats. Milk protein was significantly (P<0.05) better in does fed 10% and 20% GMMO leaf meal. Lactose content in does fed 30% GMMO leaf meal was comparable to those fed the control diet. This study concluded that, by mixing *Gmelina arborea* and *Moringa oleifera* leaf meal at the ratio of 3:1 in a *D. smutsii* hay based diet fed to Red Sokoto bucks and does, respectively produced higher dry matter intake, nutrient digestibility, nitrogen balance, weight gain and birth weight.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of the Study

Ruminant livestock have a unique digestive system that allows them to use energy from fibrous plants materials better than other herbivores. Their digestive system is designed to ferment feedstuffs and provide precursors for energy for the animal to use (Parish *et al.*, 2009).

Forages play an important role in ruminant animal nutrition. Ruminants are able to ruminate or regurgitate ingested high forage diets to reduce particle size for improving their digestibility (Ranjbar, 2007; Parish *et al*., 2009). However, inadequate supply of all year round quality forage is a major constraint to livestock production in the tropics (Ajayi *et al*., 2005; Ogunbosoye and Babayemi, 2010a). Most available ruminant feeds/feedstuffs during the dry season are poor in nutrients which deteriorate rapidly with increasing fibre and decreasing protein (Babayemi, 2007).

Sources of cheaper alternative forages of high quality for ruminants have been a subject of research in recent years (Alan *et al*., 2013) especially for farmers in the tropics. Browse plants have great potential as source of high quality nutrient for ruminants, being high in protein, minerals and vitamins (Babayemi *et al.,* 2003). They are available all year round because of their drought resistance, persistence, vigorous growth, re-growth and palatability (Reynolds and Atta-Krah, 2006).

The use of browse plants as supplement have been shown to enhance intake, improve growth rate and increase reproduction in ruminants (Osakwe and Udeogu, 2007; Lamidi *et* *al.,* 2009; Okafor *et al*., 2012). However, most of these forage trees have not been widely used because they often contain anti-nutritional compounds that have deleterious effects on animal performance (Ghosh *et al*., 2007).

Moringa oleifera Lamarck which originated from India is widely distributed and has become naturalized in many locations in the tropics (Fahey, 2005). It is a non-leguminous multipurpose tree and one of the fastest growing trees of the world. *Moringa* is one of the promising plants which could contribute to increased intake of some essential nutrients and health-promoting phytochemicals (Alikwe and Omotosho, 2013; Nweze and Nwafor (2014). It has a high crude protein content ranging from 20-26% CP in leaves (Kakengi *et al*., 2005; Ben Salem *et al.,* 2004; Asaolu *et al.,* 2011) with negligible contents of anti-nutrients (Makkar and Becker, 1996). Moringa has been reported for its unique nutrient profile (Ofoh *et al.,* 2011). Moringa can grow up to 12m in height at maturity, with a yield up to 120 t/ha/yr when it is densely planted for use as forage crop (Makkar and Becker, 1996).

Gmelina arborea Roxb. (Family verbenanceae) is a fast growing deciduous tree that can grow up to 40 m tall and 140 cm in diameter (Jensen, 1995). Even though *Gmelina arborea* can shed some of its leaves when the dry season is approaching, the regrowth of new leaves could serve as animal feed during this period.

The leaves are high in nutrient. Previous records (Okafor *et al.,* 2012; Osakwe and Udeogu, 2007; Ahamefule *et al*., 2006) have shown that the leaves contain as much as 10.01-38.4% crude protein and 3.10-30.46 % crude fibre with low level of anti nutritional compounds.

1.2 Justification for the study

Small ruminants are kept for meat, milk, wool and skin. In Nigeria, they are primarily produced for meat. The meat from goat is preferable to those from other animal species because of its flavour, tenderness and palatability (Idiong and Orok, 2008).

There is demand for chevon (goat meat) and goats have characteristics as the species of animals that can meet this demand because they are highly prolific (Webb and Mamabolo, 2004). They are able to utilize degraded land, and thrive under conditions that other species cannot cope with (Devendra, 1999).

There is need therefore to provide adequate nutrition to goats to allow them produce optimally, and address the problem of weight loss and reduction in milk production during the dry season. As a result of these nutritional issues, supplementation of goat diets is necessary. The usual practice has been to supplement livestock diets with protein rich ingredients such as groundnut cake (GNC), soybean meal (SBM) and cotton seed cake (CSC). These supplements are often not fed due to their unavailability and their high costs (Nouala *et al*., 2006; Olomola *et al*., 2008).

Cheaper and more available supplements are needed to enhance productivity in the tropics. In earlier studies with Red Sokoto goats (Abdu *et al*., 2012; Okafor *et al*., 2012), high nutrient digestibility, nitrogen utilization and average daily weight gain were reported for animals on *Gmelina arborea* leaves. This study investigated the use of Gmelina leaf meal in combination with Moringa leaf meal in the diet of Red Sokoto goats.

1.3 Aim and Objectives

This study was designed to investigate the effect of mixed *Gmelina arborea* and *Moringa oleifera* leaf meal inclusion on performance of Red Sokoto goats fed *D. smutsii* hay based diets.

The specific objectives were to determine:

- Effect of mixed *Gmelina arborea* and *Moringa oleifera* (GMMO) leaf meal inclusion on dry matter intake, growth and nutrient digestibility of Red Sokoto bucks in *D. smutsii* hay based diets.
- Effect of GMMO leaf meal on dry matter intake, growth, pregnancy, birth weight of Red Sokoto kids and milk composition in lactating Red Sokoto does.
- Effect of GMMO leaf meal inclusion on haematological and serum biochemical parameters in Red Sokoto goats fed *D. smutsii* hay based diets.
- The cost benefit of feeding GMMO leaf meal inclusion to Red Sokoto goats.

1.4 Hypotheses

1. H_o: Mixed *Gmelina arborea* and *Moringa oleifera* (GMMO) leaf meal inclusion has no significant effect on dry matter intake, growth and nutrient digestibility in Red sokoto bucks fed *D. smutsii* hay based diets.
2. H_o: Mixed *Gmelina arborea* and *Moringa oleifera* leaf meal inclusion has no significant effects on dry matter intake, growth, pregnancy, birth weight of Red Sokoto kids and milk composition in lactating Red Sokoto does.
3. H_o: GMMO leaf meals inclusion has no significant effect on cost benefit of Red Sokoto goats fed *D. smutsii* hay based diets.

4. H_a: Mixed *Gmelina arborea* and *Moringa oleifera* (GMMO) leaf meal inclusion has significant effect on dry matter intake, growth and digestibility in Red Sokoto bucks fed *D. smutsii* hay based diets.
5. H_a: Mixed *Gmelina arborea* and *Moringa oleifera* leaf meal inclusion has significant effects on dry matter intake, growth, pregnancy, birth weight of Red Sokoto kids and milk composition in lactating Red Sokoto does.
6. H_a: GMMO leaf meals inclusion has significant effect on cost benefit in Red Sokoto goats fed *D. smutsii* hay based diets.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Importance of small ruminants

Almost all of the milk and about 50% of the meat consumed by people in the world is provided by ruminants (Cunningham *et al.,* 2005). Ruminants are most important species in converting grasses and other forages into marketable products like meat, milk, wool, hides and other by-products.

Small ruminants especially sheep and goats form an integral part in the livestock economy system in Nigeria (Hamito, 2008). The arid and semi arid areas are home to over 80% of small ruminants and their sustenance is reducing due to dependence on natural pastures (Kosgey *et al.,* 2008) supporting 46-58% of pastoral households. They play a significant role in the food chain and overall livelihoods of rural households, where they are largely the property of women and their children (Lebbie, 2004). Small ruminants are the principal domesticated animals in terms of total numbers and production of food and fibre products. This attribute may partly be due to their lower feed requirements compared to cattle, because of their body size (Okunlola *et al*., 2010). Lower feed and of course the lower capital requirement allows for easy integration into different farming systems (Hirpa and Abebe, 2008; Pollot and Wilson, 2009). Small ruminants have served as means of ready cash and reserve against economic and agricultural production hardship (Hamito, 2008). It acts as an insurance against crop failure and provides alternative source of livelihood to the farmers all the year round (Selvam and Safiullah, 2002; Hamito, 2008).

In Nigeria sheep and goats are kept principally for meat, hides and skin. Milk from small ruminants is an important source of nutrition for the population. Farmers use small ruminants as savings that generate cash when the environment is harsh such as during drought years (Blench, 1999; Hamito, 2008).

Nigeria was estimated to have about 16.3 million cattle, 40.8 million goats, and 27 million sheep (Lombin, 2007), however, Nigeria was reported to have a population of 53.8 million goats and 33.9 million sheep being 6.2 and 3.1% of world goat and sheep population (FAOSTAT, 2009), respectively. Small ruminants are very important livestock and contribute an estimated 35% of the total meat supply in Nigeria, (Oni, 2002).

According to Shiawoya *et al.* (2001), small ruminant production is already a prominent feature amongst rural families in Nigeria. Farmers in the Northern states have been found to be actively involved in rearing small ruminants which are marketed to supplement the family income from other sources (Adamu and Ndako-Gona, 2003). Goats occupy a significant niche in the rural economy of Nigeria. With their inherent qualities of early maturity, ability to thrive even under harsh environment, low capital investment, etc. Thus, even with as little financial input as was observed, the enterprise can be profitable, so meeting the nutrient requirement of the animals is a major concern to nutritionists (Aka *et al*., 2009).

2.2 Goat production in Nigeria

Goats are characterized by their efficient grazing behaviour and functional digestive system and thrive well under the tropical arid and semi-arid regions. Compared to other farm animals, the population of goats has increased rapidly in the harsh environmental and feed scarcity zones of the tropics (Gutierrez, 2003; Cunningham *et al.*, 2005). Goats are considered superior to other ruminant species in their utilization of poor quality and high fibre feeds (Oyeyemi and Akusu, 2005). Goats are by far the most important domesticated small ruminants in Nigeria (FAOSTAT, 2009).

The world goat population is estimated at 790 million and most (96%) are found in developing countries (FAO, 2006) where they are of great importance. Goat population in Nigeria makes it the second most important livestock species. Goats are the most prolific of all domesticated ruminants under tropical and subtropical conditions (Webb and Mamabolo, 2004). They are the "cattle of the poor" reared as sources not only of milk and meat for family consumption but also as source of income. Goats in the country are kept mainly for meat production; their milk is rarely used for human consumption (Butswat *et al.*, 2002 and Midau *et al.*, 2010). However, there is a growing awareness of the importance of goats as a source of milk for man (Malau-Aduli *et al.*, 2001). Goat contributes 24% to Nigeria meat supply (Oni, 2002). They also feature prominently in the economic and social lives of Nigerians (Ajala, 2004). Odeyinka and Ajayi, (2004) reported that goats are used for customary rites in addition to meat production and religious purpose in South West Nigeria.

2.3 Breeds of goat and their distribution in Nigeria

There are three recognized breeds in Nigeria, namely, the West Africa Dwarf (WAD), the Sahel (SH) and Red Sokoto (Maradi) goats (Osinowo and Abubakar, 1988; Osinowo, 1992).

2.3.1 West African Dwarf (WAD) Goats

West African Dwarf (WAD) goats are found mainly in the forest belts of the southern Nigeria. They have small body sizes and strongly set short legs. The breed is black, brown or white or a combination of black, brown and white. They are prolific, kidding twins and triplets (Phillips, 1977). The breed is used mainly for meat but also has dairy potentials (Blench, 1999). Studies have shown that the WAD goats are not particularly adapted to high ambient temperature (Montsma *et al.,* 1985). High temperature and relative humidity (e.g. 30^0C and 60% R.H.) cause a reduction in feed intake. The WAD goats in the semi-arid zone resemble the Red Sokoto goats in their body proportions (Blench, 1999). The ears are erect and the legs are short and thick. This breed is about 50 cm in height and 20-30 Kg in weight, tending to be larger towards the savanna zone. The breed is hardy and recent work has shown that they are endowed with the capacity to resist trypanosome and intestinal nematode infections more effectively than any other known breed of goat (Chiejina *et al*., 2009; Chiejina and Behnke, 2011).

2.3.2 Sahel or Desert Goats

It is found more abundantly in the Sahelian part of the country. They have varying coat colours, but usually mixed black, white and brown. They possess fine hair coats, short ears and long legs. The breed is adapted to nomadic and wide range grazing. This is probably, because of its long legs which enable it trek long distances. They are meat animals, although they could be used for milk and skin production. The mature body weight varies from 35-40kg in males and 25-30kg in females (Blench, 1999).

2.3.3 Red Sokoto Goats (Maradi)

The Red Sokoto (Maradi) is the most important breed that is widely distributed in Northern Nigeria (Makun *et al.,* 2005). It is the most common village goats in the northern two-thirds of the country (Adebambo *et al.*, 2011).The breed weighs about 1.5–2.0 kg at birth and reaches about 12.0 kg when weaned at 3 months under good management. Weights of adult does and bucks are 20–35 kg and 25–40 kg, respectively (Osuhor *et al.,* 2002). Both sexes are horned. The goats have an average milk yield of 3.8 kg per week (Makun *et al.,* 2005). The Red Sokoto goats are still known for their suitability for fine leather.

2.4 Importance of Browse Plants

Browse refers to leaves and twigs from shrubs and trees available to ruminants as feed and in a broader sense including also flowers and fruits or pods. Browses have multiple roles in farming systems such as feed, fuel wood and as source of human and veterinary medicines (Luseba and Van der Merwe, 2006). As a major source of animal feeds in Africa, fodder trees and shrubs are highly valued by farmers. These forage species contain appreciable amounts of nutrients that are deficient in other feed resources such as grasses during dry seasons. They can be dried for stall feeding during feed scarcity periods (Habib *et al.*, 2013). Bhatta *et al.* (2005) reported that although fodder trees are often valuable sources of dietary protein and energy for livestock in semi-arid regions, maximum nutritional and economic benefits could be harvested, if used as supplement rather than as a sole feed.

Okoli *et al.* (2003) recorded that over 160 species were used for ruminant feeding by indigenous farmers in south eastern Nigeria. Anthelmintic properties have been reported in many plants that are browsed (Hammond *et al.*, 1997), that by improving the nutritional status of the animals, increase their ability to resist the harmful effects of parasites (Hoste *et al.*, 2006). Browses are to improve the efficiency of protein digestion in the rumen and have been incorporated into feeding regime to improve the nutritional status of the animals (Rubanza *et al*., 2007). Browse plants are used as feed by both domestic animals and wild life as they are known to provide vitamins and frequently mineral elements which are lacking in grassland pasture during the dry and rainy seasons. The crude protein and crude fibre of browses range from 15.3 to 33.3% and 2.7 to 15.6%, respectively (Oji and Isilebo, 2000 and Okoli *et al*., 2014). Hassen *et al*. (2010) observed that parts of the browse species utilized by livestock were leaves, pods, twigs and flowers.

2.4.1 Use of Browse Plants in Ruminant Nutrition

Trees of several species could provide palatable and nutritious fodder during drought and scarcity periods by lopping their branches (Reddy, 2006). As a major source of animal feeds in Africa, fodder trees and shrubs are highly valued by farmers.

Ibrahim *et al*. (2014) reported that Sabara (*Guiera senegalensis*) leaf meal can be incorporated into goats' diet. Average daily weight gain of 50g/d was obtained when Red

Sokoto bucks were fed diet containing 20% Sabara leaf meal. There was no adverse effect on performance, nutrient digestibility and hematological values.

Ladipo and Akinfemi (2014) observed that tropical tree leaves have high crude protein and low crude fibre contents. They also reported high organic matter digestibility, metabolizes energy and short chain fatty acid and that means inherent potential to improve the performance of ruminants.

Reddy and Elanchezhia (2008) observed that the leaf fodder of some trees is almost as nutritious as the leguminous fodder crops. Browse plants have great potential as source of high quality nutrient for ruminants, being high in protein, minerals and vitamins (Yahaya *et al.,* 2000; Babayemi *et al.*, 2003). Minerals are important to the proper nutrition of animals. Calcium, phosphorus and sodium are essential for small ruminants for optimum productivity (Ghazanfar *et al.,* 2011). Supplementing goats with forage trees have been observed to improve body weight and general health of the animals. Improvement of goats' body weights could have a positive effect on meat quality characteristics (Oni *et al.,* 2010). The fodder tree leaves are harvested several times during summer and fed to livestock and also stored as hay (Javed *et al*., 2008; Habib *et al.*, 2013).

Goats fed 60% cassava foliage as replacement to Gliricidia was reported to have highest average daily weight gain of 46.55g/d with least value (34.74g/d) recorded for those on 60% Gliricidia (Fasae *et al*., 2010). The researchers reported that replacement of Gliricidia leaves with cassava foliage in the diet of goats resulted in enhanced dry matter intake with improvement in the digestibility of the diets, increased body weight gain with no adverse effect on the blood parameters.

Fasae *et al*. (2011) reported improved average daily gain of 24.03 to 44.03g/d for village goats fed maize residues supplemented with Leucaena leaf. Results of Wada *et al*. (2014) showed that average daily gain, dry matter intake and feed conversion ratio did not differ significantly for diets supplemented with *Parkia biglobosa* forage compared with the control. However, *Parkia biglobosa* forage inclusion significantly affected nutrient digestibility and nitrogen balance of Yankasa rams.

Study on utilization of five tropical browses revealed that they have positive effects on weight gain, birth weight of WAD goats (Ogunbosoye and Babayemi, 2010b). They obtained average daily gain of 37.10 – 85.30g/d when WAD goats were fed the different tropical browses and guinea grass.

Halvorson *et al*., (2004) reported that Crude Protein concentration of 14.1- 16.5% in Bamboo leaf can meet the maintenance and growth needs of goats. Aye and Adegun (2015) reported improved dry matter intake, average daily gain and feed conversion ratio for sheep fed basal diet supplemented with Gliricidia based multi-nutrient blocks. Feed intake ranges from 1102- 1584.67g/d in unsupplemented and supplemented sheep. They reported average daily gain of 9.5g in control to 57.10g in supplemented animals.

Also research on *Acacia korroo* supplementation showed that supplemented kids had higher ($p<0.05$) growth rates and meat quality than the animals on the control diet (Mapiye *et al*., 2010; Ngamba *et al*., 2013).

Improvement in average daily gain of supplemented animals had been reported to result from increased voluntary intake which may be as a result of an improved ruminal environment and digestibility of diets (Kabir *et al*., 2004 and Torrest-Acosta *et al*., 2006).

Research has proven that supplementation is economically feasible and is necessary to ensure farm viability because of large difference in term of average daily gain between supplemented and non-supplemented animals (Ammar *et al*., 2011). Reports of Njidda and Ikhimioya (2010) showed that ADG, DMI (70g/d and 641.37g) and feed conversion ratio (0.12) were significantly better with goats on diet supplemented with *Ziziphus mauritiana*. The results also revealed that same diet had the best in terms of feed cost per kg gain and percent reduction in feed cost (53.04%). Earlier work by Sawe *et al*. (1998) reported ADG of 57-68 g/d with tree leaves and pods supplementation of goats in Kenya.

