# EVALUATION OF NEEM LEAF MEAL AS A PROTEIN SOURCE FOR SHEEP ON LOW QUALITY FORAGE

**BY**

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## DECLARATION

The work presented in this thesis was undertaken by me while I was a postgraduate student at the Department of Animal Science, College of Basic and Applied Sciences, University of Ghana, Legon.

I hereby declare that, except for references to other peoples work (published and unpublished) which have been duly acknowledged by means of references, this work is the result of my original research. I further declare that, this thesis either in whole or in part has neither been presented for another degree nor is currently being submitted for another degree in this university or elsewhere.

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## DEDICATION

I dedicate this to my family for their support and care. I also want to dedicate it to my lovely wife for her patience, care and support throughout my study. Finally I want to dedicate this work to all friends who helped me in diverse ways.

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## ABSTRACT

In Ghana the dominant sheep breed is the West African Dwarf Sheep (Djallonké). It is trypanotolerant, hardy, prolific and suitable for year round breeding but has its productivity to be less than optimal. Due to poor nutrition it has poor growth rate and reproductive performance. Therefore it is important to improve its nutrition and productivity. With a crude protein level of 20.9% as compared to other tree leaves, Neem leaves can be included in the diets of ruminants in the form of supplements. This study was undertaken to determine the effect of neem leaf meal (NLM) supplementation on the Djallonke sheep (WAD). Two experiments were conducted. The first experiment was a preference trial to ascertain the maximum acceptable level of inclusion of NLM in the test supplement. Four male sheep with mean body weight of 16.6±1.50kg were used for the preference trial. Each sheep was offered four different supplements containing 0 % (Control), 20%, 40% and 60% Neem Leaf Meal (NLM) at the same time for an hour and a basal diet of rice straw and water at *ad libitum*. The second experiment was to determine the effect of replacing SBM with NLM in supplements on feed intake, digestibility of the diet, growth, feed conversion efficiency of sheep and blood parameters. Twenty (20) sheep with mean body weight of 14.6 kg were allotted to four treatments in a randomized complete design. Five animals (3 males and two females) were allotted to each treatment. Sheep in T1, T2, T3 and T4 group were fed supplements containing 0 % (Control), 20%, 30% and 40% Neem Leaf Meal (NLM) respectively and a basal diet of rice straw and water at *ad libitum*. Sheep weights and blood samples were taken fortnightly. In experiment one, there was a significant difference ($P<0.05$) in the acceptability of the supplement. Supplement 1(0% NML) was the highest followed by

supplement 2 (20% NLM), then supplements 3 (40% NLM) and then supplement 4 (60% NLM). In experiment two, dry matter intake (DMI), Crude Protein intake (CP), Neutral Detergent Fibre intake (NDF) and Acid detergent fibre intake (ADF) had significant differences ($P<0.05$) among the treatments. The dry matter digestibility (DMD), Crude Protein digestibility (CPD) Neutral Detergent Fibre digestibility and Acid Detergent Fibre digestibility (ADF) also had significant differences ($P<0.05$) among the treatments. There was significant difference ($P<0.05$) in the average daily gain and feed conversion efficiency of sheep among the treatments. The Haemoglobin (Hb), Packed Cell Volume (PCV), Red Blood Cells (RBC) and White Blood Cells (WBC) were similar ($P>0.05$) across the treatments.

The results from the study suggest that NLM supplement is acceptable to WAD sheep up to 40% level but acceptability declined with increasing level of NLM. This could be due to the bitter taste of neem leaves. NLM helps to increase dry matter intake and digestibility of rice straw when offered as a supplement in the dry season. NLM also helps to maintain the weight of WAD sheep during the dry season. West African Dwarf Sheep supplemented on 40% NLM were able to efficiently convert their feed better than WAD sheep supplemented on 30% and 20% NLM. NLM has no effect on the Hb, PCV, RBC and WBC in WAD sheep fed NLM as a supplement.

## LIST OF ACRONYMS

| | |
|---|---|
| ADF | Acid Detergent Fibre |
| ADFI | Acid Detergent Fibre Intake |
| AENNSC | Alcohol Extracted Neem Seed Cake |
| ATNKC | Alkali Treated Neem Kernel Cake |
| ATNSC | Alkali Treated Neem Seed Cake |
| BGA | Blue Green Alga |
| BNF | Biological Nitrogen Fixation |
| BW | Body Weight |
| CP | Crude Protein |
| CPI | Crude Protein Intake |
| DCP | Digestible Crude Protein |
| DM | Dry Matter |
| DMI | Dry Matter Intake |
| DNSC | Deoiled Neem Seed Cake |
| DNSC | Decorticated Neem Seed Cake |
| Hb | Haemoglobin |
| LIPREC | Livestock and Poultry Research Centre |
| ME | Metabolizable Energy |
| NDF | Neural Detergent Fibre |
| NDFI | Neutral Detergent Fibre Intake |
| NFE | Nitrogen Free Extract |
| NKC | Neem Kernel Cake |

| | |
|---|---|
| NLM | Neem Leaf Meal |
| NSC | Neem Seed Cake |
| OM | Organic Matter |
| PCV | Packed Cell Volume |
| PNM | Peanut Meal |
| RBC | Red Blood Cells |
| TDN | Total Digestible Nutrient |
| UANKC | Urea-ammoniated Neem kernel Cake |
| UNSC | Undecorticated Neem Seed Cake |
| WBC | White Blood Cells |
| WWNKC | Water Washed Neem Kernel Cake |
| WWNSC | Water Washed Neem Seed Cake |

# CHAPTER ONE

## 1.0 INTRODUCTION

### 1.1 BACKGROUND AND JUSTIFICATION

Animal production is an imperative part of Ghana's agricultural economy. Ruminants commonly reared in Ghana are cattle, goats and sheep, while the non-ruminants reared are pigs and poultry (Kosgey, 2004). Micro-livestock production for example rabbits, grasscutters, bees, snail and fish farming are also gaining much importance (Adzitey, 2013). Livestock production accounts for 40% of the world's gross agricultural production (MoFA, 2000). This is due to the fact that in developing countries especially, there is a shift in the dietary habits of people to increased meat consumption, especially among high income earners (Ranjhan, 2001).