Obua (2013) and Jamala *et al*. (2013) observed that since man and his domestic animals such as ruminants still depend on the availability of biological diversity for sustenance, there is need for *in-situ* conservation of animal feed resources. So, there is need for useful information on the rich diversity of browse plants in Nigeria to enable the selection process to meet the preferences of the indigenous farmers (Chah *et al*., 2009; Njidda and Ikhimioya, 2010). Report of Okoli *et al*. (2014) concluded that the future of sustainable livestock agriculture partly lies in the identification and domestication of selected highly nutritious plants that can be used for fodder purposes by farmers.

2.6 Anti-nutritional factors in browse plants

Anti-nutritional factors are a chemical compounds synthesized in natural food and or feedstuffs by the normal metabolism of species and by different mechanisms (for example inactivation of some nutrients, diminution of the digestive process or metabolic utilization of food/feed) which exerts effect contrary to optimum nutrition (Soetan and Oyewole, 2009). They reduce nutrient utilization and/or food intake and often referred to as anti-nutritional factors (Shanthakumari *et al.,* 2008).

Anti-nutrients are chemicals which have been evolved by plants for their own defense, among other biological functions and reduce the maximum utilization of nutrients especially proteins, vitamins, and minerals, thus preventing optimal exploitation of the nutrients present in a food and decreasing the nutritive value. The presence of anti-nutrients in plant protein sources for livestock feeding is a major constraint that reduces their full utilization (Akande *et al.,* 2010). However, there can be potential health benefits and adverse effects of major anti-nutritional factors in plant foods.

2.6.1 Tannins

Tannin is an astringent, bitter plant polyphenolic compound that either binds or precipitates proteins and various other organic compounds including amino acids and alkaloids (Redden *et al*., 2005; Nupo *et al*., 2013). Tannins are heat stable and they decreased protein digestibility in animals and humans, probably by either making protein partially unavailable or inhibiting digestive enzymes and increasing fecal nitrogen excretion. Tannins are known to be present in food products and inhibit the activities of trypsin, chemotrypsin, amylase and lipase, decrease the protein quality of foods and interfere with dietary iron absorption (Felix and Mello, 2000; Nwocha *et al*., 2014). Tannins are known to be responsible for decreased feed intake, growth rate, feed efficiency and protein digestibility in animals (Ngwa *et al*., 2003; Patra and Saxena, 2010). Tannins also form insoluble complexes with proteins and the tannin-protein complexes may be responsible for the anti-nutritional effects of tannin containing foods (Kyriazakis and Whittenmore, 2006). So, whether by choice or necessity, herbivores consume tannins and these secondary compounds can have detrimental or beneficial effects on animal nutrition depending on their concentration and nature and also animal species, physiological state of animal and the composition of the diet (Makkar, 2003; Min *et al*., 2003; Waghorn and McNabb, 2003; Abdu *et al*., 2008).

Potential benefits include protein sparing in the rumen and anthelminthic effects (Hoste *et al.*, 2006), whereas some unfavorable effects are microbial inhibition and decreased feed digestibility and animal performance. Moringa leaves are unique because of their tremendous amounts of minerals but lower amounts of harmful compounds. In moringa, tannins and phytates are 12 and 21 g kg–1 of DM, respectively, while 65% supplementation of *Leucaena leucocephala* leaves in the normal diet of ruminants may give rise to tannins and phytates up to 29.40 and 1.43 mg 100 g–1 of dry matter, respectively (Idiong and Udom, 2011).

Ruminants' digestive systems are well adapted for extracting nutrients from woody tissue and detoxifying secondary compounds like tannins and terpenes. Goats have larger livers (relative to body size) than sheep or cattle, and the detoxification capacity of their digestive organs is generally greater than in other livestock species. Wisenewski *et al*. (1987) shows that detoxification in the liver is more active and effective in goats than in sheep or cattle.
Nastis and Malachek (1981) have indicated a threshold for tannins of 2-5% for cattle and 9% for goats. Silanikove *et al*. (1996) concluded that goats have the ability to consume large amounts of tannin rich plant without exhibiting toxic syndromes (due to a detoxifying enzyme in the saliva), which is not the case for other ruminants.

2.6.2 Phytate

Phytic acid occurs naturally throughout the plant kingdom and is present in considerable quantities within many of the major legumes and oilseeds. Phytic acid acts as a strong chelator, forming protein and mineral-phytic acid complexes; the net result being reduced protein and mineral bioavailability (Khare, 2000; Santos, 2011; Mugendi *et al*., 2010).

Phytic acid is reported to chelate metal ions such as calcium, magnesium, zinc, copper, iron and molybdenum to form insoluble complexes that are not readily absorbed from the gastrointestinal tract (Nelson *et al*., 1968).

Phytate can react with proteins to form phytate-protein complex thereby rendering the protein unavailable to the animals. This reaction is influenced by the pH of the medium. Phytate is not destroyed readily by heat or soaking, but fermentation does liberate phosphates from phytate. Paul and Sontgate, (1978) reported 1.06mg/g as lethal dose of phytate that cannot be tolerated by ruminant animals.

2.6.3. Oxalates

Oxalate is found in nature in some plants in the form of soluble and insoluble salts and as oxalic acid; the simplest organic acid (Ilelaboye *et al*., 2013). Oxalates affects calcium and magnesium metabolism and react with proteins to form complexes which have an inhibitory effect in peptic digestion (Galloway and Cowling, 2002; Akande *et al*., 2010). Oxalic acid binds the calcium and forms calcium oxalate which is insoluble. Calcium oxalate adversely affects the absorption and utilization of calcium in the animal body (Olomu, 1995; Weaver *et al*., 1997). They also cause muscular weakness and paralysis (Soetan and Oyewole, 2009). Oxalate can increase the risk of developing kidney stones (Holmes *et al*., 2001; Acamovic *et al*., 2004).

Oxalate contents of browses ranged between 0.52mg/100g and 0.82mg/100g which are within tolerable limit, (Sodeinde *et al*., 2007). Ruminants, unlike monogastric animals, can consume considerable amounts of high oxalate plants without adverse effects, due principally to microbial decomposition in the rumen (Oke, 1969). However, at a high concentration, oxalate may cause digestive and physiological disturbance (Acamovic *et al*., 2004).

2.6.4 Saponins

Saponins are naturally occurring triterpenes or steroid glycosides which exhibit surface active properties and are found in a wide variety of plants. Saponins are known astringent components of food materials and this could lead to reduced palatability (Enujiugwa *et al*., 2014). They have characteristic bitter taste and foaming properties (Agarwal and Rastogi, 1974; Sanusi *et al*., 2013) and haemolyse red blood cells (Prohp and Onoagbe, 2012). They are known to depress growth performance in both poultry and swine. Their anti-nutritional properties seem related to their ability to form complexes with sterols, in particular those in membranes of animal cells. Saponins have been reported to increase microbial nitrogen flow from the rumen and decrease methane production, presumably due to defaunation of ruminal protozoa (Teferedegne, 2000; Abreu *et al*., 2004; Babayemi *et al.,* 2004).

However, in ruminants because saponins may undergo bacterial degradation in the rumen, they may not retard their growth. Shodipo and Arinze (1985) have indicated a threshold for saponins of 2g for ruminants. Some authors reported tolerable level of saponins in *Gmelina arborea* leaves (Aderiuboye and Onwuka, 2010; Adamu, 2011 and Okafor *et al*., 2012). The extracts of moringa leaves contain amounts of saponins ranging between 4.7 and 5 g kg–1 of DM, and so they can be consumed by livestock and human beings without any adverse effects (Foidl *et al.,* 2001).

2.6.5 Alkaloids

Alkaloids are compounds that contain nitrogen in a heterocyclic ring, are generally basic and often have a bitter taste. The word alkaloid simply means 'alkali-like'. Alkaloids are present in many plants whereby they are thought to serve as a chemical defense against herbivores (Kim *et al.*, 2007). Some alkaloids are reported to cause infertility (Olayemi, 2007). Alkaloids have powerful effects in animal physiology and are of interest in pharmaceutical industries for drug manufacture (Edeoga and Erinta, 2001). They are stimulants and act by prolonging the action of several hormones. The presence of alkaloids in *Gmelina arborea* plant is also of great importance to humans because of their medicinal values as significant quantities are used as anti-malarial, analgesic and as stimulants (El-Mahmood *et al*., 2010).

2.7 Tree Leaves as Animal Feeds

Manaye *et al*. (2009) showed that there was improvement in intake, digestibility and body weight gain when a low-quality grass is supplemented with tree leaves. Utilization of fodder trees and shrubs could be a potential strategy for increasing the quality and availability of feeds for resource-limited livestock farmers during the dry season. The trees provide a good and cheaper source of protein and micronutrients (Moyo *et al.,* 2012). In recent years, there has been increased research on alternative protein sources from forage trees and shrubs that can be fed to goats, such as *Acacia senegal* (Sanon *et al*., 2008), *Acacia etbaica*, *Dichrostachys cinerea* (Yayneshet *et al*., 2008), *Manihot esculenta* (Oni *et al*., 2010), *Moringa oleifera* (Olugbemi *et al*., 2010), *Gmelina arborea* (Amata and Lebari (2011); Abdu *et al.*, 2012; Okafor *et al*., 2012).

Tree leaves may have limitations in terms of productivity, palatability, presence of toxic substances and adaptability (Akinbamijo *et al.*, 2006). The potential of leaf meals from tropical trees and shrubs to yield relatively higher levels of crude protein and minerals, and lower crude fiber levels than tropical grasses has also been recognized, (Okagbare *et al*., 2004; Amata, 2010).

A lot of research work has been published on the use of leaf meal to reduce the cost of protein sources and to enhance profit (Emenalom *et al.,* 2009).

2.8 Gmelina (*Gmelina arborea*)

2.8.1 *Gmelina arborea Roxb*

This is a deciduous tree of medium size grows up to 40m in height and has a diameter of 60-100cm (Jensen, 1995). The leaves are simple and are more or less heart shaped and are usually 10-25cm long and 5-18cm wide. Recent study (Amata and Iwelu, 2012) show the potentials of the fresh fruit pulps of *Gmelina arborea* as nonconventional feeding materials.

2.8.2 Importance of *Gmelina arborea*

Gmelina arborea Roxb contributes a large portion of fodder to animals. When planted along the fence lines of paddocks particularly, it may serve as shade for animals grazing in the paddock. In northern parts of Nigeria, *Gmelina* is planted in rows to serve as wind breaker along some major roads. *Gmelina* is a white wood, used as timber in construction, furniture, carriage, spurts, musical instruments, artificial limbs and the pulp is used in paper making (Orwa *et al*., 2009). Once seasoned, it is a very steady timber and moderately resistant to decay and ranges from very resistant to moderately resistant to termites. In

Gambia, there is dual purpose planting for firewood and honey. It is also planted as an ornamental avenue shade tree. The wood makes a fairly good charcoal. According to Little (1983), the leaves are harvested for fodder for animals and silkworm; the bitter-sweet fruits used to be consumed by humans. Gmelina fruit pulps, seeds and flowers have also been very useful in the feeding of livestock (Amata and Iwelu, 2012).

Gmelina is extensively used traditionally as anthelmintic, antimicrobial, antidiabetic, diuretic, hepatoprotective and antiepileptic agent in India (Amrutha and Bhaskar, 2010; Sravani *et al*., 2011 and Sylvie *et al*., 2012). Many studies have shown an antibacterial activity of its stem bark and leaves (Duke and Wain, 1981; El-Mahmood *et al.*, 2010; Ashalatha and Kuber, 2014). Vijay *et al*. (2011) have also been described the cardio-protective and antioxidant activity of Gmelina leaves.

2.8.3 Feeding Value of *Gmelina arborea*

Several Crude Protein (CP) values have been reported in the literature of *Gmelina arborea* leaves. Ahmed (2000) and Omokanye *et al.* (2001) reported CP value of 26.7%, Leng (1992) reported 34%, Adu *et al.* (1996) reported 28.6 to 38.4%, Lamidi *et al*. (2009) obtained 14.51% while Taiwo *et al.* (2009) reported 20.39% for protein, Omokanye *et al.* (2001) obtained 20.50 %. Taiwo *et al.* (2009) and Ahamefule *et al*. (2006) reported 15.00% and 3.10% for crude fibre, respectively.

Osakwe and Udeogu (2007) reported crude fibre content of 30.46%, 44.69% nitrogen free extract and 3.59KJ/g DM Gross Energy (GE). Taiwo *et al.* (2009) obtained 42.79% Acid Detergent Fibre (ADF), 64.11% Neutral Detergent Fibre (NDF), 88.68% Dry Matter (DM). Adeyele and Fasae (2008) reported DM and NDF values of *Gmelina* leaves as 91.60% and 55.76 % respectively. According to Amata and Lebari (2011) the nutrient profile of the fresh leaves reveal appreciable levels of crude protein (14.60% DM), crude fiber (6.70 % DM), ash content (1.30 % DM), ether extract (12.70 % DM) and metabolizable energy (1368 Kcal Kg-1). Gmelina leaves can be suitable as both energy and protein sources in livestock diets. Also Okafor *et al.* (2012) obtained crude protein (13.38%), crude fibre (19.00%), ash content (7.85%), and ether extract (3.34%) on dry matter basis. The anti-nutritional content of the leaves is low, implying that the overall nutritional value of the leaves will not be affected (Amata and Lebari, 2012).

The differences in chemical composition of feed ingredients may be due to natural variations as a result of genetic background, environment, cultivation method, variations due to sample preparations and analysis (Brisibe *et al*., 2009; Njidda, 2010).

2.8.4. Effect of Feeding *Gmelina arborea* on Livestock Productivity

Gmelina arborea has been identified as one of the most preferred browse species by sheep during the dry season in a part of sub-humid Nigeria (Omokanye *et al*., 2001). Results of Sevilla and Meriales (1999) showed significantly higher daily weight gain of sheep fed Gmelina leaves (36 g/d) and better feed efficiency (14.5 kg/kg) compared with those fed paragrass (19 g/d and 37.7 kg/kg, respectively).

Goats fed 50 % *G. arborea* leaves as supplement with 50 % *P. purpureum* had the best performances in terms of feed intake and digestibility (Isah *et al.,* 2013; Moemeka *et al*., 2014).

Okafor *et al.,* (2012) reported that bucks fed replacement forage containing 50% Gmelina leaves recorded the highest DMI, live weight gain, and nitrogen retention. They obtained similar ADG of 43.33-47.78g/day for Red Sokoto bucks fed varying levels of Gmelina leaves. Abdu *et al.* (2012) recommended that Gmelina leaf meal can be included at 20% in a sorghum glum based diet without adverse effect on intake and digestibility of nutrients in goats. Dry Matter Intake (DMI) of the complete diets ranged from 498.28 g in animals fed 30% to 562.89g in animals fed 20%.

Recent report by Okpara *et al*. (2014) suggested 0.50 kg of Gmelina leaves in the diet of grazing goats as the optimum as higher inclusion resulted in weight reduction. Results of Aye and Tawose (2015) recorded DMI of 425.00 – 598.80g/d for rams on varying levels of Gmelina leaves.

2.9 Moringa

2.9.1. *Moringa oleifera Lam*.

Moringa (*Moringa oleifera* Lam.) is a multipurpose tropical tree. It is mainly used for food and has numerous industrial, medicinal and agricultural uses, including animal feeding. Moringa is a small to medium evergreen or deciduous tree that can reach up to 10-12 m. It has a spreading open crown, typically umbrella-shaped. Moringa originated from the southern hills of the Himalayas and was introduced in many tropical and subtropical areas, particularly by migrant Asian populations (Bosch, 2004; Radovich, 2009). Moringa is now naturalized in most African countries, in the Caribbean Islands and in Central America (Francis *et al*., 2005). Moringa is an important crop in India, Ethiopia, the Philippines and the Sudan (FAO, 2014).

2.9.2. Importance of *Moringa oleifera*

All parts of Moringa are consumed as food. The plant produces leaves during the dry season and during times of drought, and is an excellent source of green vegetable when little other food is available (FAO, 2014). The leaves are very nutritious and rich in protein, vitamins A, B and C, and minerals. They are highly recommended for pregnant and nursing mothers as well as young children (FAO, 2014). Moringa leaves can serve as feed for animals. They are valuable source of protein for ruminants but used in poultry, pigs, and fish diets in limited amount because of fibre and anti-nutrients.

Moringa seed powder has antibacterial properties that make it useful as a natural clarifier for water purification systems and fish ponds (Aruna and Srilatha, 2012). Moringa leaf extract is used as growth enhancer. Foidl *et al*. (2001) reported that spraying Moringa leaf extract on leaves increases plant production by 20-35%.

Moringa plant has been reported to have many medicinal uses (Orwa *et al*., 2009: Olugbemi *et al*., 2010). *Moringa oleifera* leaves are widely used traditionally for its antimicrobial abilities (Suarez *et al*., 2005) and its pharmacological properties (Mehta *et al*., 2003). It contained phytosterol (beta-sitosterol) which is a plant substance similar to cholesterol. Beta-sitosterol was reported to reduce cholesterol levels by limiting the amount of cholesterol that is absorbed in the digestive tract (Ghasi *et al*., 2000; Longe, 2008). The beta-sitosterol in *Moringa oleifera* leaf was also reported to be responsible for its hypolipidaemic and antioxidant properties (Rajanandh and Kavitha, 2010).

Moringa has industrial uses; seed oil is used in perfume industry and in making of paintings and lubricants (Bosch, 2004; Foidl *et al*., 2001). It is also used in purification of drinking water. Moringa timber is soft and can only be used for light constructions but can produce fibre for ropes and mates. The bark is a source of dye (Bosch, 2004; Foidl *et al*., 2001).

2.9.3 Feeding Value of *Moringa oleifera*

Moringa oleifera leaves contain between 257.00 to 261.00 g kg-1 DM crude proteins (Sultana *et al*., 2014). According to Kakengi *et al*. (2003), *Moringa oleifera* leaf contained 86% DM, CP 29.70 %, CF 4.38%, EE 29.90 %, 3,056 kcal/kg energy, Calcium 0.26%, phosphorus and negligible amount of tannin (1.23g/kg). Makkar *et al*. (1996) and Kakengi *et al*. (2005) reported that protein content of Moringa leaves can vary from 15 to even more than 30% DM depending on the stage of maturity and respective proportions of leaves to stems. Moringa foliage dried meal, on the other hand, contains 214.80 to 216.20 g CP kg/DM, 268.30 to 310.29 g ADF kg/DM and 347.1 to 381.8 g NDF kg /DM (Sultana *et al*., 2014). The fibre contents ranges from 8 to 30 % DM. Price (2007) reported that Moringa leaves contain high amounts of vitamins (β-caroten, ascorbic acid, vitamin B1, B6 and niacin).

The leaves are also found to contain flavonoids which are more potent antioxidants than ascorbic acid (Yang *et al.*, 2006). The lipid concentration is relatively high ranging from 5-10% (Moyo *et al*., 2011 and Olaofe *et al*., 2013). Its protein and organic matter is readily digestible (Ndemanisho *et al*., 2007 and Guttierrez *et al*., 2012). Several authors (Nouala *et al*., 2006; Ogbe and Affiku, 2011 and Aye and Adegun, 2013) found that Moringa leaves contained negligible amounts of anti-nutritive compound. According to Ferreira *et al*. (2008), Moringa leaves lack lectins, trypsin, and amylase inhibitors.

Sarwatt *et al*. (2002) and Bakhashwain *et al*. (2010) reported that the leaves contain low amount (12g/kg dry matter) of tannins which is tolerable to ruminants. Results of Bennett *et al*. (2003) and Amaglo *et al*. (2010) showed that Moringa leaves contained levels of glucosinolates not harmful to ruminant animals. However, Moringa leaves contained saponins which may impair palatability. Chemical compositions of plants may be affected by climatic, seasonal and processing methods (Dei *et al*., 2007). Dried moringa leaf can be stored for longer periods without deterioration in nutritive value (Mendieta- Araica *et al*., 2011a).

2.9.4. Effect of Feeding *Moringa oleifera* on Ruminant Livestock Productivity

Moringa leaves have been used as protein supplement for medium to low producing dairy cows fed low-quality forages. Moringa leaves have been shown to alter favorably ruminal protein fermentation characteristics thus spare protein by a decreased reakdown/deamination of protein/ amino acids (Karim *et al.*, 2015). The effect of feeding Moringa leaves on DM intake and milk yield varied but did not affect milk composition. In research work carried out in Tanzania reported that increasing the levels of Moringa leaves increased forage DM intake from 545 to 552g and milk yield from 7.8 to 8.6 kg but did not change the milk composition. However, Reyes Sanchez *et al*. (2006) recorded that Moringa supplementation decreased DMI of hay from 8.8 to 7.7 kg/d when the level of Moringa leaves increased. Dry matter digestibility and milk yield improved with Moringa leaves supplementation.

In a more recent work on dairy cow, it was observed that processing has effect on DMI and DM digestibility of the diet (Mendieta-Araica *et al*., 2011a). Animals on ensiled Moringa leaves have higher DMI and DM digestibility than that of fresh leaves and the basal diet Napier grass. The researchers reported that there was no significant difference on milk yield and composition. Mendieta-Araica *et al.* (2011b) found no effect on forage DMI or DM digestibility when soybean meal was replaced with Moringa leaf meal. Milk yield was reduced but there was no effect on milk composition.

Nouala *et al*. (2009) reported depressed DM intake but increased daily weight gain of growing steers fed on groundnut hay when Moringa leaves replaced a commercial concentrate. Moringa leaves have also been used in small ruminant animal nutrition. Research with growing lambs fed on low-quality hay showed increased hay intake, diet digestibility and daily weight gain ranging from 324 to 355g DM, 60 to 70% and 52 to 62g/d, respectively when Moringa leaves replaced cottonseed cake in the diet (Murro *et al*., 2003).

Ben Salem *et al.*(2009) found that increasing the levels of defatted moringa seed meal at 0, 2, 4, or 6g/d into the diet of growing Barbarine male lambs fed oat vetch hay and soybean meal did not change hay DMI or DM digestibility (65.8%) of the diet. Average daily gain was higher with 4g/d level of defatted Moringa seed meal (97 g/d) compared to the control diet (64 g/d). Feeding of growing goats with Moringa leaves as sole forage or combined with legume tree leaves in the diet had no significant effect on total DMI (278-289 g/d) and diet digestibility (76-77 %), (Asaolu *et al*., 2011).

Sarwatt *et al*. (2002) concluded that complete substitution of sunflower meal with Moringa leaves in the diet of goats resulted to increased DMI and DM digestibility but there was no change in daily weight gain. Aregheore (2002) recorded no significant difference in DMI in an experiment with goats; however, inclusion of 20 – 50% Moringa leaves in the diet resulted in higher daily weight gain, DM and CP digestibility. Ndemanisho *et al*. (2007) reported similar DMI and daily weight gain with Moringa compared to other shrubs but higher daily gain with cotton seed cake.

In a more recent work, Asaolu *et al*. (2012) compared moringa leaves to commercial concentrate, gliricidia and leucaena leaves offered as sole supplement with cassava peels. They found that cassava DMI improved with concentrate than with moringa, gliricidia, and leucaena leaves. Dry matter intake of moringa leaves was higher than that of other tree leaves (123 g/d) but lower than concentrate intake (160 g/d). Daily weight gain of animals fed with moringa was similar to those on concentrate but higher than those on other tree leaves.

Supplementation with Moringa leaf meal had effect on meat quality. Moyo *et al.* (2014) reported that supplementation of growing goats fed on grass hay and wheat bran with moringa leaf meal instead of sunflower cake resulted in higher meat quality. Research by Adegun *et al.* (2011) showed that supplementation of Moringa–based multinutrient blocks in small ruminants' diet can enhance performance and pose no health challenges to the animals.

2.9.5 Effects of feeding Moringa leaf meal on Poultry Production

Reports of Olugbemi *et al*. (2010) and Banjo (2012) observed that inclusion rate as low as 5- 10% of Moringa leaf meals in broiler diets results in depressed growth performance. Ige *et al.* (2006) observed that increasing fibre content of diet may impair nutrient digestibility and absorption in broiler chicken.

Inclusion Moringa leaf meal at 20% or more in the diet have been reported to have detrimental effect on performance (Tesfaye *et al.,* 2013; Gakuya *et al*., 2014). Aderinola *et al*. (2013) concluded that the consumption rate or acceptability of MOLM based diet by broiler birds is very low so also the utilization potential. Moringa leaf meal is recommended at very low level (less than 2%) for slow-growing chickens to maintain performance (Melesse *et al*., 2011).

2.10 Feed Intake in Ruminants

Feed is the single largest cost associated with improvement of small ruminants, and it accounts for 60% or more of total production cost (Opara *et al.,* 2005). Nutrition exerts a very large influence on flock reproduction, milk production, and lamb or kid growth.

Therefore, animals receiving inadequate diets are more prone to disease and will fail to reach their genetic potential (Schoenian, 2003).

Feed intake has been described by Masafu (2006) as a measure of diet appreciation, selection and consumption by an animal. Intake pattern could be a reflection of the relative acceptability and palatability of supplemented feed to animal. It is a key process which determines the quantity of feed stuff which is ingested over a period of time, usually per day (McDonald *et al.*, 1993). It is one of the factors which determine potential animal performance other than feed digestibility (Beever, 1993). Feed intake and its utilization in ruminants were mainly influenced by the kind of roughage and roughage to concentrate ratio in the diet (Haddad, 2005; Cantalapiedra *et al.*, 2009).

The dry matter intake of most farm animals is between 2.5 and 4% of body weight. Dry matter consumption ranges from 1.5 to 2 percent of body weight in older animals on maintenance ration to about 2.5 to 3.5 % for finishing lambs and beef cattle or as much as 3.8 to 4.0 % for dairy cow during peak production (Cunningham *et al*. 2005).The daily feed intake is influenced by body weight, % of dry matter in the feeds eaten (12-35% in forages, 86-92% in hays and concentrates), palatability, and physiological stage of the goats. It is recommended to maintain at least 12% crude fibre in the diet. The exact amount depends on the roughage to concentrate ratio. The recommended ratio for goats is 60% roughage to 40% concentrate (Lakpini, 2002; Ogundipe, 2002).

2.11 Effect of browse plants on nutrient intake, digestibility and nitrogen balance

Voluntary intake is inversely related to the fibre content and directly proportional to chemical composition of herbages consumed which affect the survivability and productivity of animals (Van Soest, 1994). Several authors (Kawashima *et al*., 2007; Abidi *et al.*, 2009 and Riaz *et al*., 2014) reported that the CP concentration of diets had a positive effect on DMI and digestibility while fibre fractions depressed DMI of the animals.

Manaye *et al.* (2009) showed that there was improvement in intake, digestibility and body weight gain when a low-quality grass is supplemented with tree leaves. Okoli *et al*. (2003) reported that browses contain low to moderate ADF and NDF values which make them more available for degradation by rumen microbes.

Abdu *et al.* (2012) who reported decrease in CP digestibility with increasing Gmelina leaf meal in the diets of Red Sokoto bucks. Anbarasu *et al*. (2004) reported that most browse leaves have high crude fiber (CF) content, and attributed it to high cell-wall constituents usually present in browse leaves.

Similarly, the results of Adegun (2014) showed that nitrogen intake values of browse plants ranged from 6.08 g/day in *M. oleifera* to 6.20 g/day in *G. sepium* and *M. oleifera* mixture which were significantly higher ($P<0.05$) than the nitrogen intake of sheep on control diet (4.79 g/day).

Nitrogen retention is the proportion of nitrogen utilized by farm animals from the total nitrogen intake for body process, hence the more the nitrogen is consumed and digested the more the nitrogen retained and vice versa, as observed by Okeniyi *et al.* (2010). Kaswari *et al*. (2007) suggested that losses of N in urine are mainly caused by an oversupply of CP and/ or an imbalance in the supply of amino acids. The positive N retention indicates that the intake of nitrogen-containing compounds exceeds loss of N from the body, and the rations can meet the requirement of the goat.

Reduced nitrogen excretion in the urine was reported to be an indication that diet was well balanced in energy and protein which were attributed to better nitrogen retention (Noblet and Van Milgen, 2004). Okoruwa and Adewumi (2010) reported nitrogen retention values of 17 to 79%.

Aye and Tawose (2015) reported nitrogen balance ranged from 3.89g/d to 8.24g/d while the nitrogen retention values ranged from 52.63g/d to 75.11g/d in the study with Gmelina leaf meal. Swan and Lamming (1967) reported reduced nutrient digestibility as a result of increased passage rate at higher levels of supplementation. Reports of authors asserted that there were better production outcomes in browse mixtures than single browses as a result of improved palatability due to the combination of two fodders (Asaolu *et al*., 2012; Adegun, 2014).

2.12 Hematological Parameters

Blood is a bodily fluid in animals that delivers necessary substances such as nutrients and oxygen to the cells and transports metabolic wastes product away from same cells. The various functions are made possible by the individual and collective actions of its constituents- the biochemical and hematological components. Whatever affects the blood; drug, disease or nutrition will certainly affect the entire body adversely or moderately in terms of health, growth, maintenance or reproduction (Oke *et al.*, 2007; Gupta *et al.*, 2007).

Haematological studies represent a useful tool in the investigation of the extent of damage to the blood (Ogunbanjo *et al*., 2009). Etim *et al.* (2014) reported that it provides the opportunity to clinically investigate the physiological, nutritional and pathological status of an animal.

Nutrition, age, sex, breeds, reproductive status, housing stress and environmental factors are known to affect the haematological and biochemical parameters in farm animals (Addass *et al.*, 2010, Daramola *et al.*, 2005). Iriadam (2007) reported that nutritional status and management practices can influence the physiological attributes and ability of animals to cope with stress.

2.12.1 Importance of Haematological Evaluation of Animals in Nutrition

The importance of examining blood for their constituents and the use in monitoring and evaluation of health, reproduction and nutritional wellbeing of animals has been well documented (Gupta *et al.*, 2007; Opara *et al.*, 2010 and Tambuwal *et al.*, 2002). Reports of Daramola *et al.* (2005) and Addass *et al.* (2010) have documented the haematological parameters of indigenous goats.

The nutritional value of a feedstuff could therefore be reflected through parameters such as: white blood cell (WBC), red blood cell (RBC), packed cell volume (PCV), haemoglobin (Hb), mean corpuscular haemoglobin (MCH), lymphocytes, and neutrophilis. The full blood count (FBC), sometimes referred to as a full blood examination or complete blood count, is one of the most commonly performed blood tests, as it cantell us so much about the status of our health. It is important for diagnosing conditions in which the number of blood cells is abnormally high or abnormally low, or the cells themselves are abnormal.

2.12.2. Red blood Cell

Red blood cell is erythrocyte which contains haemoglobin responsible for transportation of oxygen from lungs to the tissues and carbodioxide from tissues to the lungs. It gives the blood its red colour (Ologun and Ikeobi, 2006). Etim *et al.* (2014) reported that a decrease in the red blood cell count indicated a reduction in the level of oxygen that would be carried to the body tissues. Red blood cell test can help in diagnosis of anaemia and other conditions affecting red blood cells (Bunn, 2011). Red blood cell test provides information about the haemoglobin content and size of red blood cells which abnormal values of the red blood cells indicate the presence of anaemia (Gernsten, 2009).

2.12.3. Packed Cell Volume

Packed Cell Volume is derived from the red blood cell. Anaemia is reflected when the mean ratio of red cell in fluid is below normal in the blood or when there is a fall in packed cell volume below the minimum range of the wide species study. Haemo-concentration is the opposite of anaemia and results when packed cell volume exceeds the maximum of the normal range. Decrease in fluid could arise as a result of lowered intake of water or excess loss of water, thereby increasing red blood cell concentration (Chineke *et al*., 2006 and Etim *et al*., 2014). Reduction in packed cell volume and red blood cell values are indicative of low protein intake or mild anemia.

2.12.4. Haemoglobin

Haemoglobin is the protein molecule in the red blood cells that carries oxygen from the lungs to the body's tissues and returns carbon dioxide from the tissues back to the lungs (Ugwuene, 2012; Soetan *et al*., 2013 and Isaac *et al*., 2013). Haemoglobin deficiency decreased blood oxygen carrying capacity (Etim *et al.,* 2013). Haemoglobin concentrations are also indicative of adaptation of adverse environmental conditions (Kumar and Pachaura, 2000). According to Minka and Ayo (2007) haematological values are used to assess stress and welfare in animal.

Results of Bello and Tsado (2013) reported that haemoglobin values within normal range imply that the dietary proteins fed to animals were of high quality and adequate.

2.12.5. White Blood Cell

White blood cell is an intrinsic body defense system. They are also produced in the bone marrow and carried in the blood stream. The major functions of the white blood cell and its differentials are to fight infections, defend the blood by phagocytosis against invasion by foreign organisms and to produce or at least transport and distribute antibodies in immune response. Thus, animals with low white blood cells are exposed to high risk of disease infection. A low level of white blood cell in the blood could be as a result of no disease condition or fall in the production of defensive mechanism to combat infection (Eheba *et al.* 2008 andSoetan *et al*. 2013). High WBC count is usually associated with microbial infection or the presence of foreign body or antigen in the circulating system. Furthermore, Reilly (1993) reported that normal range of values for WBC indicated that the animals were healthy because decrease in number of WBC values below normal range is an indication of allergic conditions, anaphylactic shock and certain parasitism.

Animasheun *et al.* (2006) emphasized that nutritional studies should not be limited to only performance, carcass characteristics and nitrogen balance but its effect on blood constituents is also of great importance. Clifford and Briggs (2007) reported that the comparison of an animal's haematological and biochemical values with reference interval provides evidence for numerous conditions such as reflection, malnutrition and stress.

Laboratory tests on blood are very good to detect any deviation from the normal in the animal body (Alemede, 2010). The dietary content and form in which the feed is fed (processing method) can affect the blood profile of animal's health (Ajao *et al.,* 2013 and Aya *et al.,* 2013). Gramb *et al*. (2011) similarly reported that haematological component are influenced by the quantity and quality of feed fed to the animals.

Amata (2010) reported that partial replacement of energy and protein sources from conventional feeding materials by browse leaf meal had no effects on hematological and serological characteristics.

Blood chemistry constituents reflect the physiological responsiveness of the animal to its internal and external environments which include feed and feeding (Esonu *et al*., 2001; Iheukwumere and Okoli, 2002). Diets containing poor protein would usually result in poor transportation of oxygen from the respiratory organs to the peripheral tissues (Roberts *et al*., 2000). Total serum protein has been reported as an indication of the protein retained in the animal body (Esonu *et al*., 2001), while total blood protein and creatinine contents have been shown to depend on the quantity and quality of dietary protein (Awosanya *et al*., 1999; Esonu *et al*., 2001).

2.13 Linear body measurement

Linear body measurement is a method of evaluating livestock especially important in rural areas where weighing scales are not conveniently available (Sowande and Sobola, 2008; Yakubu, 2010). It has been used in animals to estimate body weight (Afolayan *et al.*, 2006; Prasad and Neeraj, 2008) and price of animals in open markets (Iyiola-Tunji *et al.,* 2011). It can be used to examine economic characteristics and reproductive performance (Akpa, 2000; Ozoje and Mgbere, 2002). Ozoje and Mgbere (2002) reported that linear body measurement like height at withers, shoulder width, and heart girth as good indicator of live weight and condition score. It can also be used to predict reliably body weight without the use of weighing scales (Chineke, 2005). It is important for a herdsman to have reasonable skill in estimating weight as it will frequently be necessary to know weights when a weighing scale is not readily available or its use is not practically feasible (Singh and Mishra, 2004). The weight of the animal is very important in the computation of balanced ration, determination of growth and assessment of its health status.

Linear body measurement is influenced by breeds, age, and sex of the animal (Otoikhian *et al*., 2008; Semakula *et al*., 2010). Otoikhian *et al*. (2008) also reported that body weight of goats can be assessed up to 74.29 percent by regressing body measurement of the animal on its body weight without the farmer having to contend with the difficult process of weighing the animal.

It therefore implies that the results from body measurement studies can be utilized by farmers to make varied records as well as support standard marketing process in goat production (Otoikhian *et al*., 2008; Iyiola-Tunji *et al.,* 2011). The biometric parameters commonly used in predicting body weight (BW) in small ruminants include: body length (BL), chest girth (CG) and height at withers (HW) (Eghahi *et al*., 2011). According to Akpa *et al.* (2011), growth is the sum total of increase in size of different structural body components measured from gain in body weight and linear body measurements. According to Otoikhian *et al*. (2008), there is positive relationship between parameters such as ear length and weight; tail length; distance between eyes and body weight in goats.

2.14 Importance of Body Condition Score in Livestock Production

Body condition scoring (BCS) is a means of evaluating an animal based upon muscle and external fat cover. The evaluation is accomplished by assigning a score to the amount of fat observed on several skeletal parts of an animal. The two most common scoring systems for body condition for sheep and goats range from 1 to 5 or from 1 to 9, (Pennington, 2010). The two systems utilize a middle point of 3 or 5, respectively, as neither too fat nor too skinny. However, most small ruminant producers use 1-5 system.

Body Condition Score is a simple, useful procedure that producers can use to make management decisions regarding the health of their animals and the quality and quantity of feed needed to optimize performance (Girma and Alemu, 2012). Nutrition had been reported as key factor for increased conception and subsequent lambing and kidding (Rosa and Bryant, 2002 and Deribe, 2009).

Body condition score is a subjective way to evaluate the nutritional status of a flock (Zahraddeen *et al.,* 2008) and acts as a potential indicator for goat owners to increase the production efficiency in their flock (Sejian *et al*., 2010). The nutritional status or balance of an animal, evaluated through BCS, reflects the body reserves available for basic metabolism, growth, lactation and activity. When goats have low body energy reserves they may have a greater probability of suffering from diseases, metabolic disorders, reproductive failure and reduction in milk yield. It is not good for an animal to be too thin or too fat. Healthy sheep and goats in most cases should have a BCS of 2.0 to 3.5. Research by Villaquirán *et al.* (2012) recommended a BCS of 3.0 to 3.5 as optimal for goats in the breeding season. It has been observed that does with good body condition have greater ovulation rate than does with lesser body condition (Meza-Herrera *et al*., 2008). A body condition score below 2.0 is an indication of management or health problem. Girma (2007) reported that a BCS of 4.5 or 5 is almost never observed under normal management conditions. Reports of Mehmet and Şeniz Öziş (2013) concluded that a herd of goat that is in good body condition will not only produce more, but will also be less susceptible to metabolic disorders, diseases, mastitis and reproductive problems.