The significance of small ruminants (sheep and goats) to the socio-economic well-being of people in developing countries like Ghana in terms of nutrition, income, insurance against emergencies, cultural and ceremonial purposes cannot be overemphasized. They also play a corresponding role to other livestock in the utilisation of available feed resources and provide a means of using vast areas of natural grassland in regions where crop production is impractical (Kosgey, 2004).

In recent times, urban livestock productions have emerged as an important industry and it contributes to the provision of animal protein to the urban community (Oppong-Anane,

2011). For example urban and peri-urban dwellers raise approximately 25% of the 13.3 million of small ruminant population in Ghana (Oppong-Anane, 2011).

In developing countries, livestock are fed mainly on low quality roughages including crop residues and agro-industrial by-products which in most cases are deficient in protein, minerals and vitamins (IAEA, 2006). In addition, the quality of pasture being grazed substantially deteriorates due to seasonal influences, consequently reducing productivity as experienced in ruminant production systems in Ghana where the animals depend extensively on pasture (Amaning-Kwarteng, 1991; Siaw *et al.*, 1993). Improving the nutrition of ruminants is therefore key for increased productivity. According to the IAEA (2006), the use of foliage from tree leaves or supplementation with seed meals, or urea-molasses multinutrient blocks, can improve the utilization of low quality roughages mainly through the supply of nitrogen to the rumen microbes.

According to Peters, (1992) crude protein is one of the major limiting nutrients in grasses during the dry season. However, most leguminous fodder tree leaves have been found to contain high levels of crude protein content even in the dry season. They could therefore serve as an important source of feed for grazing ruminants (Peters, 1992; Leng, 1997).

Leaf meals made from fodder shrubs, leguminous crops and trees are currently being utilized to improve the productivity of livestock (Esonu *et al.*, 2002; Nworgu and Fapohunda, 2002; Ogbuewu *et al.*, 2011). Some of these leaf meals including velvet

beans *Mucuna pruriens (L.)* and neem (*Azadirachta indica A. Juss*.) have been found to have high crude protein content (Omoikhoje *et al*., 2006; Ogbuewu, 2008).

Neem tree (*Azadirachta indica*) is a non-leguminous plant from the *Melicea* family (Adjorlolo *et al*., 2016). According to Girish and Shankara (2008) and Orwa *et al*. (2009) the neem plant is native to the Indian subcontinent and Senegal. However, it can also be found in other countries around the world. (Orwa *et al*., 2009). In Ghana, the neem plant was introduced in 1915 (Streets, 1962) and has grown all over the country. The neem plant can tolerant drought, does well in areas with long dry seasons and also in areas with low rainfall of 130mm per annum (Gowda and Sastry, 2000). The neem tree does well in most soils and can withstand a soil pH of four to ten (Arbonnier, 2002; Girish and Shankara, 2008). In afforestation programmes, neem tree is usually used and more importantly in the semi-arid region (Adjorlolo *et al*., 2016). In Northern Ghana, neem is the exotic tree plant found in soils that are deficient in nutrients (Nanang *et al.*, 1997) and it is mostly found in the Accra plains (Timpong-Jones, 2011). The use of neem leaves has however not received much attention (Adjorlolo *et al*., 2016). There is a constant decline in availability of forage throughout the dry season. The neem plant can adapt to intense drought seasons, poor soils (Ogbuewu *et al*., 2011) and also contribute considerably towards assuaging the nutritional inadequacies of ruminants throughout the dry season

Neem leaves have high levels of crude protein (20.9%) as compared to many tree leaves (Ogbuewu *et al.*, 2011). Neem leaves can be used as an alternate protein supplement in

diets of ruminants due to its low level of fibre and high crude protein level. (Adjorlolo *et al*., 2016)

The West African Dwarf sheep (Djallonké) is the dominant sheep breed in Ghana. It is acknowledged for its hardiness, trypanotolerance, prolificacy and suitability for year round breeding (Oppong-Anane, 2006). However, its productivity is less than optimum characterized by poor growth rates and reproductive performance due to inadequate nutrition. There is therefore the need to improve the nutrition of this breed to increase its productivity.

## 1.2 OBJECTIVES

The main objective of this study was to evaluate the effect of neem leaf meal as feed supplement on intake, growth and physiology of the West African Dwarf Sheep. The specific objectives of this study are

i) To determine the effect of neem leaf meal on voluntary feed intake of the sheep.

ii) To evaluate the effect of neem leaf meal on digestibility of the basal diet of sheep.

iii) To assess the effect of neem leaf meal on growth rate and feed conversion efficiency of the sheep.

iv) To determine the effect of neem leaf meal on the levels of some haematological parameters of the sheep.

Information from this study will lead to the development of supplementary feed package which should enhance nutritional and physiological status of the West African Dwarf Sheep and hence improve its productivity.

# CHAPTER TWO

## 2.0 LITERATURE REVIEW

### 2.1 Ruminant feeding and constraints in West Africa

It has been established that ruminants gain weight in the rainy season as there are abundant green natural pasture which is nutritionally rich. However, they lose weight in the dry season because of low quality fodder which is compounded by its unavailability (Otchere *et al.*, 1977). Rose-Innes (1960) recorded up to 11% weight loss in cattle and Otchere *et al*. (1977) recorded 15% weight loss in sheep at the Accra plains in Ghana during the dry season and attributed it to poor quality and unavailable fodder. This brings about the need for feed supplementation of the ruminant in the dry season to maintain or improve weight gain and reproductive performance. Supplementation often depends on the energy rich grains. This is often scarce and expensive and not economical to use (Karbo *et al.*, 2002).