Important times to condition score animals include pre-breeding, mid-gestation, early lactation, weaning, and before sale. Body condition at mating is important as animals in poor condition may have difficulty conceiving and have fewer offspring. There are reports indicating a positive correlation between BCS at mating and reproductive performance (Sejian *et al*., 2010 and Yilmaz *et al*., 2011). Good condition of does brings about viability and survivability of kids. Zahraddeen *et al.* (2008) observed that kids from does with good body conditions tend to be superior in weight during all stages of life. It is advisable to evaluate animals to prevent drastic losses in production and optimize productivity.

2.14.1 Factors affecting birth weight in Small Ruminants

Birth weight is the single most important factor determining postnatal survival. Extremely heavy birth weight is more associated with dystocia, while lighter birth weight kids, typical of twins and triplets, have higher mortality rates (Turkson *et al*., 2004). Birth weight of animals is one of the most important factors influencing the pre-weaning growth of the young and has a positive correlation between birth weight and subsequent live body weight development (Awgichew, 2000; Deribe, 2009).

The most important effects on birth weight in small ruminants are breed, the dam's age and litter size (Gardner *et al*., 2007 and Zahraddeen *et al*., 2008), however, birth weight is highly dependent on the dam's nutrition and in particular energy intake during the last month of the pregnancy. Inadequate energy intake during this period results in reduced birth weights which in turn affect the kids' survivability (Huston, 2002). Mortality in multiple births is attributed to low energy reserve which renders the kid susceptible to harsh environmental conditions (Aganga *et al*., 2005). However, variations in birth weight maybe due to dam age and birth type (Ince, 2010).

2.14.1 Breeds

Research of Zahraddeen *et al*. (2008) showed that birth weights of indigenous Nigerian goats vary according the breeds. The authors reported that Sahelian does had the largest weight at birth (1.91kg) followed by Red Sokoto (1.76kg) which was significantly higher than that of West African Dwarf goats (1.65kg).

2.14.2 Sex

Zahraddeen *et al.* (2008) reported higher birth weight for males than females in their work with Nigerian indigenous goats. Heavier birth weight for male implies that sex effects are pronounced even at birth (Otuma, 2005). Zhou *et al*. (2003) in their research with Mongolia cashmere goats recorded significantly higher birth weight for males compared to the females. The heavier weight of the male compared to the female is reported be associated with the anabolic effect of the male hormone androgen, unlike the depressing effect of estrogen of female animals (Nwakalor *et al.,* 2000).

2.14.3. Litter size

Litter size of animals increased with parity. Incidence of twining, triplets and so on increased with increasing parity. Earlier reports by Awemu *et al*. (1999) obtained litter size for Red Sokoto does in 1, 2, 3, 4, 5, and 6th parity were 1.8, 2.0, 1.8, 1.9, and 1.8, respectively. Litter size affects the birth weight of the animals. Results of Netsanet *et al.* (2016) reported that the differences in birth weight in different litter size might be due to the small size and weight of the twin in the uterus. Earlier works of Robinson *et al.* (1981) and Das *et al*. (1996) reported that for kids in the uterus, that as the number of fetuses increases, the number of caruncles attached to each fetus decreases, thereby reducing the feed supply to the fetus and hence a reduction in the birth weight. Litter size reduces the birth weight and survival rate of indigenous South African goat kids (Lehloenya *et al*., 2005).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Experimental Site

The experiments were conducted in the Experimental Unit of the Small Ruminant Research Programme of the National Animal Production Research Institute (NAPRI), Shika, Zaria, Kaduna State, Nigeria. Shika is located on latitude 11º 10´57.43´´N and longitude 7º 36´ 16.64´´ E, with an altitude of 640m above sea level (GPS, 2015). It has an average annual rainfall and temperature of 1107 mm and 24.4°C respectively. The seasonal distribution of rainfall in Shika is approximately 0.1 % (11.0 mm) in the late-dryseason (January–March), 25.8 % (285.6 mm) in the early-wet season (April–June), 69.6 % (770.4 mm) in the late-wet season (July– September) and 4.5 % (49.8 mm) in the early dry season (October–December). Maximum air temperature of 37°C is recorded in May and minimum air temperature of 11.5°C recorded in December/January and relative humidity of approximately 70% during the rainy season (IAR, 2015).

3.2 Preparation of Feed

Fresh *Gmelina arborea* (GM) leaves were harvested within Ahmadu Bello University Main Campus, Samaru from October 2014 to March 2015. Leaves were allowed to air-dry for three days. Dried Moringa leaves were sourced from Sabon-Gari market, Zaria. *Digitaria smutsii* (Wooly finger grass) hay was sourced from the Forage Production Unit, NAPRI. The dried leaves and *D. smutsii* hay were ground with a hammer mill fitted with 2cm screen for easy mixing with other feed ingredients. The ground ingredients were packed in sacks and stored in a well-ventilated store room.

3.3 Experiment 1: Growth Performance of Red Sokoto bucks fed inclusion levels of mixed Gmelina (*Gmelina arborea*) and Moringa (*Moringa oleifera*) leaf meal in *D. smutsii* hay based diets

3.3.1 Experimental animals and management

Twenty (20) bucks between 4 and 5 months of age with an average weight of 12.00±0.20 kg were used. The animals were obtained from Small Ruminant Research flock, NAPRI. They were individually penned and given prophylactic treatment, consisting of Ivermectin® at 200µg/kg body weight (BWT) against endo and ectoparasites and Terramycin Long Acting (LA) ® at 20mg/kg BWT against bacterial diseases 7 days before the commencement of the experiment.

3.3.2 Experimental treatments, design and feeding of animals

Four isonitrogenous complete diets were formulated, with 40% *D. smutsii* hay base. The complete diets were compounded to contain 13% CP. *Gmelina arborea and Moringa oleifera* leaf meals were mixed at a ratio of 3:1, respectively. The mixed leaf meal was included at 0, 10, 20 and 30%. Each level of inclusion served as a treatment. Other ingredients in the complete diet include maize offal, cotton seed cake, common salt and bone meal (Table 3.1).

The diets were mixed fortnightly to maintain freshness and samples were taken to determine the chemical composition. Animals were weighed, balanced for weight and randomly alloted to the four treatments with five animals per treatment in a completely randomized design. Each animal served as a replicate.

The experimental animals were offered their daily ration at 4% of their body weight at 8:00 hr, daily. The bucks were weighed on weekly basis.

Table 3. 1: Ingredient Composition of Experimental diets (%) fed to Growing Red Sokoto goats

Ingredients	Level of GMMO leaf meal inclusion (%)			
	0	10	20	30
75GM:25MO	0	10	20	30
Cottonseed Cake	23.40	20.00	16.00	12.30
Maize offal	34.60	28.00	22.20	15.80
Bone meal	1.5	1.5	1.5	1.5
Common salt	0.5	0.5	0.5	0.5
D.smutsii hay	40	40	40	40
Total	100	100	100	100
Calculated analysis				
% Crude Protein	13.01	13.06	13.02	13.00
Cost/kg feed (₦)	44.14	40.63	37.12	33.52

75 GM: 25 MO= 3:1 mixture of Gmelina and Moringa leaf meal.

Weight changes were recorded as the difference between weight of the previous week and the current. Weekly weights of the bucks were used in adjustment of the quantity of feeds offered, in order to maintain the pre-determined level.

The animals had free access to clean drinking water. The growth trial was carried out for a period of 90 days after 14 days adjustment period. Daily feed intake and weekly body weight of the animals were recorded before feeding in the morning throughout the experiment.

3.4 Blood Sampling and Analysis

Blood samples (5ml) were collected from three randomly selected bucks per treatment at the beginning, middle and end of the experiment through the jugular vein using a 5 ml syringe. Two ml of the blood sample collected was transferred into a sampling bottle containing ethylene diamine tetra acetic acid (EDTA) as anti-coagulant and was shaked gently to ensure easy mixing of blood with the anti-coagulant. The blood samples collected were taken to the Veterinary Teaching Hospital, Ahmadu Bello University, Zaria for determination of haematological parameters. The packed cell volume (PCV), red blood cell (RBC), white blood cell (WBC) and haemoglobin (Hb) counts were determined as outlined by Schalm *et al*. (1975) and Kelly (1979).

3.5 Evaluation of Blood Biochemical Constituents

The remaining blood sample (3ml) was poured into plain bottle and allowed to clot at room temperature within 3 hours of collection. Plasma was separated by centrifugation at 3500 revolutions per minute (r.p.m) for 15 min and serum was thereafter frozen at -20ºC for the determination of total protein, albumin, total cholesterol, glucose, creatinine and urea nitrogen with the use of Elisa Multiplex Commercial Kits (Pfizer Animal Health, New York, NY).

The serum biochemical assay was carried out using standard chemical procedures: Total serum protein (TP) by Golgberg refractometer method (Kohn and Allen, 1995), albumin (Alb) by Bromocresol green method (Peters *et al*., 1982), creatinine (Cr) (Boisness and Taussky, 1985), blood urea nitrogen (BUN) (Baker and Silverton, 1985), serum glucose (Gl) (Toro and Ackerman, 1979). Creatinine (Cr) was determined by the Jaffe reaction method of Seaton and Ali (1984) and cholesterol (Cho) was determined using the procedure described by Kaneko (1989). The globulin values were obtained by subtracting the values of albumin from the corresponding values of total protein (Coles, 1974).

3.6 Feed Cost Analysis

Market prices in Zaria and its environs were used to determine the cost of bucks and feeds as at the time of the study trial. The costs of harvesting and transportation of Gmelina leaves were used as it is not sold in the market. Feed consumed was multiplied by cost per kg of feed to obtain the cost of feeding. The market prices were used in calculating the total cost of feeds consumed per treatment, value of gain, and net benefit.

3.7 Metabolism Trial

Twenty (20) intact Red Sokoto bucks (same bucks used for growth trial) were used for metabolism trial. The animals were housed in individual metabolism cages with facilities for separate collection of feces and urine as described by Osuji *et al*. (1993). Each buck was individually offered its appropriate ration to evaluate the digestibility of the diets. The study comprised of 7 days preliminary period of adjustment to the cage and 7 days of sample collection.

The fecal and urine samples were collected each morning just before feeding. Urine samples were collected into plastic containers acidified with 25ml of 10% of H_2SO_4 acid to trap ammonia. Urine collected was recorded and 10% of total daily urine collected was sub-sampled and kept for each animal at -4°C in a freezer. Daily total fecal samples were also collected from each animal, weighed, sub-sampled and stored in polythene bags. At the end of the 7 day collection period, the fecal and urine samples were separately bulked, mixed thoroughly and sub-sampled for each animal. The samples were kept at -4°C in freezer until required for chemical analysis.

Nutrient digestibility was calculated as the portion of nutrient intake not recovered in faeces. Nitrogen retention (NR) was calculated as the amount of average daily nitrogen intake (NI) not excreted in feces (FN) and urine (UN).

$$\text{Apparent digestibility} = \frac{\text{Nutrient intake-Nutrient output}}{\text{Nutrient intake}} \times 100$$

Where Nutrient intake (g) =Feed intake × Nutrient in diet; Nutrient output (g) =Faecal output × Nutrient in faeces.

NR = NI (g/d) – (FN + UN) (g/d)

3.8 Experiment 2: Growth Performance of Red Sokoto does fed inclusion levels of mixed Gmelina (*Gmelina arborea*) and Moringa (*Moringa oleifera*) leaf meal in *D. smutsii* hay based diets

3.8.1 Experimental animals and management

Twenty eight (28) does aged between 6 and 7 months with a mean weight of 14.71±0.09 kg were used with 7 animals per treatment. The management and feeding of animals were the same as described in experiment 1. The animals were kepton the experimental diets for a period of 60 days, after 14 days adjustment period.

3.8.2 Body linear measurement of Red Sokoto does

Body linear measurements of 28 does were recorded forthnightly during the growth trial. They were recorded in centimeter using a measuring tape.

Height at wither (WH): Vertical distance from ground to the point of withers measured vertically from the ridges between the shoulder bones to the fore hoof.
Body Length (BL): This was measured as the distance between points of shoulder to the point of hip that is the distance from the first thoracic vertebrae to the base of tail.
Shoulder width (SW): is the horizontal distance between the two shoulders.

Chest girth: This was measured as the circumference posterior to the forelegs at right angles to the body axis. Body measurements were carried out according to the methods of Salako *et al*., (2007).

3.9.1 Estrus Synchronization and mating of Does

The estrous cycles were synchronized using combination of Controlled Internal Drug Release (EAZI-BREEDTM, CIDR®, New Zealand) and Synchromate® injection (synthetic prostaglandin). Controlled Internal Drug Release (CIDR) device containing 330 mg Natural progesterone was inserted into the vagina of the does using special applicator. The vulva of the does was cleaned to avoid introducing dirt into the vagina. The inserts were left in place for seven days, on removal, 250μg Synchromate® (Cloprostrol Sodium) synthetic prostaglandin was administered intramuscularly (IM) per doe (Romano, 2016).Three Red Sokoto breeding bucks were introduced to the does at the end of the synchronization and they were naturally mated.

3.9.2 Pregnancy Diagnosis

The does were examined to confirm pregnancy using Ultrasound machine by an experienced personnel from Diagnostics Imaging Centre, Veterinary Teaching Hospital, Ahmadu Bello University, Zaria. Ultrasound waves were converted to electrical energy in the form of audible or visual signal. These units detect fluid-filled organs at a depth of 10-20cm. The transducer was placed low in the right flank near the udder of the doe. Clipping a small area of hair in this region allowed optimal contact. A coupling agent (commercial ultrasonic gel) was applied to the transducer to eliminate air space between the skin and the transducer head. The pregnancy diagnosis was performed on the 67th day after mating because there was need to determine pregnancy and fetal numbers.

3.10 Experiment 3: Performance of pregnant Red Sokoto does fed inclusion levels of mixed Gmelina (*Gmelina arborea*) and Moringa (*Moringa oleifera*) leaf meal in *D. smutsii* hay based diets

Twenty- four (24) pregnant does aged between 13 and 14 months with a mean weight of 22.50 ±0.12 kg were randomly assigned to four treatments with six animals (in their last trimester of pregnancy) per treatment in a completely randomized design.

The feeding of the animals was the same as in experiment 1 except that the experimental diets were formulated to contain 15% CP to meet the requirements of the pregnant does (Table 3.2). The experimental diets were offered at 4% of BWT to all the animals. Water was provided *ad libitum* to the animals. The does were adjusted to the experimental diets for 14 days before data collection. The does and kids were weighed after parturition (kidding).

3.11 Milk Sample Collection

Milk samples (50ml) were collected from three does per treatment 7 days after parturition using hand-milking. This was to allow the kids suckle in order to get colostrum. The samples were immediately taken to the laboratory and refrigerated to avoid deterioration before analyses.

Table 3. 2 : Ingredient Composition of Experimental diets (%) fed to pregnant Red Sokoto does

Ingredients	Levels of GMMO leaf meal inclusion (%)			
	0	10	20	30
75GM:25MO	0	10	20	30
Cottonseed Cake	34.40	30.50	26.70	23.00
Maize offal	23.60	28.00	11.30	5.00
Bone meal	1.50	1.50	1.50	1.50
Common salt	0.50	0.50	0.50	0.50
D.smutsii hay	40	40	40	40
Total	100	100	100	100
Calculated analysis				
% Crude Protein	15.10	15.05	15.02	15.02
Cost/kg feed (₦)	45.79	42.21	38.64	35.08

75 GM: 25 MO= 3:1 mixture of Gmelina and Moringa leaf meal.

3.12 Chemical analysis

The feeds and faecal samples were analyzed for Dry Matter (DM), Crude Protein (CP), Ether Extract (EE), Crude Fibre (CF), and Ash using the procedures outlined by the Association of Official Analytical Chemists (A.O.A.C., 2005). Acid Detergent Fibre (ADF) and Neutral Detergent Fibre (NDF) were determined according to Van Soest *et al.* (1991) procedures. Urine N was determined using Micro Kjeldal method (A.O.A.C., 2005).

The anti-nutritional factors; tannins were determined using Folin Ciocalteu as described by Makkar (2000), saponins and alkaloids were determined according to A.O.A.C. (2005), oxalates (Oke, 1969) and phytates (Reddy *et al*., 1982) on experimental diets.

Milk composition (total solid, fat, crude protein and ash) were determined by method outlined by A. O. A. C. (2005). Solid non fat (SNF) was calculated as total solid minus fat. The lactose content was calculated as Total solid-(Protein+Fat +Ash).

3.13 Statistical Analysis

All data generated on dry matter intake, live weight, nutrient digestibility, nitrogen balance, cost benefit, birth weight and milk composition were analyzed statistically using the General Linear Model (GLM) Procedure of SAS (2005). Significant differences between treatment means were determined according to Duncan's Multiple Range Test of SAS (2005). The model used was:

$Y_{ij} = \mu + t_j + e_{ij}$,

Y_{ij} is the response of animal i in treatment j

μ is the overall mean, t_j is the fixed effect of jth treatment (j=0, 10, 20, 30)

e_{ij} is the random error

Repeated model was used to analyze the haematological and serum parameters which were collected at three periods (beginning, middle and end of experiement).

Repeated model below was used:

$Y_{ijk} = \mu + t_j + p_k + (t*p)_{jk} + e_{ijk}$

$Y_{ijk} =$ the response of animal i in treatment j at the period k;

μ = overall mean;

$t_j =$ a fixed effect of the j^{th} treatment (0%, 10%, 20%, 30%);

p= the fixed effect of the k^{th} period (beginning, middle, end);

$(t*p)_{jk} =$ the interaction between the j^{th} treatment and kth period;

$e_{ijk} =$ the random error.

CHAPTER FOUR

4.0 RESULTS

4.1. Chemical composition of *Gmelina arborea, Moringa oleifera* leaf meal, the mixture and major feed ingredients

The result of the chemical composition of Gmelina leaf meal (GLM), Moringa leaf meal (MOLM), mixtures and other major feed ingredients are presented in Tables 4.1. The DM content of the feed ingredients ranged from 91.20% (CSC) to 97.36% (*D. smutsii* hay). The CP of GLM, MOLM and the mixture were 14.50%, 26.47% and 17.17%, respectively while Cotton Seed Cake, Maize offal, and *D.smutsii* hay had 28.94%, 11.00% and 5.50%, respectively.

Neutral Detergent Fibre of the feed ingredients ranged from 22.79 to 67.06% in MOLM and *D. smutsii* hay respectively. Acid Detergent Fibre content of the major feed ingredients varied 11.09% (MOLM) to 46.39% (*D. smutsii* hay). The ash contents were 9.33%, 7.68%, 8.68%, 7.54%, 6.67% and 9.15% in GLM, MOLM, the mixture of GLM and MOLM, CSC, Maize offal and *D. smutsii* hay, respectively.

4.2. Chemical composition (%) of experimental diets fed to growing Red Sokoto bucks

The chemical composition (%) of experimental diets fed to growing Red Sokoto bucks is shown on Table 4.2. The dry matter content varied from 93.90 to 94.44% across the treatments. The crude protein content of 13.09%, 13.00%, 13.15% and 13.25% were recorded for 0%, 10%, 20% and 30% levels of GMMO leaf meal inclusion in the diets, respectively. Ash content ranged from 6.47 to 6.85%, while NDF and ADF varied from 41.59 to 46.22 and 22.56 to 26.94 %, respectively.

Table 4.1 Chemical composition (%) of major feed ingredients used for the experiments

Parameters	Gmelina leaves	Moringa leaf meal	3GM:1 MO	CSC	Maize offal	*D.smutsii* hay
Dry matter	96.23	94.85	96.17	91.20	91.56	97.36
Crude protein	14.50	26.47	17.94	28.94	11.00	5.50
Crude fibre	17.00	11.51	14.89	23.50	13.38	30.80
Ash	9.33	7.68	8.68	7.54	6.67	9.15
Ether Extract	3.78	4.03	3.8	6.96	6.88	2.99
NDF	49.31	22.79	46.45	48.45	46.62	67.06
ADF	27.99	11.09	21.50	39.84	21.85	46.39

NDF=neutral detergent fibre; ADF=acid detergent fibre. 3 GM: 1 MO= 3:1 mixture of Gmelina and Moringa leaf meals

Table 4. 2: Chemical composition (%) of experimental diets fed to growing Red Sokoto goats

Parameters	Levels of GMMO leaf meal inclusion (%)			
	0	10	20	30
Dry matter	94.44	94.10	93.90	94.08
OM	87.59	87.63	87.19	87.23
Crude protein	13.09	13.00	13.15	13.25
Crude fibre	27.43	25.26	23.27	28.23
Ash	6.85	6.47	6.71	6.85
Ether Extract	7.91	5.66	5.08	5.88
NDF	41.59	46.22	45.71	43.51
ADF	22.56	26.94	26.41	24.51

OM= Organic Matter; NDF=neutral detergent fibre; ADF=acid detergent fibre.

4.3. Anti-nutrients contents of Gmelina leaf meal (GLM), Moringa leaf meal (MOLM) and experimental diets fed to growing Red Sokoto bucks

Table 4.3 shows the result of anti-nutrients contents of GLM, MOLM and experimental diets fed to growing Red Sokoto bucks. Tannin, phytate and oxalate concentrations varied from 0.37 to 1.97 mg/100g, 0.32 to 1.44 mg/100g and 0.56 to 3.00 mg/100g, respectively. Alkaloid content increased with increasing level of GMMO leaf meal in the experimental diets. Saponin contents of GLM and MOLM were 1.52 mg/100g and 1.70 mg/100g, respectively but there was no trend in the experimental diets.

4.4 Effect of mixed Gmelina (*Gmelina arborea*) and Moringa (*Moringa oleifera*) leaf meal inclusion on dry matter intake and growth performance of Red Sokoto bucks fed *D. smutsii* hay based diets

The growth performance parameters of Red Sokoto bucks fed *D. smutsii* hay based diets containing levels of GMMO leaf meal are presented in Table 4.4. The daily feed intake was significantly higher ($P<0.05$) in animals fed 30% GMMO leaf meal compared to those on 0%. Daily feed intake ranged from 237.79g/d in 0% to 330.17g/d in animals on diet containing 30% leaf meal. Dry matter inake (g/kg $W^{0.75}$) was significantly ($P<0.05$) higher in animals fed GMMO leaf meal than those on 0%. Weight gain and average daily gain increased with increasing level of mixed Gmelina and Moringa leaf meal inclusion up to 20% and declined. Weight gain varied from 2.86 to 4.20kg while average daily weight gain ranged from 31.78 to 46.67 g/d in animals fed diets with 0% and 20% leaf meal respectively. Feed conversion ratio was significantly ($P>0.05$) across the treatments. Feed conversion ratio was better in animals fed 10% and 20% GMMO leaf meal inclusion levels. Figure 4.1 shows the trend analysis of the inclusion of mixed Gmelina and Moringa leaf meal in the diets of Red Sokoto bucks. The optimum level of inclusion of GMMO in the diets of growing Red Sokoto bucks was 21.95% as obtained by regression equation.

Table 4.3: Anti-nutrients contents of Gmelina leaf meal, Moringa leaf meal and experimental diets fed to growing Red Sokoto bucks in (mg/100g)

			Levels of GMMO leaf meal inclusion (%)			
Anti-nutrients	GLM	MOLM	0	10	20	30
Tannins	0.43	0.37	0.96	1.43	1.76	1.97
Phytate	0.32	0.50	0.72	0.95	1.06	1.44
Oxalate	1.25	0.56	1.32	2.26	2.40	3.00
Alkaloid	1.38	2.48	2.41	2.68	2.85	2.96
Saponin	1.52	1.70	1.20	1.54	1.79	1.50

GLM=Gmelina leaf meal; MOLM=Moringa leaf meal; GMMO=Mixture of Gmelina and Moringa leaf meal.

Table 4.4: Effect of GMMO leaf meal inclusion levels on dry matter intake and growth performance of Red Sokoto bucks fed *D. smutsii* hay based diets

	Levels of GMMO leaf meal inclusion (%)				
Parameters	0	10	20	30	SEM
Feed intake (g/d)	237.79^{b}	260.11^{b}	296.86^{ab}	330.17^{a}	29.58
DMI (g/kgW $^{0.75}$)	31.64^{b}	38.81^{a}	36.62^{ab}	42.45^{a}	2.60
Initial weight (kg)	11.80	12.00	11.80	11.90	1.04
Final weight (kg)	14.66	15.20	16.00	15.60	1.14
Weight Gain (kg)	2.86^{b}	3.20^{ab}	4.20^{a}	3.70^{ab}	0.53
ADG (g/d)	31.78^{b}	35.56^{ab}	46.67^{a}	41.11^{ab}	5.91
FCR	7.48^{b}	7.31^{ab}	6.36^{a}	8.03^{b}	0.52

a,b, Mean values with different superscripts within a row differed significantly ($P<0.05$) SEM standard error of mean; DMI=dry matter intake; ADG=average daily gain; FCR= feed conversion ratio.

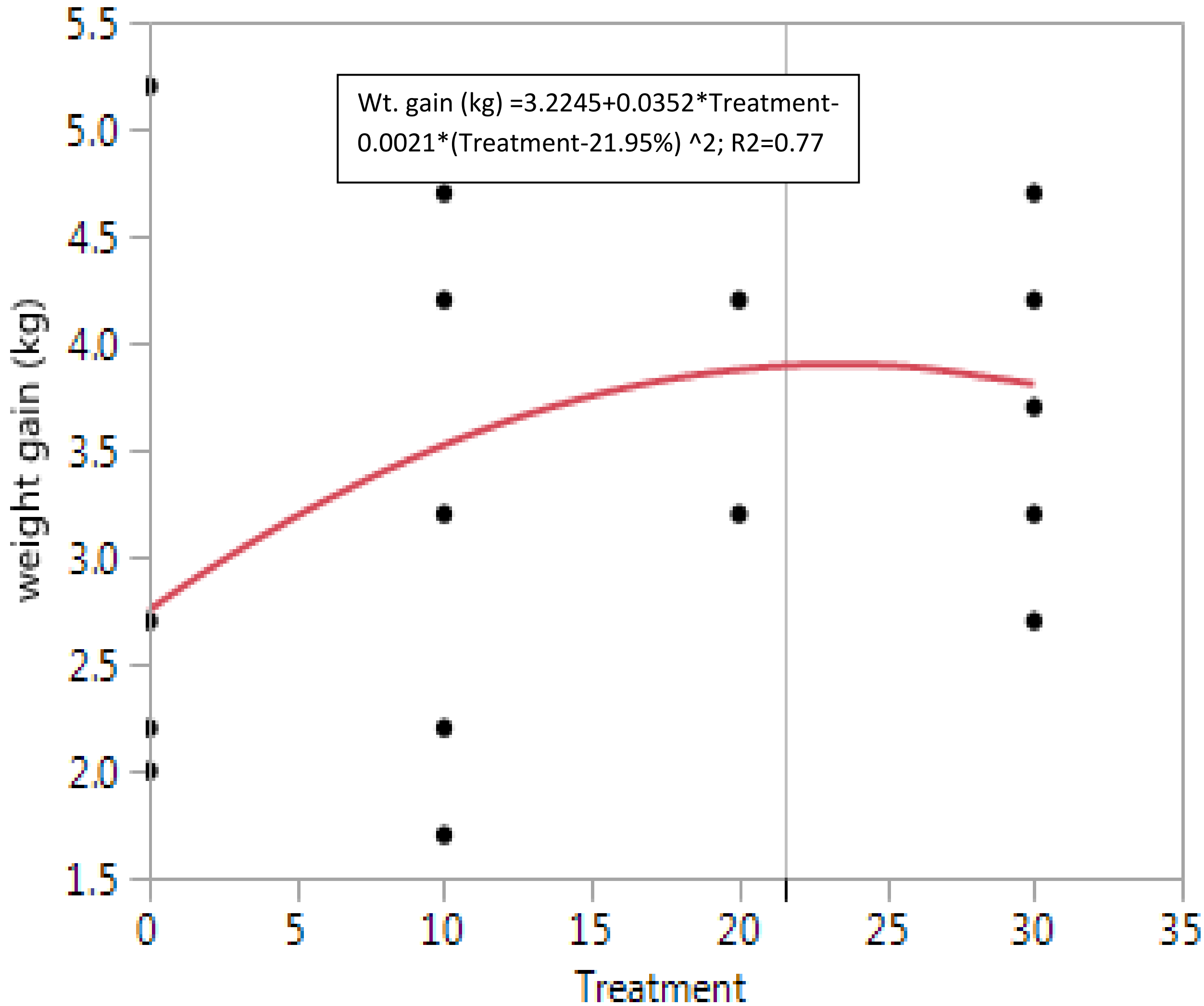

Figure 4.1: Trend analysis of inclusion of combined GMMO leaf meal in the diets of Red Sokoto bucks.

4.5 Effect of GMMO leaf meal inclusion on feed cost benefit in Red Sokoto bucks fed *D. smutsii* hay based diets

The feed cost benefit of inclusion of GMMO leaf meal in the diets of Red Sokoto bucks is shown on Table 4.5. The result showed that the net profit increased with increasing GMMO leaf meal inclusion in the diets. The analysis indicated that treatment group fed 20% Gmelina and Moringa leaf meal had the highest net profit of ₦1108.30 followed by treatment group fed 30% (₦ 853.90). The treatment group fed 10% had net profit of ₦648.90 while the control treatment group had the least net profit of ₦485.00. Reduction in feed cost/kg gain was 7.29%, 34.79% and 22.30% in treatment group fed 10%, 20% and 30% of GMMO leaf meal.

4.6 Effect of GMMO leaf meal inclusion on haematological parameters of growing Red Sokoto bucks fed *D. smutsii* hay based diets

The result of effect of GMMO leaf meal inclusion on haematological parameters of growing Red Sokoto bucks fed *D. smutsii* hay based diets is presented in Table 4.6. The dietary treatments significantly ($P<0.05$) affected the Packed Cell Volume (PCV), Haemoglobin (Hb) and Red Blood Cell (RBC). The PCV, Hb and RBC were statistically higher ($P<0.05$) in treatment groups with GMMO leaf meal than the control group. The PCV and haemoglobin varied from 31.33 to 38.56% and 8.37 to 10.82×10g/L in treatment groups fed 0% and 20%, respectively. The RBC count in this study ranged from 5.23 to 6.31×10^{12}/L in dietary treatment with 30% and 20% leaf meal inclusion, respectively. White Blood Cell (WBC) count was not affected by the dietary treatments.

Table 4.5: Effect of GMMO inclusion on feed cost benefit in Red Sokoto bucks fed *D. smutsii* hay based diets

	Levels of GMMO leaf meal inclusion (%)			
Parameters (₦)*	0	10	20	30
Total feed intake (kg)	21.41	23.41	26.72	29.72
Feed cost/kg	44.14	40.63	37.12	33.52
Total cost of feed	944.60	951.10	991.70	996.10
Cost/kg Gain	353.99	328.18	230.84	275.04
Value of gain	1430.00	1600.00	2100.00	1850.00
Net Profit	485.00	648.90	1108.30	853.90
% Reduction in feed cost/kg gain	_	7.29	34.79	22.30

* Naira = Nigerian currency (100 kobo= 1 naira); Net profit=value of gain minus feed cost.

Table 4.6: Effect of GMMO leaf meal inclusion on hematological parameters of growing Red Sokoto bucks fed *D. smutsii* hay based diets

Parameters	Levels of GMMO leaf meal inclusion (%)				SEM
	0	10	20	30	
PCV (HCT) (%)	31.33^{b}	36.56^{a}	38.56^{a}	36.55^{a}	2.12
Hb (g/dl)	8.37^{b}	10.74^{a}	10.82^{a}	10.46^{a}	0.85
RBC ($\times 10^{12}$/L)	10.21^{b}	11.54^{a}	11.47^{a}	11.41^{a}	0.45
WBC ($\times 10^{12}$/L)	5.54	5.81	6.31	5.23	0.60

a,b, Mean values with different superscripts within a row differed significantly (P<0.05), SEM= Standard Error of Means .WBC = White blood cells; RBC = Red blood cells; Hb = Haemoglobin; PCV (HCT) = Packed cell volume (Haematocrit).

4.7 Effect of GMMO leaf meal inclusion on serum biochemical constituents of growing Red Sokoto bucks fed *D. smutsii* hay based diets

Results of the effect of GMMO leaf meal inclusion on serum biochemical constituents of growing Red Sokoto bucks fed *D. smutsii* hay based diets are presented in Table 4.7. Dietary treatments did not affect the total protein, albumin, globulin, urea nitrogen, glucose and creatinine. There was significant difference ($P<0.05$) in cholesterol concentration across the treatments. The cholesterol concentration decreased with increasing level of GMMO leaf meal inclusion. Cholesterol concentration was significantly higher ($P<0.05$) in animals fed dietary treatments with 0% and 10% (106.61 and 106.50 mg/dL, respectively) than those fed 20% and 30% leaf meal.

4.8. Effect of sampling periods on haematological parameters of Red Sokoto bucks fed GMMO leaf meal inclusion levels in *D. smutsii* hay based diets

Table 4.8 shows the effect of sampling periods on haematological parameters of Red Sokoto Bucks fed levels of GMMO leaf meal in *D. smutsii* hay based diets.There were significant differences in packed cell volume and haemoglobin levels across the treatments. The PCV was higher ($P<0.05$) at the end of the experiment (36.83%) than at the middle of the experiment (33.83%) although similar to values obtained at the beginning. The haemoglobin was higher ($P<0.05$) statistically at the beginning and end of the experiment than at the middle. There were no significant ($P>0.05$) differences in red blood cell and white blood cell across the periods.

Table 4.7: Effect of GMMO leaf meal inclusion on serum biochemistry of growing Red Sokoto bucks fed *D. smutsii* hay based diets

Parameters	Levels of GMMO leaf meal (%)				SEM	Reference Range
	0	10	20	30		
Total protein	69.22	68.44	64.78	67.78	3.06	64-70g/l
Albumin	33.11	32.78	35.56	31.89	2.64	27-39g/l
Globulin	36.11	35.67	29.22	35.89	4.02	27-41g/l
Glucose	61.44	59.22	59.67	56.44	6.81	50-75mg/dl
Creatinine	105.67	105.22	97.67	113.33	8.59	88.40-159µmol/L
BUN	5.48	5.80	6.21	6.00	0.89	3.60-7.10 mmol/L
Cholesterol	106.61^{a}	106.50^{a}	84.22^{b}	82.91^{b}	5.67	80-130mg/dl

a,b,Mean values with different superscripts within a row differed significantly (P<0.05), BUN= Blood Urea Nitrogen; SEM= standard error of mean.

Table 4. 8: Effect of sampling periods on haematological parameters of Red Sokoto bucks fed levels of GMMO leaf meal inclusion in *D. smutsii* hay based diets

	Sampling periods			
Parameters	Beginning	Middle	End	SEM
PCV (HCT) (%)	36.58^{ab}	33.83^{b}	36.83^{a}	1.39
Hgb (×10g/L)	10.67^{a}	9.23^{b}	10.40^{a}	0.54
RBC ($\times 10^{12}$/L)	11.48	10.67	11.31	0.47
WBC ($\times 10^{12}$/L)	5.90	5.76	5.52	0.29

a,b, Mean values with different superscripts within a row differed significantly (P<0.05), SEM= Standard Error of Means .WBC = White blood cells; RBC = Red blood cells; Hb = Haemoglobin; PCV (HCT) = Packed cell volume (Haematocrit).

4.9 Effect of sampling periods on serum biochemical parameters of Red Sokoto bucks fed levels of GMMO leaf meal in *D. smutsii* hay based diets

Results of the effect of sampling periods on serum biochemical parameters of Red Sokoto bucks fed levels of GMMO leaf meal in *D. smutsii* hay based diets are presented on Table 4.9. Total protein and albumin were significantly (P<0.05) affected by the sampling periods. Total protein was higher (P<0.05) significantly at beginning and middle of the experiment 69.92 and 67.58 g/L than at the end of the experiment (65.17g/L). The albumin was significantly (P<0.05) higher at the beginning than other periods. There were no significant (P>0.05) differences on globulin, glucose, creatinine, urea nitrogen and cholesterol levels across the periods. There were no significant difference (P>0.05) in interaction between treatment and sampling periods.

4.10 Apparent nutrient digestibility in Red Sokoto bucks fed *D. smutsii* hay based diets containing levels of GMMO leaf meal

The results in Table 4.10 showed that apparent nutrients digestibility was high across the dietary treatments. Digestibility increased with increasing leaf meal inclusion up to 20% and then declined. Dry matter digestibility was significantly (P<0.05) higher in animals fed 10% (75.86%) and 20% (73.16%) leaf meal inclusion than other treatments. Organic matter digestibility differed significantly (P<0.05) across the treatments. Animals fed 10% and 20% GMMO leaf meal inclusion levels showed significantly (P<0.05) higher organic matter digestibility (84.97% and 84.98%), respectively than the other treatments. There was similar (P>0.05) crude protein digestibility in this study. The range is from 72.60% in animals fed 30% leaf meal to 77.62% in those fed 20%. Crude fibre digestibility was significantly (P<0.05) different in this study. Crude fibre digestibility was significantly (P<0.05) higher in animals fed 20% GMMO leaf meal (76.15%) than other treatments.

Table 4.9: Effect of sampling periods on serum biochemical parameters of Red Sokoto bucks fed GMMO leaf meal inclusion levels in *D. smutsii* hay based diets

	Sampling Periods			
Parameters	Beginning	Middle	End	SEM
Total protein	69.92^{a}	67.58^{ab}	65.17^{b}	1.71
Albumin	36.92^{a}	32.33^{b}	33.75^{b}	1.54
Globulin	36.00	35.25	31.42	2.37
Glucose	60.83	58.17	58.58	3.90
Creatinine	107.50	99.58	109.33	5.18
BUN	5.66	5.72	6.24	0.51
Cholesterol	94.98	95.22	94.98	4.74

a,b, Mean values with different superscripts within a row differed significantly (P<0.05), SEM= Standard Error of Means,SEM= Standard Error of Means; BUN= Blood Urea Nitrogen

Table 4.10: Apparent nutrient digestibility of Red Sokoto bucks fed inclusion levels of GMMO leaf meal in *D. smutsii* hay based diets

	Levels of GMMO leaf meal inclusion (%)				
Parameters (%)	0	10	20	30	SEM
Dry matter	66.54^{b}	75.86^{a}	73.16^{a}	65.28^{b}	2.55
Organic matter	79.79^{b}	84.97^{a}	84.98^{a}	78.82^{b}	1.59
Ether extract	76.00	70.31	75.55	72.21	3.70
Crude Protein	77.38	76.75	77.62	72.60	2.84
Crude Fibre	64.82^{b}	69.14^{b}	76.15^{a}	66.37^{b}	3.02
NDF	61.41^{b}	70.25^{a}	69.93^{a}	68.13^{a}	2.92
ADF	49.42^{b}	62.67^{a}	62.32^{a}	60.89^{a}	3.67

a,b, Mean values with different superscripts within a row differed significantly ($p<0.05$)
SEM standard error of mean; NDF=Neutral Detergent Fibre; ADF=Acid Detergent Fibre

NDF digestibility was significantly higher (P<0.05) in animal fed diets containing GMMO leaf meal than the control. ADF digestibility followed the same pattern with the NDF digestibility.