A major problem in ruminant production is the change and fluctuations in the seasons which affect the quality of forage crop availability in the dry season. One factor that accounts mostly to shortage of feed is unreliable rainfall patterns (Olanite *et al.*, 2004). The capacity of ruminants to also utilize nutrients and energy in feed is a challenge during the dry season along with the low quality feed available which has the ability to affect productivity (Allen, 1996). A study done by Peters *et al.* (1997) reports a decline in nutrient content of forage during the dry season where crude protein levels reduced to as low as 3.7% during the dry season.

Another major problem that impedes the establishment and production of pasture is unavailability of land, capital, labour and seed and this has led to the lack of motivation and unwillingness of farmers to cultivate pasture (Onwuka, 1992).

According to Smith *et al.*(1988 ) rumen degradability in small ruminants as well as nutritive value of forage grasses shows that grasses such as *pennisetum puerperium* were of low quality during the dry season and suggested supplementation with browse and crop residue. It is important that efforts must be put in place to improve the utilization of feed by integrating the use of crop residues, browse trees and legumes which serve as a good feed resource as well as supplement.

The productivity of high quality forage needs input and improved management which must be made available to farmers by incorporating it into their farming practices in the tropics. Other readily available feed resources must therefore be used to complement fodder trees and browses (Rutagwenda *et al*., 1985). This can be achieved by practicing inter cropping and alley cropping which are cropping systems that aid in the use of multiple trees and crops with high crude protein to sustain production in the dry season (Ademosun *et al*., 1988).

**2.2 Contribution of fodder trees and shrubs to ruminant feeding**

Fodder is an agricultural term used for animal feed, and fodder trees and shrubs are plants (shoots or sprouts, especially tender twigs and stems of woody plants with their leaves, flowers, fruits or pods) that can be used as feed for livestock. Fodder plants are plants that

are grown so as to provide the nutritional needs of animals (Adjorlolo *et al*., 2016). Babayemi and Bamikole (2006) reported that fodder and shrubs are important parts of ruminant diet and have been found to play major roles in the nutrition of grazing animals in areas where few or no alternative feeds are available. Osemeobo (1996) also reported that consumption of fodder in the livestock industry and the savannah areas accounts for about 10-15% fodder.

Browse species are a major and integral part of diet for rangeland ruminants and has been a good feed source for ruminants since time immemorial (Baumer, 1992). Other important feed resources for ruminants are leguminous fodder and browses because they have more than 25% crude protein while grasses seldom exceed 15%. However, the palatability, digestibility and associative effect of these trees and browses with other feed are also important when considering them as feed for ruminants (Smith, 1992).

Studies by Saha and Muinga (2008) reported that reproductive performance and milk yield was not affected in cattle when 42% of leucaena fodder was used as a supplement in place of soy bean in a concentrate formula. Although tree fodder shrubs did not affect the performance of cattle it represents poor quality for cattle because of its high lignified stem and bitterness and may serve as a preferred and good choice for goats. (Luginbuhl *et al*., 1998)

Goats are able to tolerate the bitter taste of fodder and resist eating the stems due to their browsing abilities and therefore benefit from the high crude protein in the leaves of the

plants. Cattle on the other hand do well on low quality high cell walled straw which will not provide maintenance for goats.

Feed intake in ruminants' increases with increased protein supplementation in animals fed low basal quality diet compared to unsupplemented animals (Hennessy *et al.*, 1983). Holmes and Hoogendoorn (1983) suggested that higher response will be achieved when supplementation is done in situations where there is inadequate supply or availability of herbage and grasses.

**2.3 The Neem Tree**

The neem tree (*Azadirachta indica*) is a non-leguminous plant from the *Melicea* family (Adjorlolo *et al.*, 2016). The neem tree has medicinal properties and has therefore been used as medicine for more than 400 years (Girish and Shankara, 2008). "The plant parts of neem such as fruits, seeds, leaves, bark and roots have compounds with proven antiseptic, antiviral, antipyretic, anti-inflammatory, antiulcer and antifungal uses. The Sanskrit name 'nimba' comes from the term 'nimbati swasthyamdadati' which means 'to give good health'. The uses of neem are enumerated in ancient documents 'Charak-Samhita' and 'Susruta-Samhita', which form the foundation of the Indian system of natural treatment. It is commonly called 'Indian lilac' or 'Margosa' and belongs to the family *Meliaceae*" (Sateesh, 1998; Ogbuewu *et al.*, 2011).

A lot of research has been conducted on the neem tree and the results are promising (Thakkar, 1997). In fields like medicine, pest management and environmental protection,

the neem plant has huge potentials. The neem tree can be processed and used as insecticides, pesticides and agrochemicals (Brahmachari, 2004; Ogbuew *et al*., 2011).

Neem is a huge tree that can grow about 25 m in height with semi-straight to straight trunk, 3m in breadth and has branches spreading to form an expansive crown. Normally, the neem tree starts fruiting after 3-5 years and becomes fully productive in about 10 years. It can produce about 50kg of fruits yearly from the tenth year (Kumar, 2003). It is reported that the neem plant can survive for two centuries and can adapt to various environmental factors such as topography and climate. The neem plant needs a lot of sunlight and little water to thrive (Sateesh, 1998). The neem plant can survive up to a 1500m altitude (Chari, 1996; Jattan *et al*., 1995; Tewari, 1992). It can grow in a temperature range of $0^{o}$C to $49^{o}$C (Hegde, 1995) but performs poorly in poorly drained soils and water-logged areas. It can grow in soils with a pH range of 4 to 10. Neem tree grows well in loamy soils but can also grow well on most soils. It can also make acidic soils neutral by using a special process known as calcium mining (Hegde, 1995).

### 2.3.1 Origin and distribution of neem

Jattan *et al*. (1995) and Hegde (1995) have reported of two species of *Azadirachta*. They are *Azadirachta excelsa Kack* confined to the Philippines and Indonesia and *Azadirachta indica A. Juss*-native to the Indian subcontinent. *Azadirachta indica A. Juss* grows as a wild tree in India, Bangladesh, Burma, Pakistan, Sri Lanka, Malaysia, Thailand and Indonesia. Currently neem trees are growing successfully in about 72 countries worldwide. They include Asia, Africa, Australia, North, Central and South America (Ahmed *et al.*, 1989; Sidhu, 1995; Sateesh, 1998; Fathima, 2004).

It is estimated that about 25 million neem trees are growing all over India, with about 55.7% found in Uttar Pradesh, 5.5% in Karnataka and 17.8% found in Tamilnadu respectively. India is the highest neem seed producer. Annually, the neem plant produces about 442,300 tons of seeds resulting in 353,800 tons of neem cake. (Rembold, 1996).

### 2.3.2 Botanical Description of Neem

Neem tree is a fast-growing tree that is hardy, has a straight trunk with its branches spreading. The least height of a mature neem tree is 7m whiles the highest height can be 15m (Ogbuewu, 2008). The neem tree produces yellowish fruits within four years and can survive for a long period (approximately 200 years). The neem tree has pinnately compounded leaves that are thin and can be 6cm long and produces a lot of flowers (Ogbuewu, 2008). In plantation stands neem tree is propagated using seeds in nurseries or also planting directly onto the field (Ogbuewu, 2008). When the fruit of neem is ripe or matured, it is yellowish in colour and it is about 1 inch long with a seed in it (Ogbuewu, 2008).

### 2.3.4 Chemistry of Neem

Terpenes and Limonoids are the major chemical constituents of neem. Azadirachtin, l-tigloyl-3-acetyl-11- methoxyazadirachtin, 3-deacetyl-3-cinnamoylazadirachtin, 22, 23-dihydro-23P-methoxyazadirachtin, 3-tigloylazadirachtol, nimbanal, margocinin, margocilin and 3-acetyl-salannoV nimbidioV margocin are some of the major active components in the limonoids. Examples of Terpenoids are 6 nimbocinolide,

isoazadirolide, nibonolone, nimbonone, Margosinone and methylgrevillate (Ogbuewu, 2008).

### 2.3.5 Neem and Environmental Protection

Afforestation: Planting neem trees on a large scale helps to combat deforestation, desertification, reduce excessive global warming and soil erosion (Sateesh, 1998). Neem helps to purify the environment because it has a high rate of photosynthesis and releases lots of oxygen than many other tree species (Nigam *et al.*, 1994). Neem leaves in powdered form is often used as a bio-sorbent. For example it can be used to remove Congo red from water (Bhattacharyya and Sharma, 2004). Other uses of neem in agro-forestry include firewood, wind breaks, providing shade, shelter belt and check against desertification.

When the neem tree is pruned, it is able to re-sprout and grow its canopy. Therefore it is highly recommended for pole production (Ahmed *et al.*, 1989). According to Nwokeabia (1994) about 90% of neem trees were planted as part of an afforestation programme in 12 different states in Nigeria. Also, about 17% of tree covers in Chad are neem trees. Countries from Somalia to Mauritania have used neem tress to help reduce the spread of the desert (Ohabuike, 1995).

### 2.3.6 Pest Management Prospects of Neem

In the early and middle of twentieth century, the huge dependency on synthetic chemicals encouraged the large scale synthesis of newer chemicals (pesticides). Most of the synthetic pesticides had side effects which were more serious than the problems they

were made to solve. They also caused a lot of health challenges to farmers that came into contact with them. According to the World Health Organization, it estimated that about 220,000 people die every year when they come into contact with these synthetic chemicals (Sateesh, 1998).

Pesticides made from neem have been found to be safer. Inclination towards green technology has gained a lot of attention recently. For this reason neem has gained some importance internationally. Neem products have no dangerous effects on humans and animals and have no residual effect on agricultural produce, making neem the best reliable substitute to hazardous pesticides (Sateesh, 1998). As more and more neem pesticides are used, it will lead to a drop in the demand of chemical pesticides and this will result in the reduction of synthetic chemicals in the environment (Ogbuewu *et al*, 2011).

In modern societies today, people are turning their attention towards nature for solutions. The neem tree which has a lot of promise can help in this approach of solving problems. For example neem wood has been found to last for a long period, resistant to termite and is being used as a mulch material. Neem as a pesticide can be used as a repellent, insect growth regulator, antifeedant and reduce the reproductive rate or performance of insects. About 413 insect pest species were sensitive to neem products (Schmutterer and Singh, 1995). Principally, the neem acts as a hormone that blocks the growth and reproductive developments of insects. This makes the female and male insects sexually inactive. Margosan O®, Neemix (™), Azatin®, NIM-20 and NIM-76 are neem pesticides that proved to be less toxic to mammals (Schmutterer, 1990; Govindachari *et al*. 2000).

Neemix (™) was therefore registered for use on vegetables in US due to its inherent safety. In many trials, synthetic pesticides such as Permethrin, Pirimiphos-methyl (Actellic 25 EC) and Lindane (y BHC) performed poorly as compared to neem pesticides (Ogunwolu and Oddunlami 1996; Lale and Mustapha 2000).

Brahmachari (2004) also reported that neem pesticides can easily be prepared, are cost effective and therefore will be useful to poor farmers in the third world countries. Neem pesticides are biologically friendly and can protect plants for a long period of time. Neem based pesticides do not affect bees, pollinator insects, and other useful organisms (Tanzubil, 1996).

Organic fertilizer prospects: A useful and cheap fertilizer is neem seed cake. A potential source for organic manure is the neem plant debris (Brahmachari, 2004). According to Gajalakshmi and Abbasi (2004) urea coated neem cake has been found to increase nitrogen assimilation better than untreated urea. Neem leaves can also be used in the preparation of fertilizer (Vermi-compost).

Biological Nitrogen Fixation (BNF) maintains soil nitrogen (N) fertility. Non-symbiotic microorganisms like photosynthetic bacteria and Blue Green Algae (BGA) enhance this process. Neem cake can be used to increase fertility and water holding capacity of soils. In field experiments, neem seed cake also improved the growth of algae by subduing grazers especially Ostracods (class: Crustacea). This tripled Blue Green Algae (BGA) biomass and increased N-fixation activity by 10 fold (Grant *et al*., 1983). Ketkar (1983) reported that there was a steady release of nitrogen which improved the utilisation of fertilizer when neem cake was mixed with a urea fertilizer. Root-knot nematodes reduced

significantly and that had an impact on the growth of tomatoes when neem cake was used as a fertilizer. The cake prevented the emergence and hatching of the root-knot nematode larval.