4.11 Effect of GMMO leaf meal inclusion on nitrogen balance in Red Sokoto bucks fed *D. smutsii* hay based diets

The N intake was significantly (P<0.05) different as presented in Table 4.11. The result showed that animals fed 20% leaf meal had significantly (P>0.05) similar nitrogen intake (7.90g/d) with those on 10% inclusion level. Nitrogen excreted in urine was not significantly different across the treatments. However, result of fecal N differed significantly (P<0.05) in this study. Fecal N was significantly (P<0.05) higher in animals fed 20% and 30% leaf meal in than other treatments.

Nitrogen retention was positive across the treatments. Animals fed 20% leaf meal had significantly (P<0.05) higher nitrogen retention (5.37g/d) but similar to those on 0% and 10%. Nitrogen retention in animals fed 30% inclusion level of GMMO leaf meal was statistically similar to that of 0% (control) level.

4.12 Effect of GMMO leaf meal inclusion on intake and growth performance of Red Sokoto does fed *D. smutsii* hay based diets

The results of the effect of GMMO leaf meal inclusion on intake and growth performance of Red Sokoto does fed *D. smutsii* hay based diets are presented in Table 4.12. The result showed no significant (P>0.05) difference in feed intake across the treatments. The feed intake varied from 421.50 to 455.95g/d in animals fed 30% and 20%, respectively. Dry matter intake as g/kg metabolic weight was not significantly (P>0.05) different across the treatments. Final weight of does was not significant (P>0.05) but increased with GMMO leaf meal inclusion. Animals on 30% leaf inclusion had the least final weight.

Table 4. 11: Nitrogen Balance in Red Sokoto bucks fed inclusion levels of GMMO leaf meal in *D. smutsii* hay based diets

	Levels of GMMO leaf meal inclusion (%)				
Parameters (g/d)	0	10	20	30	SEM
Nitrogen intake	6.50^{b}	7.47^{ab}	7.90^{a}	6.55^{b}	0.67
Urinary nitrogen	0.52	0.45	0.51	0.61	0.10
Fecal nitrogen	1.76^{b}	1.98^{b}	2.02^{a}	2.08^{a}	0.10
Total N output	2.27^{b}	2.43^{ab}	2.69^{a}	2.53^{ab}	0.17
Nitrogen retention	4.22^{ab}	5.05^{ab}	5.37^{a}	3.86^{b}	0.75
N retention (as % of intake)	64.06	66.11	66.32	58.02	4.80

a,b, Mean values with different superscripts within a row differed significantly (P<0.05) SEM standard error of mean, N=nitrogen

Table 4. 12: Effect of GMMO leaf meal inclusion on feed intake and growth performance of Red Sokoto does fed *D. smutsii* hay based diets

	Levels of GMMO leaf meal inclusion (%)				
Parameters	0	10	20	30	SEM
Feed intake (g/d)	455.31	447.08	455.95	421.50	35.23
DMI (g/kgW $^{0.75}$)	52.80	50.97	51.94	50.07	1.77
Initial weight (kg)	14.79	14.71	14.71	14.71	1.22
Final weight (kg)	17.59	18.01	18.04	17.07	1.16
Metabolic Wt $^{(0.75)}$	8.58	8.73	8.74	8.39	0.42
Total wt gain (kg)	2.80^{ab}	3.30^{a}	3.38^{a}	2.33^{b}	0.52
ADG (g/d)	46.67	55.00	55.48	38.81	8.60
FCR	11.74	8.73	8.80	13.18	2.41

a,b, Mean values with different superscripts within a row differed significantly (P<0.05) SEM standard error of mean; DMI=Dry matter intake; ADG=average daily gain; wt=weight; FCR= feed conversion ratio.

The weight gain followed the same pattern as the final weight. Animals on 10% and 20% leaf meal inclusion had higher ($P<0.05$) weight gain than the other treatment groups. Average daily weight gain (ADG) in this study showed no significant ($P>0.05$) difference across the treatments. The ADG varied from 38.81 to 55.48 g/d. There was no significant ($P>0.05$) difference in feed conversion ratio. It varied from 8.73 to 13.18 in animals fed 20% and 30% leaf meal inclusion, respectively.

Figure 4.2 showed the trend analysis of the inclusion of GMMO leaf meal in the diets of Red Sokoto does. The optimum level of inclusion of GMMO in the diets of growing Red Sokoto bucks was 15.20% as obtained by regression equation.

4.13 Cost-benefit analysis of including varying proportions of GMMO leaf meal in *D. smutsii* hay based diets fed Red Sokoto does

Table 4.13 showed the result of the cost-benefit analysis of experimental diets fed to growing Red Sokoto does. The total feed cost ranged from ₦847.74 in 30% to ₦1205.84 in the control. The feed cost/kg gain ranged from ₦ 326.75 in 20% followed by ₦354.59, ₦ 441.74 and ₦518.30 in 10%, 30% and 0%, respectively. Net profit was higher on treatment diets with GMMO leaf meal than the control. The values varied from ₦ 194.20 to ₦ 648.80. Reduction percent in feed cost/ kg gain was highest in animals fed 20% GMMO leaf meal (36.96 %) and least in those on 30 % (14.77%).

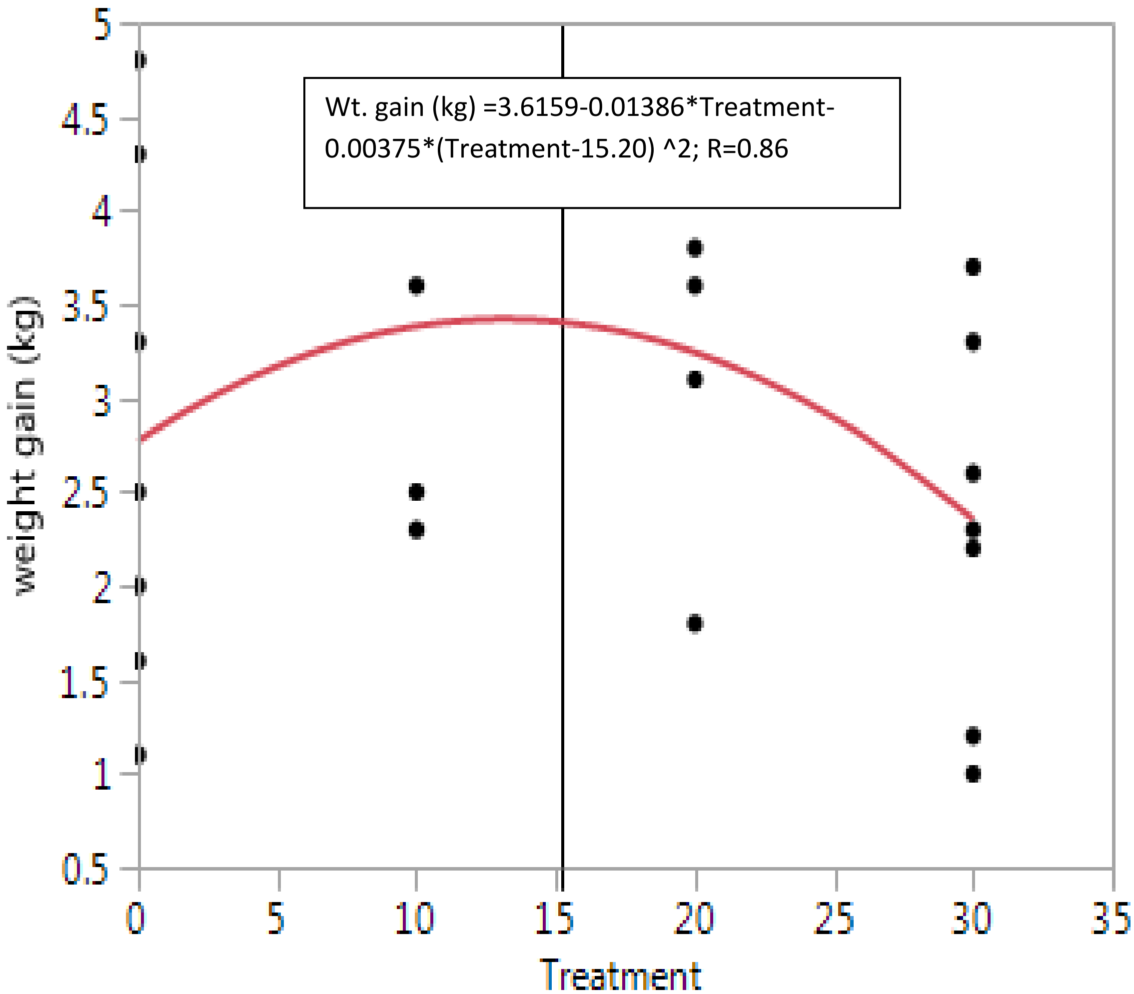

Figure 4.2: Trend analysis of inclusion of GMMO leaf meal in the diets of Red Sokoto does.

Table 4.13: Cost-benefit analysis of including varying proportions of GMMO leaf meal in *D. smutsii* hay based diets fed Red Sokoto does

	Levels of GMMO leaf meal inclusion (%)			
Parameters (₦)*	0	10	20	30
Total feed intake (kg)	27.32	26.83	27.36	25.29
Weight Gain (kg)	2.80	3.30	3.38	2.33
Cost/kg	44.14	40.63	37.12	33.52
Total cost	1205.84	1089.89	1015.49	847.71
Cost/kg Gain	518.30	354.58	326.75	441.74
Value of gain	1400.00	1650.00	1664.30	1164.30
Net Profit	194.20	560.10	648.80	316.60
% Reduction in feed cost/kg gain	-	31.59	36.96	14.77

* Naira = Nigerian currency (100 kobo = 1 naira)

4.14 Linear body measurement and Body condition score of growing Red Sokoto does fed levels of GMMO leaf meal in *D. smutsii* hay based diets

Results of the linear body measurements and Body condition score of growing Red Sokoto does fed levels of GMMO leaf meal in *D. smutsii* hay based diets are presented in Table 4.14. Among the parameters measured, body length, height at withers, and body condition score were significant (P<0.05) across the treatments. Body length was significantly higher (P<0.05) in animals on 30% than those on other treatments though similar to those on 10%. Height at withers was significantly higher for animals on 20% GMMO leaf meal than the other treatment groups. It varied from 20.20 to 24.39cm; animals on the control diet had the least height at withers. The body condition score followed similar pattern as the body length and height at withers. Body condition score was significantly similar (P>0.05) for animals on 0% and 20% GMMO leaf meal.

4.15 Effect of GMMO leaf meal inclusion on haematological parameters in growing Red Sokoto does fed *D. smutsii* hay based diets

The effects of GMMO leaf meal inclusion on haematological parameters in growing Red Sokoto does fed *D. smutsii* hay based diets are presented in Table 4.15. Significant differences were observed in all the parameters measured. The PCV, Hb and RBC were significantly higher (P<0.05) in 10% compared to other treatments. White blood cell count was statistically higher (P<0.05) in animals fed 30% than those on 20% but comparable to values recorded in 0% and 10%, respectively.

Table 4. 14: Linear body measurement and Body condition score of Growing Red Sokoto does fed levels of GMMO leaf meal in *D. smutsii* hay based diets

	Levels of GMMO leaf meal inclusion (%)				
Parameters (cm)	0	10	20	30	SEM
Initial body wt (kg)	14.79	14.71	14.71	14.71	1.22
Final body wt (kg)	17.59	18.01	18.04	17.07	1.16
Initial BL	18.00	17.79	17.57	17.29	0.75
Final BL	21.86^{b}	22.29^{ab}	23.34^{a}	21.47^{b}	0.73
Initial HW	19.29	19.30	18.91	19.43	0.79
Final HW	20.20^{c}	23.43^{ab}	24.19^{a}	22.83^{b}	0.67
Initial chestgirth	22.00	21.14	22.39	22.43	0.71
Final chest girth	23.43	23.45	24.39	23.79	0.62
Initial shoulder L	13.00	13.29	13.53	13.07	0.54
Final shoulder L	14.71	14.86	14.90	15.00	0.51
Initial BCS	2.48	2.47	2.33	2.21	0.14
Final BCS	2.89^{ab}	2.79^{b}	3.16^{a}	2.66^{b}	0.18

a,*b*,c, Mean values with different superscripts within a row differed significantly (P<0.05), SEM= standard error of mean, BL=body length, HW=height at withers, L=length, BCS=body condition score.

Table 4. 15: Effects of GMMO leaf meal inclusion on haematological parameters of growing Red Sokoto does fed *D. smutsii* hay based diets

	Levels of GMMO leaf meal inclusion (%)				
Parameters	0	10	20	30	SEM
PCV (HCT) (%)	35.89^{b}	41.11^{a}	33.78^{b}	34.44^{b}	2.46
Hgb (×10g/L)	11.93^{b}	13.69^{a}	11.22^{b}	11.46^{b}	0.82
RBC ($\times 10^{12}$/L)	16.03^{ab}	16.96^{a}	15.72^{b}	15.71^{b}	1.16
WBC ($\times 10^{12}$/L)	9.51^{ab}	9.93^{ab}	8.10^{b}	12.22^{a}	1.91

a,b, Mean values with different superscripts within a row differed significantly (P<0.05), SEM= Standard Error of Means .WBC = White blood cells; RBC = Red blood cells; Hb = Haemoglobin; PCV (HCT) = Packed cell volume (Haematocrit).

4.16 Effect of GMMO leaf meal inclusion on serum biochemistry of growing Red Sokoto does fed *D. smutsii* hay based diets

Table 4.16 shows the results of the effect of GMMO leaf meal inclusion on serum biochemistry of growing Red Sokoto does fed *D. smutsii* hay based diets. Significant (P<0.05) differences were observed in cholesterol levels of the animals across the treatments. The cholesterol level decreased with increasing level of Gmelina and Moringa leaf meal inclusion. The cholesterol level was significantly higher (P<0.05) in animals fed 0% (107.90 mg/dL) and 10% (107.57 mg/dL) compared to other treatments. There were no significant differences (P>0.05) in total protein, albumin, globulin, glucose, creatinine and urea nitrogen.

4.17 Effect of sampling periods on haematological parameters of growing Red Sokoto does fed levels of GMMO leaf meal in *D. smutsii* hay based diets

Table 4.17 shows the result of the effect of sampling periods on haematological parameters of growing Red Sokoto Does fed *D.smutsii* hay based diets supplemented with GMMO leaf meal inclusions. There were significant differences (P<0.05) in all the parameters measured except white blood cells count. Pack cell volume and haemoglobin were statistically similar at the beginning and middle of the experiment than at the end of experiment. Red blood cell was significantly (P<0.05) higher at the beginning of experiment than other periods.

Table 4.16: Effect of GMMO leaf meal inclusion on serum biochemistry of growing Red Sokoto does fed *D. smutsii* hay based diets

	Levels of GMMO leaf meal inclusion (%)				
Parameters	0	10	20	30	SEM
Total protein (g/L)	66.67	66.44	68.22	67.33	5.09
Albumin (g/L)	38.00	32.56	35.11	34.44	9.46
Globulin (g/L)	28.67	33.89	33.11	32.89	9.94
Glucose (mg/dL)	61.67	70.11	59.56	61.78	9.42
Creatinine (µmol/L)	108.44	102.44	107.78	116.00	21.66
BUN (mmol/L)	5.97	5.32	5.28	5.49	1.69
Cholesterol (mg/dL)	107.90^{a}	107.57^{a}	86.28^{b}	81.07^{b}	10.53

a,b, Mean values with different superscripts within a row differed significantly (P<0.05), BUN= Blood Urea Nitrogen; SEM= standard error of mean.

Table 4.17: Effect of sampling period on haematological parameters of growing Red Sokoto does fed levels of GMMO leaf meal inclusion *in D. smutsii* hay based diets

	Sampling Periods			
Parameters	Beginning	Mid	End	SEM
PCV (HCT) (%)	38.08^{a}	35.33^{ab}	33.17^{b}	1.59
Hgb (×10g/L)	12.67^{a}	11.36^{ab}	10.91^{b}	0.47
RBC ($\times10^{12}$/L)	12.10^{a}	8.18^{b}	9.55^{b}	1.12
WBC ($\times10^{12}$/L)	16.28	16.29	15.75	0.36

a,b, Mean values with different superscripts within a row differed significantly (P<0.05), SEM= Standard Error of Means .WBC = White blood cells; RBC = Red blood cells; Hb = Haemoglobin; PCV (HCT) = Packed cell volume (Haematocrit).

4.18 Effect of sampling periods on serum biochemical parameters of growing Red Sokoto does fed levels of GMMO leaf meal inclusion *in D. smutsii* hay based diets

The results of effect of sampling periods on serum biochemical parameters of growing Red Sokoto does fed levels of GMMO leaf meal inclusion *in D. smutsii* hay based diets are presented in Table 4.18. There were significant differences (P<0.05) on total protein and globulin. The other parameters measured were not significant across the sampling periods. Total protein ranged from 65.58 to 69.75 g/L at the end and middle of the experiment, respectively. It was significantly higher (P<0.05) at the mid than other periods. The values of globulin were statistically higher (P<0.05) at mid and end of the experiment than at the beginning.

4. 19: Chemical composition (%) of experimental diets fed to pregnant Red Sokoto does

Table 4.19 shows the result of the chemical composition (%) of the experimental diets fed to pregnant Red Sokoto does. Dry matter varied from 88.62 to 90.03% while crude protein ranged from 15.10 to 15.31%. Ash content was 4.88%, 6.34%, 5.32%5 and 4.62% for 0%, 10%, 20% and 30%, respectively. The NDF and ADF contents of the experimental diets decreased with increasing GMMO leaf meal inclusion. The NDF ranged from 33.36 to 55.85% while ADF varied from 27.81 to 44.82%.

Table 4.18: Effect of sampling periods on serum biochemical parameters of growing Red Sokoto does fed levels of GMMO leaf meal inclusion *in D. smutsii* hay based diets

	Sampling Periods			
Parameters	Beginning	Mid	End	SEM
Total Protein	66.17^{b}	69.75^{a}	65.58^{b}	1.35
Albumin	37.58	35.08	32.42	2.68
Globulin	28.58^{b}	34.67^{a}	33.17^{a}	2.79
Glucose	62.83	62.17	64.83	2.92
Creatinine	95.92	118.08	112.00	11.53
BUN	5.66	5.61	5.28	0.49
Cholesterol	92.54	97.31	97.26	4.69

a,b, Mean values with different superscripts within a row differed significantly (P<0.05), SEM= Standard Error of Means; BUN= Blood Urea Nitrogen

Table 4.19: Chemical composition (%) of experimental diets fed to pregnant Red Sokoto does

Parameters	Level of GMMO leaf meal inclusion (%)			
	0	10	20	30
Dry matter	89.68	89.51	90.03	88.62
OM	84.80	83.17	84.71	84.00
Crude protein	15.31	15.25	15.19	15.10
Crude fibre	33.90	35.73	32.14	30.99
Ash	4.88	6.34	5.32	4.62
Ether Extract	6.32	6.48	5.38	4.36
NDF	55.11	55.85	37.67	33.36
ADF	44.82	38.06	35.89	27.81

OM= Organic Matter; NDF=neutral detergent fibre; ADF=acid detergent fibre.

4.20 Anti-nutrients contents of experimental diets fed to pregnant Red Sokoto does

Results of the anti-nutrients contents of the experimental diets fed to pregnant Red Sokoto does are shown on Table 4.20. The tannin, oxalate, alkaloid and saponin contents of the diets increased numerically with increasing level of GMMO leaf meal inclusion. The tannin content ranged from 0.90 to 1.87 mg/100g. Phytate content was lowest in diet with 0% GMMO (0.97 mg/100g) and highest in 30% (1.51mg/100g).

4.21 Effect of GMMO leaf meal inclusion on haematological parameters of pregnant Red Sokoto does fed *D. smutsii* hay based diets

Results of the effects of GMMO leaf meal inclusion on haematological parameters of pregnant Red Sokoto does fed *D. smutsii* hay based diets are shown on Table 4.21. There were significant differences in all the parameters measured. The PCV was significantly ($P<0.05$) higher (36.33%) in treatment group fed 30% GMMO compared to other treatments. Haemoglobin was significantly ($P<0.05$) higher in treatments with GMMO inclusion compared to the control group. Red blood cell count was significantly similar ($P>0.05$) in treatments with inclusion levels of 0%, 20% and 30%. White blood cell count for inclusion levels of 20% (12.87×10^9/L) and 30% (12.97×10^9/L) were statistically similar ($P>0.05$) to that of 0% inclusion level.

Table 4.20: Anti-nutrients contents of experimental diets fed to pregnant Red Sokoto Does (mg/100g)

	Levels of GMMO Leaf meal inclusion (%)			
Anti-nutrients	0	10	20	30
Tannins	0.90	1.23	1.50	1.87
Phytate	0.97	1.18	1.28	1.51
Oxalate	1.89	1.20	2.50	2.67
Alkaloid	2.50	2.68	2.98	3.10
Saponin	1.50	1.65	1.92	1.98

GMMO leaf meal= mixed Gmelina and Moringa leaf meal

Table 4.21: Effects of GMMO leaf meal inclusion on haematological parameters of pregnant Red Sokoto does fed *D. smutsii* hay based diets

Parameters	Levels of GMMO leaf meal inclusion (%)				SEM
	0	10	20	30	
PCV (HCT) (%)	26.37^{b}	23.33^{b}	26.73^{b}	36.33^{a}	2.36
Hgb (×10g/L)	9.97^{b}	10.80^{a}	10.87^{a}	11.37^{a}	0.38
RBC ($\times 10^{12}$/L)	9.53^{ab}	8.87^{b}	9.57^{ab}	11.47^{a}	0.55
WBC ($\times 10^{12}$/L)	10.63^{ab}	9.50^{b}	12.87^{a}	12.97^{a}	1.61

a,b, Mean values with different superscripts within a row differed significantly (P<0.05), SEM= Standard Error of Means .WBC = White blood cells; RBC = Red blood cells; Hgb = Haemoglobin; PCV (HCT) = Packed cell volume (Haematocrit).

4.22 Effect of GMMO leaf meal inclusion on serum biochemical parameters of pregnant Red Sokoto does fed *D. smutsii* hay based diets

Results of effect of GMMO leaf meal inclusion on serum biochemical parameters of pregnant Red Sokoto does fed *D. smutsii* hay based diets are presented in Table 4.22. The albumin content was statistically (P>0.05) similar in animals fed 20% and 30% while globulin and glucose contents were better in animals fed 0% and 10%, respectively.There were significant (P<0.05) differences in urea nitrogen and cholesterol concentrations. The urea nitrogen decreased with increasing level of GMMO inclusion. Blood urea nitrogen (BUN) was significantly (P<0.05) higher in control than other dietary treatment. It ranged from 5.00 in control to 3.71mmol/L in treatment containing 30% GMMO leaf meal. Cholesterol concentration was higher (P<0.05) statistically in does fed 0% and 10% GMMO leaf meal than those on 20% (85.62mg/dL) and 30% (92.13mg/dL) leaf meal respectively. There were no significant (P>0.05) difference in total protein and creatinine concentrations across the treatments.

4.23 Effect of GMMO leaf meal inclusion level on intake, weight changes and birth weight of kids of Red Sokoto Does fed *D. smutsii* hay base diets

Results of the effect of Gmelina and Moringa leaf meal inclusion level on feed intake, weight changes and birth weight of kids of Red Sokoto Does fed *D. smutsii* hay base diets are presented on Table 4.23. The dry matter intake (DMI) was statistically similar (P>0.05) all inclusion levels of GMMO (10%, 20% and 30%). Animals fed 20% GMMO leaf meal was similar to those on 10% and 30% but significantly (P<0.05) higher than those on control diet. Dam's weight at kidding was not significant ($P>0.05$) across the treatments. Birth weight was significantly similar ($P>0.05$) in does fed 30% (1.68kg) and 20% (1.58kg) GMMO leaf meal. The birth weight in 30% GMMO leaf meal inclusion was significantly ($P<0.05$) higher than that of the control.

Table 4.22: Effect of feeding of GMMO leaf meal inclusion on serum biochemical parameters of pregnant Red Sokoto does fed *D. smutsii* hay based diets

	Levels of GMMO leaf meal inclusion (%)				
Parameters	0	10	20	30	SEM
Total protein (g/L)	66.05	67.43	66.24	67.60	1.35
Albumin (g/L)	26.80^{b}	30.70^{b}	33.90^{ab}	38.83^{a}	3.57
Globulin (g/L)	39.25^{a}	36.73^{ab}	32.34^{b}	28.77^{c}	3.26
Glucose (mg/dL)	65.30^{ab}	70.17^{a}	59.43^{b}	56.77^{b}	4.64
Creatinine (µmol/L)	101.00	102.67	94.33	102.00	5.36
BUN (mmol/L)	5.00^{a}	4.26^{b}	3.76^{c}	3.71^{c}	0.13
Cholesterol (mg/dL)	114.87^{a}	114.40^{a}	85.62^{b}	92.13^{b}	6.05

a,b, c, Mean values with different superscripts within a row differed significantly (P<0.05), BUN= Blood Urea Nitrogen; SEM= standard error of mean.

Table 4.23: Effect of GMMO leaf meal inclusion level on feed intake, weight changes and birth weight of kids of Red Sokoto Does fed *D. smutsii* hay base diets

	Levels of GMMO leaf meal inclusion (%)				
Parameters (kg)	0	10	20	30	SEM
DMI (g/d)	576.85^{b}	632.40^{ab}	666.89^{a}	627.49^{ab}	40.12
Initial weight	21.60	22.50	22.55	22.62	1.55
Dam weight (at kidding)	22.35	23.25	23.37	23.40	1.53
Birth weight	1.50^{b}	1.41^{b}	1.58^{ab}	1.68^{a}	0.05

a,*b*,Mean values with different superscripts within a row differed significantly (P<0.05), SEM= standard error of mean, DMI=dry matter intake.

4.24 Effect of GMMO leaf meal inclusion on milk composition of lactating Red Sokoto does fed *D. smutsii* hay based diets

Table 4.24 shows the effect of GMMO leaf meal inclusion on milk composition of Red Sokoto does fed *D. smutsii* hay based diets. There were significant difference (P<0.05) in milk protein and lactose contents across the treatments. The milk protein was statistically higher (P<0.05) in does fed 10% and 20% GMMO leaf meal (4.83 and 5.03%), respectively than the other treatments. Lactose content was significantly (P<0.05) higher in does fed 0% and 30% GMMO leaf meal than those on other treatments. There were no significant (P>0.05) differences in moisture, milk fat, ash and total solid.

Table 4.24: Effect of GMMO leaf meal inclusion on milk composition of lactating Red Sokoto does fed *D. smutsii* hay based diets

	Levels of GMMO leaf meal inclusion (%)				
Parameters (%)	0	10	20	30	SEM
Moisture	85.76	84.99	85.68	85.27	0.46
Milk Protein	4.53^{b}	4.83^{a}	5.03^{a}	4.57^{b}	0.12
Milk fat	4.37	5.07	4.50	4.77	0.37
Ash	0.81	0.81	0.81	0.81	0.00
Total Solid	14.24	15.01	14.32	14.73	0.46
Solid Non- Fat	9.88	9.95	9.82	9.96	0.13
Lactose	4.53^{a}	4.30^{b}	3.98^{c}	4.58^{a}	0.13

[a,b, c,] Mean values with different superscripts within a row differed significantly (P<0.05) SEM = standard error of mean.

CHAPTER FIVE

5.0 DISCUSSION

5.1 Chemical composition of major feed ingredients (DM %).

Dry matter content of Gmelina leaf meal (96.23%) was similar to the 92.74 and 91.60% reported by Abdu *et al*. (2012) and Taiwo *et al*. (2009), respectively.

The CP value of 14.50% obtained for Gmelina leaf meal was above the 13.38 and 10.25% recorded by Okafor *et al*. (2012) and Abdu *et al.* (2012), respectively. However, the value was lower than the 26.70 and 20.30% reported by Omokanye *et al*. (2001) and Taiwo *et al.* (2009), respectively. A similar CP value (14.60%) was reported by Amata and Labari (2011). NDF and ADF of Gmelina leaf meal in this study were lower than the 64.11 and 42.79%, respectively as reported by Taiwo *et al*. (2009).

Gmelina had high ash content of 9.33% which was lower than 11.30% reported by Abdu *et al.* (2012). However, the value was higher than 7.85% obtained by Okafor *et al*. (2012) for Gmelina leaves. This was in agreement with the report of Babayemi *et al.* (2003) that browse plants are high in mineral contents.

Crude fibre (CF) content obtained for Gmelina (17.00%) was similar to values reported by Okafor *et al*. (2012) but lower than 30.46% reported by Osakwe and Udeogu (2007). This agreed with the report of Anbarasu *et al*. (2004) that most browse leaves have high crude fiber (CF) content and attributed it to high cell-wall constituents usually present in browse leaves.

Result showed high dry matter content of Moringa leaf meal (MOLM) in this study (94.85%) and was similar to the values obtained by Adegun (2014) who reported 92.22 % DM. Crude protein content of MOLM obtained in this work was similar to the report of Sultana *et al.* (2014).

Makkar *et al.* (1996) and Kakengi *et al*. (2005) reported that the CP of Moringa leaves can vary from 15 to even more than 30% depending on the maturity and respective proportions of leaves to stems.

The crude fibre content obtained in this study for MLM was higher than 7.10 and 6.49% reported by Aderinola *et al*. (2013) and Adegun (2014), respectively. It was in agreement with the work of Sultana *et al*. (2014) who stated that crude fibre content of Moringa ranges from 8 to 30% on dry matter basis. NDF and ADF values obtained in this study were similar to findings of Sultana *et al.* (2014). High DM value was recorded for mixture of Gmelina and Moringa leaf meals. This is because both browse forages were in dry form. The chemical composition of the mixture is similar to that of the individual forages.

The differences in the chemical composition of feed ingredients may be due to natural variations as a result of genetic background, environment, cultivation method, variations due to sample preparations and analysis (Brisibe *et al*. 2009; Njidda, 2010).

5.2 Chemical composition (%) of experimental diets fed to growing Red Sokoto goats and pregnant Red Sokoto does

The CP contents of all the diets were above the level suggested as adequate to meet the nutritional requirements for moderate weight gain in goats (NRC 2007). Norton (1994) recommended a diet with 8 % CP for moderate live-weight gains in goats and according to this criteria all the diets had sufficient CP content. The chemical composition of experimental diets showed that the diets contained adequate dry matter and crude protein to support normal rumen functions (Ahamefule *et al.,* 2002).

Also the CP contents of all the diets fed to pregnant does were within the level 8.9–16.0% recommended for growth and production in goats (NRC, 2007). The chemical composition of experimental diets showed that the diets contained adequate dry matter and crude protein to support normal rumen functions (Ahamefule *et al.,* 2002) and to meet the CP requirement of pregnant Red Sokoto does. There was no adverse effect on the pregnant does during the study.

5.3 Anti-nutrients contents of Gmelina leaf meal (GLM), Moringa leaf meal (MOLM) and experimental diets fed to growing and pregnant Red Sokoto goats

Low tannin, phytates and oxalate content of Gmelina leaf meal (0.43, 0.32 and 1.52 mg/100g, respectively) were similar to the values obtained by Aderiuboye and Onwuka (2010) and Adamu (2011). Okafor *et al*. (2012) reported higher tannin and phytate levels of 1.44 and 1.14 mg/100g, respectively for Gmelina leaves. Alkaloid and saponin values obtained in this study were similar to the reports of Okafor *et al.* (2012) for Gmelina leaves.

Tannin and phytate contents of Moringa 0.37 and 0.50 mg/100g, respectively were lower than values obtained by Ogbe and Affiku (2011). Ogbe and Affiku (2011) reported similar oxalate and saponin levels for Moringa leaf meal. This result was consistent with that of several authors (Nouala *et al*., 2006; Ogbe and Affiku, 2011 and Aye and Adegun, 2013) who found that Moringa leaves contained negligible amounts of anti-nutritive compounds. The values of the anti-nutrients measured were all within the threshold for animals. This was in agreement with Nastis and Malachek (1981) who indicated a threshold for tannins of 2-5% for cattle and 9% for goats. Paul and Sontgate (1978) reported 1.06mg/g as lethal dose of phytate that cannot be tolerated by ruminant animals. Shodipo and Arinze (1985) have indicated a threshold for saponins as 2g for ruminants.

5.4 Effect of GMMO meal inclusion on feed intake and growth performance of Red Sokoto bucks fed *D. smutsii* hay based diets

Combined Gmelina and Moringa leaf meal inclusion improved feed intake of growing Red Sokoto bucks. Improved feed intake in animals fed GMMO leaf meal may be as a result of acceptability and digestibility of the feeds. This result was similar to those of Asaolu *et al*. (2011) who reported feed intake of 278-289 g/d when Moringa leaves were fed as sole forage or combined with legume tree leaves to growing goats. Abdu *et al*. (2012) however, reported higher intake of 498.28 to 562.89g/d when they fed complete diets with varying levels of Gmelina leaf meal. The overall result showed that GMMO leaf meal inclusion improved performance in terms of body weight, average body weight and feed conversion ratio. This may be as the result of higher nutrient intake, digestibility and nitrogen balance in bucks fed Gmelina and Moringa leaf meal. This finding agreed with the works of Fasae *et al*. (2011) and Fasae *et al*. (2010) that reported improved body weight gain, digestibility and daily weight gain when goats were supplemented with browse leaves. Murro *et al*. (2003) also reported improved feed intake, diet digestibility and daily weight gain when Moringa leaves replaced cotton seed cake in the diet of growing lambs fed low-quality hay. The reduction in body weight gain in treatment group fed 30% GMMO leaf meal was because after optimal inclusion of 21.95%, intake, digestibility and nitrogen balance declined. This was similar to the findings of Bamikole and Babayemi (2004) and Okpara *et *al.* (2014) who observed negative effect of high level of browse leaves in goats' diets. They suggested that it will be more profitable to feed browse leaves as supplements at a reduced level of inclusion in livestock diets.

The feed conversion ratio observed in this study showed that GMMO leaf meal inclusion improved feed utilization. This finding was similar to the reports of Nagalakshmi *et al*. (2010) who observed that complete diets increased nutrient utilization, palatability and reduced cost of feeding in ruminants.

5. 6 Effects of GMMO leaf meal inclusion on cost-benefit analysis of Red Sokoto bucks fed *D. smutsii* hay based diets

The best feed cost efficiency (net profit) was observed on bucks fed 20% GMMO leaf meal. The feed cost/kg gain was reduced by 7.29%, 34.79% and 22.30% in bucks fed 10%, 20% and 30% GMMO leaf meal, respectively. The result of this work indicated that GMMO leaf meal inclusion in the experimental diets were more profitable than the control diet due to improved feed utilization. Okafor *et al.* (2012) stated that inclusion of *Gmelina arborea* leaves in goats' diet reduced the cost of feed because of its affordability. Ammar *et al*. (2011) had proven that supplementation is economically feasible and is necessary to ensure farm viability because of large difference in terms of average daily gain between supplemented and non-supplemented animals. Similarly, Njidda and Ikhimioya (2010) revealed that diet supplemented with *Ziziphus mauritiana* had the best in terms of feed cost per kg gain and percent reduction in feed cost (53.04%).

5.7 Effect of GMMO leaf meal inclusion on haematological parameters of growing Red Sokoto bucks fed *D. smutsii* hay based diets

Haematological studies represent a useful process/tool in the investigation of the extent of damage to the blood by feed offered to animals (Ogunbanjo *et al.,* 2009). Etim *et al.* (2014) reported that it provides the opportunity to clinically investigate the physiological, nutritional and pathological status of an animal. The packed cell volume, haemoglobin, red blood cells and white blood cells observed in this study were within normal range for healthy goats 22-38%, 8-12g/dl, $8\text{-}18\times10^{12}$/L and $4\text{-}13\times10^{12}$/L, respectively (Latimer, 2010). This result suggested that the bucks were not negatively affected by the GMMO leaf meal inclusion in their diets. Clifford and Briggs (2007) reported that the comparison of an animal's haematological and biochemical values with reference interval provides evidence for numerous conditions such as reflection, malnutrition and stress. This showed that the diets fed to the bucks with varying levels of GMMO leaf meal inclusion are adequate in protein. Result of this study is in agreement with the findings of Bello and Tsado (2013) who reported that haemoglobin values within normal range imply that the dietary proteins fed to animals were of high quality and adequate.

The values of all the haematological parameters measured were within the normal ranges throughout the experimental periods. Higher packed cell volume and haemoglobin at the end of the experiment is an indication of high intake of iron and the oxygen carrying capacity of the blood. According to Isaac *et al.* (2013), Packed Cell Volume is involved in the transport of oxygen and absorbed nutrients. Increased Packed Cell Volume shows a better transportation. Chineke *et al.* (2006) stated that haemoglobin is significant in the diagnosis of anaemia and also serve as useful indices of the bone marrow capacity to produce red blood cells as in mammals. This means the experimental animals were not stressed or anaemic. It also indicated that the animals were well adapted to the dietary treatments and were not adversely affected.