### 2.4 Neem seed as a protein source for ruminants

The possibility of using Neem Seed Cake (NSC) in livestock ration was explored by Christopher (1970) based on the feeding practice of local famers in South India. Though bitter to taste in the beginning, animals got used to it and were in good health (Puri, 1999). Following such observations, several researchers evaluated the nutritive value of this agro-industrial by-products.

#### 2.4.1 Nutritive value of Neem Seed Cake

Undecorticated neem seed cake (UNSC) contained 6.5, 8.8 and 11.6% digestible crude protein (DCP) for cattle (Ananthasubramaniam *et al*., 1979), buffalo bulls (Bedi *et al*., 1975) and sheep (Gupta and Bhaid, 1980) respectively with corresponding total digestible nutrient (TDN) values of 62.6, 57.87 and 37.9% (incomplete cake consumption). However, higher digestible crude protein (DCP) values of 27.37% were reported by Rajgopal and Nath (1981) in Neem Kernel Cake (NKC) having 38.84% crude protein (CP). Reddy and Rao (1988) obtained higher true metabolizable energy (kcal/kg) for decorticated (2959) than for undecorticated (2.790) cake in broiler chicks. Gowda *et al*., (1997) reported apparent metabolizable energy (ME) value of 1.925 kcal for neem kernel meal in poultry.

### 2.4.2 Palatability of Neem Seed Cake

Neem seed cake (NSC) was found to be unpalatable to buffalo calves (Bedi *et al.*, 1975), cattle calves (Rao and Nath, 1979), crossbred bulls (Ananthasubramaniam *et al.*, 1979) and sheep (Gupta and Bhaid, 1980). Palatability though improved when neem seed cake (NSC) was fed to sheep along with barley, molasses and peanut meal (PNM), the consumption of concentrate mixture was reduced from 79 to 39 % with increase in neem seed cake (NSC) level from 59 to 90 %, respectively (Bhandari and Joshi, 1974). On the other hand, yearling sheep could completely consume concentrate mixture comprising 75 parts neem seed cake (NSC) and 25 parts maize (Gupta and Bhaid, 1980), but the consumption was reduced to one third when neem seed cake (NSC) was fed alone. The buffalo calves though continued to relish even after enhancing neem seed cake (NSC) from 5 to 15 parts when fed along with 7 and 20 parts of molasses and peanut meal (PNM) respectively, the consumption was reduced to half on withdrawal of molasses (Baxi, 1976). By feeding different proportions of neem seed cake (NSC) to buffalo calves along with molasses (4:1, 2:1), starch (4:1, 2:1) or maize (8:1, 4:1 and 2:1), it was observed that 67% neem seed cake (NSC) with 33% maize was quite palatable (Arora *et al.*, 1975). Depression of 60% feed intake could be corrected by curtailing neem seed cake (NSC) to provide digestible crude protein (DCP) requirement from 25 to 12.5% in the ration of buffalo calves (Bedi *et al.*, 1975). However, inclusion of deoiled neem seed cake (DNSC) and decorticate neem seed cake (DNSC) (Garg, 1989) up to 45% of the concentrate mixture resulted in higher dry matter (DM) intake in cow and bull calves, respectively.

### 2.4.3 Livestock performance on Neem

Performance of large ruminants

Bedi *et al*. (1975) reported poor palatability accompanied by either depressed weight gain or loss of body weight along with lowered nutrient digestibility in crossbred calves fed concentrate mixture containing neem seed cake (NSC) to contribute 12.5, 25 or 50% of digestible crude protein (DCP) requirement suggesting the NSC as such was unsuitable for animal feeding even for maintenance. Protein utilization was adversely affected in buffalo calves (Arora *et al*., 1975) due to feeding of NSC. The nimbin derivatives of neem though did not adversely affect rumen microbial protein synthesis in buffalo calves on feeding 20 parts of NSC, it severely depressed intake of feed and growth (Ludri and Arora, 1977). A short term (60 days) feeding trial of 10, 15 and 20% NSC included concentrate mixture to lactating buffaloes did not alter the milk composition and general health of the animals. However, RBC, WBC and haemoglobin levels were lower on NSC ration than control fed animals (Pyne *et al*., 1979). Safe incorporation of NSC up to 20% in concentrate mixture was suggested by Gangopadhay *et al*., (1981). The NSC extract was tried as an antifeedant to desert locusts and the oily residue of alcoholic unlike KOH or $Na_2C0_3$ extract was found less effective against aphids (Sinha and Gulati, 1964). Therefore it was presumed that alkali treatment of NSC could make it palatable probably due to neutralization of bitter principles. Boiling of NSC with NaOH (8 g/kg cake in 2.5 litre of water) for 30 min. and removal of solubles through water washing yielded a product palatable to cattle (Nath *et al*., 1978), and DM intake on 50% of such treated NSC incorporated concentrate mixture was comparable to control with low digestibility and growth rate due to lesser available energy in a 50 days feeding trial. Vijjan *et al*.,

(1978) did not observe any ill effect of alkali treated neem seed cake (ATNSC) on creatine excretion in urine. Similar DM intake, digestibility, balance of Ca, P but depressed growth rate were observed in cow calves fed concentrate mixture containing 45% ATNSC (Rao and Nath, 1979). Serum icteric index, inorganic phosphorus and alkaline phosphatase activity also were similar between control and experimental groups. A significantly ($P<0.05$) low haemoglobin content in ATNSC fed calves, however indicated that alkali treatment did not remove the toxic bitters completely though it was palatable to calves.