5.8 Effects of GMMO leaf meal inclusion on serum biochemistry of growing Red Sokoto bucks fed *D. smutsii* hay based diets

Results showed no significant effect of the dietary treatments on total protein, albumin, globulin, glucose, creatinine and urea nitrogen levels of the Red Sokoto bucks. This was comparable to the results of Ewuola *et al*. (2012) and Ologhobo *et al.* (2014) who reported no significant effect on most parameters measured for animals fed graded levels of *Moringa oleifera* leaf meal. All the parameters measured in this study were within the normal ranges for clinically healthy goats (Kaneo *et al.,* 2008). The lower cholesterol level of goats fed diets containing 20% and 30% GMMO leaf meal corroborated the work of Aderinola *et al*. (2013) who observed low cholesterol and triglyceride content in the birds with MOLM. This could be as a result of the hypocholesterolemic properties of Moringa leaf meal included in the diets (Olugbemi *et al*., 2010). Moringa leaves contain phytosterol (beta-sitosterol) which is a plant substance similar to cholesterol. Beta-sitosterol was reported to reduce cholesterol levels by limiting the amount of cholesterol that is absorbed in the digestive tract (Ghasi *et al*., 2000; Longe, 2008). The beta-sitosterol in *Moringa oleifera* leaf was also reported to be responsible for its hypolipidaemic and antioxidant properties (Rajanandh and Kavitha, 2010). This means that inclusion of GMMO leaf meal in the diets of goats can help in the regulation of blood cholesterol level.

The sampling periods affected the total protein and albumin in this study. The values were within the normal ranges for healthy goats. The reduced total protein and albumin may be as a result of decrease in retained protein. Esonu *et al*. (2001) reported that total serum protein is an indication of the protein retained in the animal body.

5.9 Nutrient digestibility of Red Sokoto bucks fed GMMO leaf meal inclusion in *D. smutsii* hay based diets

The crude protein digestibility recorded in this study was higher than values reported by Abdu *et al*. (2012) who fed complete diets to Red Sokoto goats but higher (89.35%) value by Asaolu *et al.* (2011). Reduction in digestibility at 30% GMMO leaf meal inclusion agreed with the report of Melaku *et al.* (2004) that high supplementation of tree fodder levels reduced nutrient digestibility due to increased passage rate. High digestibility recorded in this study can be attributed to the diets, as authors asserted that there were better production outcomes in browse mixtures than single browses as a result of improved palatability due to the combination of two fodders (Asaolu *et al*., 2012; Adegun, 2014).

5.10 Nitrogen balance of Red Sokoto bucks fed GMMO leaf meal inclusion in *D. smutsii* hay based diets

Nitrogen intake observed in this work followed similar trend with nutrient intake and digestibility of nutrients. The values were similar to the findings of Adegun (2014) who reported nitrogen intake ranging from 6.08 g/day in *M. oleifera* to 6.20 g/day in *Gliricidia sepium* and *M. oleifera* mixture and 4.79 g/day for animals on control diet. It has been reported that dietary nitrogen intake influenced nitrogen losses through urine and feces (Badamana and Sutton, 1992). Also reduced nitrogen excretion in the urine was reported to be an indication that diet was well balanced in energy and protein which were attributed to better nitrogen retention (Noblet and Van Milgen, 2004). Also according to McDonald *et al*. (2011), digestibility is much reduced when a ration contains little protein in proportion to the amount of readily digestible carbohydrate. Positive nitrogen balance by the bucks was an indication that the nitrogen in the diets was adequate and well utilized.

5.11 Effects of GMMO leaf meal inclusion on feed intake and growth performance of Red Sokoto does fed *D. smutsii* hay based diets

The non-significant effect of GMMO inclusion on feed intake, average daily gain and feed conversion ratio recorded in this study was similar to reports of other researchers (Aregheore, 2002; Ndemanisho *et al*., 2007; Okafor *et al*., 2012; Aye and Tawose, 2015). Higher weight gain recorded in does fed 20% GMMO leaf meal agreed with the findings of Torrest-Acosta *et al.* (2006); Ogunbosoye and Babayemi (2010a) and Fasea *et al*. (2010) who fed browse leaves to growing goats. This may be as a result of an improved ruminal environment and digestibility of diets. The finding was in agreement with the reports of Kabir *et al*. (2004) and Torrest-Acosta *et al.* (2006). The higher weight gain may be as a result of adequate crude protein content, increased intake of the diet, improved digestibility and nitrogen retained by the animal on 20% GMMO leaf meal inclusion.

The trend obtained indicated that the inclusion of GMMO leaf meal improved weight gain of the does to the optimal level and then declined. The reduction in weight after the optimal level was similar to the findings of Okpara *et al*. (2014) who reported that higher inclusion of Gmelina leaves resulted in weight reduction.

5.12 Effect of GMMO leaf meal inclusion on cost-benefit analysis of Red Sokoto does fed *D. smutsii* hay based diets

The result demonstrated that the best feed cost benefit was recorded in bucks fed 20% GMMO leaf meal. The results indicated that treatment diets with leaf meal were more cost effective than the control diet and it can be due to cheaper cost of feed and improvement in feed utilization and weight gain. The result of this study is similar to the work of Njidda and Ikhimioya (2010) who reported that diets supplemented with *Ziziphus mauritiana* reduced the cost of production. Incorporation of unconventional feed stuff has been reported to reduce the cost of feeding (Okafor *et al*., 2012).

5.13 Linear body measurement and Body Condition Score of growing Red Sokoto does fed levels of GMMO leaf meal in *D. smutsii* hay based complete diets

Linear body measurement is a method of evaluating livestock especially important in rural areas where weighing scales are not readily available (Sowande and Sobola, 2008; Yakubu, 2010). Result showed higher body length and height at withers in animals fed 20% GMMO leaf meal. This was in contrast with the reports of Eghahi *et al*. (2011) who recorded significant differences in all the parameters measured. The result observed was similar to the values reported by Adeyinka and Mohammed (2006) for Red Sokoto goats. Highest mean body condition score was recorded in goats fed 20% GMMO leaf meal. This may be as a result of better feed utilization and nutrient balance in the animals. Body condition score is a subjective way to evaluate the nutritional status of a flock (Zahraddeen *et al.*, 2008) and acts as a potential indicator for goat owners to increase the production efficiency in their flock (Sejian *et al*., 2010). Villaquirán *et al.* (2012) recommended a BCS of 3.0 to 3.5 as optimal for goats in the breeding season. This is because it has been observed that does with good body condition have greater ovulation rate than does with lesser body condition (Meza-Herrera *et al.*, 2008). No treatment group had BCS below 2.0 which is an indication of good health and management.

5.14 Effect of GMMO leaf meal inclusion on haematological parameters in growing Red Sokoto does fed *D. smutsii* hay based diets

Etim *et al.* (2014) reported that haematological parameters are indicators of the physiological, nutritional and pathological status of an animal. The result showed that packed cell volume, haemoglobin, red blood celsl and white blood cells were all within normal range for healthy goats (Latimer, 2010). This may be due to the quality and adequacy of the treatment diets. Reports of Roberts *et al*. (2000) and Bello and Tsado (2013) indicated that diets containing poor protein affect the haematology and health of animals.

5.15 Effect of feeding of GMMO leaf meal on serum biochemistry of growing Red Sokoto does fed *D. smutsii* hay based diets

The result showed significant (P<0.05) differences in glucose and cholesterol levels across the treatments. The values were within the normal ranges for healthy goats reported by Kaneko *et al.* (2008). This was in contrast with the work of Ologhobo *et al.* (2014) who reported no significant effect on most parameters measured for birds fed graded levels of *Moringa oleifera* leaf meal. The lower cholesterol level obtained in animals fed 20% and 30% GMMO leaf meal agreed with the work of Aderinola *et al*. (2013).This could be as a result of the hypocholesterolemic properties of Moringa leaf meal included in the diets (Olugbemi *et al*., 2010). The beta-sitosterol in *Moringa oleifera* leaf was reported to be responsible for its hypolipidaemic and antioxidant properties (Rajanandh and Kavitha, 2010).

5.16 Effect of sampling periods on haematological parameters of growing Red Sokoto does fed GMMO leaf meal inclusion in *D. smutsii* hay based diets

There was significantly (P<0.05) lower packed cell volume, haemoglobin and red blood cells count at the end of the study. All the values of parameters measured in this study fell within the normal range for healthy goats (Latimer, 2010). Reduction in the haemoglobin may be accompanied by a fall in the red blood cells count (RBC) and packed cell volume (haematocrit). Red blood cells are responsible for the transportation of oxygen and carbon dioxide in the blood and also involved in the manufacture of haemoglobin (Ologun and Ikeobi, 2006). Haemoglobin is an iron- containing compound found in the red blood cells, which transports oxygen around the body (Soetan *et al.,* 2006; Isaac *et al.,* 2013). Reduction in packed cell volume and red blood cell values are indicative of low protein intake or mild anemia (Oyeyemi and Ajani, 2014).

5.17 Effect of sampling periods on serum biochemical parameters of growing Red Sokoto does fed *D. smutsii* hay based diets containing levels of GMMO leaf meal

The reduced total protein observed in this study may be as a result of the quality of protein fed. The parameters measured were within the ranges reported for clinically healthy goats (Kaneko *et al.,* 2008). This implied that the animals were in good health condition and were not stressed by the nutrition or environment. Reports of Olafedehan *et al*. (2010) found that blood acts as a pathological reflector of the status of exposed animals to diseases and other conditions.

5.18 Effect of Gmelina and Moringa leaf meal inclusion on haematological and serum parameters of pregnant Red Sokoto does fed *D. smutsii* hay based diets

The importance of examining blood for their constituents and the use in monitoring and evaluation of health, reproduction and nutritional wellbeing of animals has been well documented (Gupta *et al.*, 2007; Opara *et al.*, 2010; Tambuwal *et al.,* 2002). Dietary treatments had effect on haematological parameters. However, the values obtained were within the range for healthy goats (Latimer 2010). This result can be attributed to the fact that the pregnant does were well adapted to the diets. This agreed with the observation of Iriadam (2007) who reported that nutritional status and management practices can influence the physiological attributes and ability of animals to cope with stress.

Results showed significantly ($P<0.05$) lower blood urea nitrogen and cholesterol values in does fed diets with GMMO leaf meal. Reduced urea nitrogen observed may be as a result of the type and quality of protein. The lower cholesterol level obtained in animals fed 20% and 30% GMMO leaf meal agreed with the reports of Aderinola *et al*. (2013). This can be as a result of the hypocholesterolemic properties of Moringa leaf meal included in the diets (Olugbemi *et al*., 2010).

5.19 Effect of GMMO leaf meal inclusion level on feed intake, weight changes and birth weight of kids of Red Sokoto does fed *D. smutsii* hay based diets

Increased feed intake in animals fed GMMO leaf meal inclusion may be as a result of improved feed utilization. The improved intake was likely to have resulted in higher birth weight of kids. The higher birth weight (1.58kg and 1.68kg) was observed in does fed 20% and 30% GMMO leaf meal, respectively. This was similar to 1.73kg and 1.76kg reported by Muktar *et al*. (2011) and Zahraddeen *et al*. (2008), respectively for Red Sokoto kids. Malau-Aduli *et al*. (2004) reported lower birth weight of 1.07-1.40 kg for Red Sokoto kids, however, higher value was reported by Akpa (2000) for Red Sokoto kids. Birth weight of animals is one of the most important factors influencing the pre-weaning growth of the young and subsequent live body weight (Deribe, 2009). The birth weight recorded in this work may be a result of adequate nutrition of the does. This was in agreement with the report of Huston (2002) who stated that birth weight is highly dependent on the dam's nutrition and in particular energy intake during the last month of the pregnancy. However, variations in birth weight may be due to dam age and birth type (Ince, 2010).

5.20 Effect of GMMO leaf meal inclusion on milk composition of Red Sokoto does fed *D. smutsii* hay based diets

Milk composition and quality are important attributes that determine the nutritive value and its acceptability to consumer (Zahraddeen *et al.,* 2007). Higher milk protein in does fed 10% and 20% GMMO leaf meal may be attributed to better utilization of nutrients as indicated by the higher intake and birth weight of kids at those levels of inclusion. The values of milk protein recorded were similar to the reports of Baba *et al.* (2000); Ogunbosoye and Babayemi (2010b) and Ahamefule *et al*. (2012) for goats fed browse based diets. Mahmoud *et al.* (2014) reported a similar value of 3.59% for milk protein for Damascus does. Lactose content was statistically ($P<0.05$) higher in does fed 30% GMMO leaf meal and those on 0%. This finding was in agreement with the reports of Baba *et al*. (2000) and Ogunbosoye and Babayemi (2010b) who recorded 4.41 and 4.82% for lactating Katjang-Cross and West African Dwarf does respectively fed different browse leaves. Fajemisin *et al.* (2016) reported higher lactose content of 7.53%- 8.60% in West African Dwarf goats. Lactose content has been found to be more stable than other constituents and averages 4.60 % in goat milk (Midau *et al*., 2010). Variability in milk constituents of ruminant animals may arise as a result of differences in management and location of study (El-Hassan *et al*., 2009).

CHAPTER SIX

6.0. SUMMARY, CONCLUSION AND RECOMMENDATIONS

6.1 Summary

One of the problems of ruminant livestock farmers in the tropics is the inadequate feeds during the dry season. The performance of the animals is drastically reduced in terms of weight gain, reproduction and milk production. There is need for alternative ways to solve this problem and maintain the productivity of the animals. Feeding of browse plants has been used to supplement the animals since they are available and competition is not high for the feedstuff. There is limited information on the use of mixed *Gmelina arborea* and *Moringa oleifera* leaf meal in the diets of Red Sokoto goats. The studies were designed to investigate the effect of mixed Gmelina and Moringa leaf meal inclusion on growth performance, pregnancy, birth weight of Red Sokoto kids and milk composition of lactating does. The studies were conducted at the Experimental Unit of the Small Ruminant Research Programme of the National Animal Production Research Institute (NAPRI), Shika, Zaria, Nigeria. Twenty Red Sokoto bucks and twenty eight Red Sokoto does were used for the growth trials in experiments 1 and 2, respectively. Twenty four pregnant maiden does were used to study the effect on pregnancy and birth weight of kids and milk composition of lactating does.

All data generated were analyzed statistically using the General Linear Model (GLM) procedure of SAS (2005). Significant differences between treatment means were determined according to Duncan's Multiple Range Test of SAS (2005).

Mixed Gmelina and Moringa leaf meal inclusion significantly ($P<0.05$) affected the feed intake and performance of growing Red Sokoto bucks. Weight gain and average daily gain were significantly ($P<0.05$) higher in bucks fed 20% GMMO leaf meal inclusion than the other treatments. Trend analysis showed 21.95% inclusion as the optimal level of GMMO leaf meal inclusion in the diets of growing bucks. GMMO leaf meal inclusion significantly improved nutrient intake, digestibility and nitrogen balance of the Red Sokoto bucks.

Inclusion of GMMO leaf meal significantly ($P<0.05$) improved weight gain of Red Sokoto does. Animals fed dietary treatments containing 10% and 20% of GMMO leaf meal had significantly ($P<0.05$) higher weight gain than animals on other treatments. Trend analysis showed 15.20% inclusion as the optimum level of GMMO leaf meal in the diets of growing Red Sokoto does. The inclusion of GMMO leaf meal increased reproductive performance and milk composition of the Red Sokoto does. Birth weight was significantly higher ($P<0.05$) in does fed 30% and 20% GMMO leaf meal respectively. Milk protein was significantly ($P<0.05$) better in does fed 20% GMMO leaf meal. Lactose content in does fed 30% GMMO leaf meal was comparable to those fed the control diet. The GMMO leaf meal inclusion did not have adverse affect on the haematological and serum biochemical parameters of Red Sokoto goats. The cost-benefit analysis showed that goats fed 20% GMMO leaf meal had the highest profit in both first and second experiments.

It can be concluded that mixed Gmelina and Moringa leaf meal can be included at 25% and 15% in the diets of Red Sokoto bucks and does respectively for improved weight gain and birth weight.

6.2 Conclusions

- Mixed Gmelina and Moringa leaf meal inclusion in the diets of Red Sokoto goats at 21.95% and 15.20% improved the growth performances in bucks and does, respectively.
- Apparent digestibility and nitrogen balance in Red Sokoto bucks were improved by GMMO leaf meal inclusion.
- The GMMO leaf meal inclusion enhanced the birth weight (kids) and milk protein of lactating Red Sokoto does.
- Inclusion of GMMO leaf meal did not have adverse effect on the haematological and serum biochemical parameters of Red Sokoto goats.
- GMMO leaf meal inclusion at 20% improved total weight gain by 46.85% and 20.71% respectively in growing Red Sokoto bucks and does
- The cost-benefit analysis showed that feeding 20% GMMO leaf meal gave more profit in both first and second experiments. Gmelina and Moringa leaf meal inclusion reduced cost of feed/kg gain by 34.79% and 36.96% in the diets of Red Sokoto bucks and does, respectively.

6.3 Recommendations

- It is recommended that Gmelina and Moringa leaf meal be mixed at the ratio of 3:1 and fed at 20% level of inclusion in the diets of Red Sokoto goats for improved feed intake, weight gain, birth weight and milk composition.
- Further research need to be done on the effect of GMMO leaf meal inclusion on carcass characteristics and meat quality.

- Further research need to be also carried out using different browse mixtures for improved productivity.

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APPENDIX

Appendix 1: Haematological values of Healthy Goats

Parameters	Normal Ranges
Pack cell volume	22-38%
Haemoglobin	8-12 g/dl
Red blood cell	8-18x10^{12}/L
White blood cell	4-13x10^{12}/L

Source: Latimer (2010).

Appendix 2: Serum Biochemical Reference Ranges for Goats

Serum metabolites	Ranges
Total protein	64-70g/l
Albumin	27-39g/l
Globulin	27-41g/l
Urea Nitrogen	3.6- 7.10mmol/l
Glucose	50-75 mg/dl
Creatinine	88.4-159µmol/l
Cholesterol	80-130 mg/dl

Source: Kaneko *et al*. (2008).

Appendix 3: Birth weights of Goat Breeds in different zones

S/N	Breeds	Location	Birth weight(kg)	References
1	Red Sokoto goats	Northern Nigeria	1.90	Akpa (2000)
		Bauchi	1.76	Zahraddeen *et al.* (2008)
		Adamawa	1.73-2.07	Muktar *et al*., (2011)
		Zaria	1.07-1.40	Malau-Aduli *et al*. (2004)
		Kano	2.87-3.09	Garba *et al*., (2015)
2	West African dwarf	Bauchi	1.65	Zahraddeen *et al*. (2008)
		South West, Nigeria	1.66	Odubote and Akinokun (1992)
		South Eastern Nigeria	1.19	Ukanwoko *et al*., (2012)
3	Sahel goats	Bauchi	1.91	Zahraddeen *et al*. (2008),
		Delta State	1.28-1.66	Otuma and Osawe (2008)
4	Barbari goat	Northwestern India	1.84-1.92	Bharathidhasan *et al*.2009
5	Boer goats	North-western, Croatia	1.70-5.4	Đuričić *et al*. (2012)
6	Central Highland	Meta-Robi, Ethiopia	2.68	Netsanet *et al*., (2016)
7	Woyto-Guji	Konso, Ethiopia	2.00	Netsanet *et al*., (2016)
8	Beetal goats	Lahore, Pakistan	3.07-.09	Ahmad *et al*. (2014)
9	WADXRS crosses	South East Nigeria	1.48	Ukanwoko *et al*., (2012)