Though NKC is rich in protein with low fibre than NSC, its incorporation at 45 % level in the concentrate mixture severely depressed the growth rate in crossbred bull calves without any effect on intake and nutrient digestibility (Rajgopal and Nath, 1981). Nath *et al*., (1983) attempted water washing of NKC after overnight soaking in NaOH (0.8%, wt/wt) followed by repeated draining off with two or three times water washing. Such water washed neem kernel cake (WWNKC) when incorporated after sun drying at 45% level in the concentrate mixture of bull calves for 273 days resulted in significantly lower growth rate with comparable DM intake, nutrient digestibility, balances of Ca, P, N and TDN intake. The blood haemoglobin, serum acid and phosphatase did not differ indicating that water washing largely removed the bitterness. In another experiment, Agrawal *et al*. (1987) observed significantly ($P<0.01$) lower DM digestibility but higher N- balance and faster growth of buffalo calves fed 40% WWNKC than in those on control diet. Incorporation of 40% WWNKC in dairy concentrate mixture for 300 days revealed no significant variation in milk yield, fat percentage, sensory evaluation of milk

and DM intake and its digestibility (Nath *et al.*, 1989). Blood haemoglobin, serum enzymes and reproductive ability of the cows were also not disturbed.

Though water washing of NSC/NKC did improve its palatability, the process was not feasible owing to the loss of nutrients in washing. Realising this, Katiyar *et al*. (1991) developed a simple method for debitterization through alkali soaking or urea-ammoniation without water washing. Such alkali (2.5%, wt/wt NaOH) soaked and urea (3.5%, wt/wt) - ammoniated NKC (ATNKC/UANKC) at 30 parts of inclusion in the concentrate mixture of buffalo calves for 150 days feeding revealed comparable feed intake and utilization (Reddy, 1992). Sensory evaluation of meat and gross pathological examination of vital organs also did not show any abnormalities.

Performance of small ruminants

In small ruminants also, few feeding trials with NSC/NKC were conducted. Replacing 100, 75 and 50% peanut meal (PNM) protein with DNSC in the lamb diet resulted in a daily body weight loss of 214, 176 and 147 g respectively within 21 days as compared to a gain of 176 g in lambs on control diet (Bhandari and Joshi, 1974). Toxicity symptoms such as stomatitis, severe gingivitis and sloughing of tongue epithelium and mucosa together with foamy discharge from the mouth were observed after 15 days of feeding DNSC diet. Gastroenteritis and diarrhoea resulted in death after 25 days of feeding. Gupta and Bhaid (1981) also observed decline in growth rate (66, 58 and 8 g/day) of lambs with increase in levels (50, 75 and 100%) of neem fruit cake during 4 months of experimental feeding. Vijjan *et al*. (1982) studied the effect of feeding raw as well as

alcohol extracted neem seed cake (AENSC) at 10, 20 and 30% level substituting the wheat bran of concentrate mixture in lambs. Lower levels (10 and 20%) of NSC/alcohol extracted neem seed cake incorporation resulted in respectively comparable and improved growth rates, while 30% inclusion of both the cakes led to body weight loss, especially with the raw cake. Blood glucose, haemoglobin and urea were similar in all the groups with no appreciable changes in organ weights and their histopathology even at 30% of NSC inclusion. Incorporation of WWNKC in the concentrate mixture of male kids at 15 and 25 parts for 180 days of feeding led to comparable intake and utilization of nutrients, besides normal balance of nitrogen, urinary creatine, blood haemoglobin, and cholesterol with lowered ($P<0.01$) blood glucose, urea and total protein (Verma *et al*., 1995). Similarly Anandan *et al*. (1999) also recorded no untoward effect in kids due to feeding of urea ammoniated neem kernel cake (UANKC) for similar period of feeding. However, on similar UANKC diet lambs digested the DM, organic matter (OM) and nitrogen free extracts (NFE) significantly ($P<0.05$) lesser with comparable balance of nitrogen and depressed ($P<0.05$) Ca and P retentions (Musalia *et al*., 1999). Further UANKC had low ($P<0.05$) digestible energy and the lambs compensated the energy requirement through higher intake of hay, culminating in similar growth and feed conversion efficiency and long term feeding did not affect the blood biochemical profile, meat or wool quality. Rumen study indicated depressed ($P<0.01$) total volatile fatty acids and total nitrogen accompanied with lowered ($P<0.05$) cellulase, protease and urease with unaltered amylase activities.

## 2.5 Leaves of fodder trees and shrubs as dry season feed supplements

Using tree leaves to feed animals has been used since ancient times (Baumer, 1992). Peters (1992) reported that in the dry season, crude protein is a limiting nutrient and therefore tree leaves which are known to maintain high crude protein content even in the dry season have become an important source of feed for grazing ruminants. The use of tree and shrub leaves in ruminant feeding has been generally studied (Speedy and Pugliese, 1992; Leng, 1997; Ansah and Nagbila 2011). Fodder leaves of legumes are of particular importance because they contain more crude protein than other leguminous species. The potential of fodder trees and browses is not only determined by its crude protein content but also by its palatability, digestibility and associative effects of other feeds. In dry season feeding, drought tolerance of the species, which determines its forage biomass availability during the dry season, is also of importance (Smith, 1992).

The leaves of legumes are a reliable source of protein for animal feed whiles its seeds and leaves are high in nitrogen. Delgado *et al*. (1999) reported that forage legumes are sufficiently supplied with protein for livestock feeding, even when harvested at a progressive stage of maturity. High nitrogen contents in legumes help to enhance the nutritional quality of ruminant diets whether grazed or cut and fed. Maroyi (2006) observed that there is an increase in animal productivity from grass – legumes mixture than pure grass stands. Tree legumes offer an extensive range of products like fodder from leaves, twigs and pods, as well as shade, live fences, timber and firewood. Fallen pods from the rain tree are highly palatable to livestock. However, fodder tree leaves contain substances such as tannins, saponins and non-protein amino acids that affect their

utilisation and may be toxic to rumen microbes. Nonetheless leaves from fodder trees are used as animal feed as they contain high levels of crude protein, minerals and vitamins (Maroyi, 2006) and are accessible during the dry season. Attoh-Kotoku (2011) reported that techniques such as sun drying helps to reduce the levels of some of these plant secondary metabolites.

### 2.5.1 Nutrient profile of neem leaves

Neem leaves are rich in crude protein but different and wide values have been reported. Bais *et al*. (2002) and Bhowmik *et al*. (2008) reported crude protein values between 17.5% and 18.7%. Ramana *et al*. (2000) also reported crude protein values of neem leaves as 9.7% whereas Ogbuewu *et al* (2011) reported a higher value of 20.9%. Differences in crude protein values can be attributed to varietal differences in the neem plant.

Low fibre contents of neem leaves have been reported. Ramana *et al*. (2000) reported Neutral detergent fibre (NDF) and acid detergent fibre (ADF) levels of 38.0% and 27.0% respectively. Bhowmik *et al.* (2008) also recorded a crude fibre level of 11.3% for neem leaves. However, Kumar and Sharma (2003) reported NDF and ADF values in the range of 27.40 to 55.23 and 18.87 to 46.30 respectively for 15 tropical fodder trees which are much higher than that reported by Ramana *et al*. (2000) and Bhowmik *et al*. (2008). Neem leaves may be an important source of readily fermentable carbohydrate in ruminant feed due to its low fibre content coupled with high nitrogen free extract (NFE) levels of 53.9% (Bhowmik *et al*., 2008).

Few reports on the mineral content of neem leaves have been reported. Some available information on mineral content of neem leaves have been provided in Table 2.1. A Calcium range between 1.48 to 1.53% and this is comparable to 1.5% reported for sesbania leaves (Ngamsaeng *et al.*, 2006). Niranjan *et al.* (2008) reported that neem leaves are deficient in copper and manganese. Rao *et al.* (2011) recorded low levels of zinc and phosphorus. Levels of minerals, especially trace minerals, are expected to vary widely due to differences in the mineral content of the soil in which the trees grow (Adjorlolo *et al*., 2016).

**Table 2.1: Mineral profile of neem leaves**

| Macro-minerals (% DM) | | | Micro-minerals (ppm in DM) | | | | | | **References** |
|---|---|---|---|---|---|---|---|---|---|
| Ca | P | Mg | Cu | Fe | Mn | Zn | Co | Cr | |
| 1.48 | 0.11 | 1.26 | 5.24 | | 30.4 | 47.7 | | | Bhowmik *et al.*(2008) |
| 0.71 | 0.28 | 0.75 | 34.0 | 745 | 60.0 | 18.0 | 10.0 | 0.80 | Ansari *et al*. (2012) |
| 1.47 | 0.12 | 0.40 | | | | | | | Ngamsaeng *et al.*(2006) |
| 1.53 | 0.25 | | 8.90 | 566 | 23.5 | | | | Niranjan *et al.*(2008) |

Source: Adjorlolo *et al*. (2016)

### 2.5.2 Acceptability of Neem leaves by livestock

Neem biomass is expected to yield about 0.35 tonnes per mature tree per annum (Panhwar, 2005) and 5 to 50 tonnes/ha (Girish and Shankara, 2008). Small holder farmers can make use of neem leaves as a valuable alternative feed resource to feed their animals. There is however a general perception that neem leaves are not acceptable by ruminants due to their bitter tastes (Nanang *et al.*, 1997). There are however contrary views to this perception. Neem leaves have been used to feed ruminants in India and other parts of

Asia during the dry season as reported by Shukla and Desai (1988). In India, one of the fodder trees used to feed ruminants is the neem tree (Singh, 1982). In 2006 and 2011, Chandrawathani *et al. and* Seresinhe and Marapana respectively reported that neem leaves was acceptable to sheep and goat. In Ghana, a survey in the Telensi-Nabdam District of the Upper East Region reported that 18.8% of farmers interviewed used neem leaves and fruits as fodder (Ansah and Nagbila 2011). Bais *et al*. (2002) reported that neem leaves compared favourably with *Albizzia lebbek* leaves in dry matter intake and digestible crude protein content when fed as sole diets. The acceptance of neem leaves by ruminant livestock despite the bitter taste may be due to feed insufficiency during periods of drought. It is also possible that ruminants get accustomed to the taste over time (Adjorlolo *et al*., 2016).

**2.6 Effect of feeding neem leaves on growth and digestibility in ruminants**

Both Neem leaves and seeds increased body weight of cattle when it was administered as anthelmintic against gastro-intestinal nematodiasis. Body weight increased by 3.33 and 3.70% for neem leaves and neem seeds respectively in 28 days of treatment (Hossain, 1994).

An increase in body weight (1.8 %) of cattle at 60 days post treatment was studied with pulverized neem seeds at 100 mg/kg body weight, where initial body weight was 105.88 ±1.67 kg and final body weight was 107.82±1.83 kg (Asaduzzaman, 1998). Neem seeds were used as treatment against nematodiasis in sheep and this resulted in an increase in their live weights Ahmed *et al*. (1994).

Paengkoum (2010) reported that average DMI (g/kg $BW^{0.75}$), DM, OM, CP, NDF and ADF digestibilities were not significantly different among the treatments as shown in Table 2.2. The Body Weight (BW) gain of goats did not differ among diets.

**Table 2.2: Dry Matter intake (DMI), digestibility and Body Weight gain (BW gain) of goats fed protein fodders supplementation**

| Ingredients | Control | Neem fodder | Leucaena fodder | SEM |
|---|---|---|---|---|
| DMI(day/g/kg BW $^{0.75}$) | 88.4 | 85.7 | 86.4 | 2.10 |
| **Digestibility (%)** | | | | |
| Dry matter | 69.3 | 67.6 | 68.9 | 1.90 |
| Organic matter | 70.3 | 68.8 | 67.1 | 2.91 |
| Crude protein | 58.6 | 57.9 | 57.3 | 1.97 |
| Neutral detergent fiber | 55.0 | 54.5 | 55.2 | 1.93 |
| Acid detergent fiber | 51.7 | 50.6 | 51.8 | 2.05 |
| BW gain (g/day) | 55.5 | 52.0 | 53.5 | 2.11 |

**(**Paengkoum, 2010)

### 2.7 Blood haematological profile of sheep fed neem leaves

Haematology refers to the study of the numbers and morphology of the cellular elements of the blood – the cells (Erythrocytes), white cells (Leucocytes), and Platelets (Thrombocytes) and the use of results in the diagnosis and monitoring of disease (The Merck Verterinary Manual, 2010). Changes in haematological parameters also assist in the determination of an animal's physiological status and stress due to nutritional, environmental and pathological factors (Afolabi *et al*., 2010).

Amin *et al.* (2010) observed that the haemoglobin and packed cell volume content of sheep was significantly increased on the 7$^{th}$, 14$^{th}$, 21$^{st}$, and 28$^{th}$ day after they were fed neem (*Azadirachta indica*), betel leaf (Piper betle), devil's tree (*Alstonia scholaris*), jute (*Corchorus capsularis*) and turmeric (*Curcuma longa*) as shown in Table 2.3 and 2.4 respectively. Rob *et al*., (2004) also reported that feeding water extracts of neem leaves increased Hb and PCV in sheep on day 28 post-treatment. Furthermore increase in Hb and PCV have been reported in goats (Rahman, 2002) and cattle (Hossain *et al*., 1996; Amin *et al*., 2010) when water extracts of neem was used.

**Table 2.3: Effects of Neem, Betel leaf, Devil's tree, Jute and Turmeric on Hb (gm %) in sheep**

| Group | Treatment | '0' day | 7th day | 14th day | 21st day | 28th day |
|---|---|---|---|---|---|---|
| A | Neem | 7.40 ± 0.14 | 7.90 ± 0.64 | 7.80± 0.14* | 7.60 ± 0.14 | 7.50 ± 0.35* |
| B | Betel leaf | 7.60 ± 0.12 | 7.90 ± 0.14 | 7.90 ± 0.07 | 7.80 ± 0.14 | 7.70 ± 1.41* |
| C | Devil's tree | 7.50 ± 0.35 | 7.70 ± 0.49 | 7.70 ± 0.14 | 7.60 ± 0.42 | 7.60 ± 0.00* |
| D | Jute | 7.30 ± 0.21 | 7.60 ± .07 | 7.90 ± 0.89* | 7.40 ± 1.41 | 7.40 ± 0.28* |
| E | Turmeric | 7.44 ± 0.22 | 7.80 ± 0.00 | 7.70 ± 0.89* | 7.70 ± 0.00 | 7.50 ± 0.00* |
| F | Control | 7.90 ± 0.14 | 7.70 ± 0.71 | 7.40 ± 0.28* | 7.20 ± 0.42 | 7.00 ± 0.35* |

The above values represent the mean ± standard deviation (SD) of 5 sheep

* = Significant at 5 per cent level ($p<0.05$)

(Amin *et al*., 2010)

**Table 2.4: Effects of Neem, Betel leaf, Devil's tree, Jute and Turmeric on PCV (%) in sheep**

| Group | Treatment | '0' day | 7th day | 14th day | 21st day | 28th day |
|---|---|---|---|---|---|---|
| A | Neem | 29.00 ± 0.71 | 31.50 ± 2.12** | 31.50 ± 0.71** | 31.00 ± 0.71** | 30.50 ± 1.41** |
| B | Betel leaf | 29.50 ± 1.41 | 31.50 ± 0.79** | 31.00 ± 0.00** | 31.00 ± 0.71** | 30.00 ± 1.41** |
| C | Devil's tree | 28.00 ± 2.12 | 30.00 ± 2.83** | 29.00 ± 0.00** | 28.50 ± 2.12** | 28.50 ± 0.00** |
| D | Jute | 28.50 ± 0.00 | 29.50 ± 0.00** | 29.00 ± 1.41** | 29.00 ± 0.00** | 28.50 ± 0.00** |
| E | Turmeric | 30.50 ± 3.54 | 31.50 ± 0.71** | 31.50 ± 0.71** | 31.00 ± 0.71** | 30.00 ± 2.12** |
| F | Control | 30.50 ± 1.41 | 29.00 ± 0.71** | 29.00 ± 0.71** | 28.50 ± 1.41** | 27.00 ± 1.41** |

The above values represent the mean ± standard deviation (SD) of 5 sheep

** = Significant at 1 per cent level ($p<0.01$)

(Amin *et al*., 2010)

# CHAPTER THREE

## 3.0 MATERIALS AND METHODS

### 3.1 Location of Study

The study was conducted at the Livestock and Poultry Research Centre (LIPREC) of the College of Basic and Applied Sciences, University of Ghana, Legon from May, 2016 to January, 2017. LIPREC is located about 8 km off the Legon-Aburi road from 'Ritz junction' at Madina within the Coastal Savannah zone on latitude $05^0$40'N and longitude $00^0$16'W. The annual rainfall is between 128-1709 mm and is distributed bimodally. The major rainy season spans between April and July and the minor rainy season occur from September to November. The mean monthly temperature is $26.9^0$C. The area is covered by natural grassland of medium tussock growth with scattered fire resistant trees and shrubs (Osei-Amponsah, 2010; GSS, 2014).

### 3.2 Preparation of Diet

Neem leaves were harvested from neem trees found at LIPREC. They were shade dried and the leaves were separated from their twigs. All the leaves were ground in a hammer mill (1-mm screen) to form the neem leaf meal (NLM). NLM was mixed with conventional feed ingredients to form the supplements used in the acceptability trial (Table 3.1) and the growth trial (Table 3.2). As the level of NLM increased, there was a decrease in the level of soy bean. The supplemental diets were isonitrogeneous.

### 3.3 Acceptability Study

Four West African Dwarf male sheep were used for this trial. Each animal was penned individually in a well- ventilated shed with free access to fresh water. The average weight of the sheep was 16.6 ± 1.50 kg. They were fed a leaf concentrate mixture shown in Table 3.1. Each sheep was offered the four (4) supplements in a cafeteria style at 08:00 hours and rice straw was then offered *ad libitum* for 14 days as adjustment period and 14 days for the measurements.

**Table 3.1: Ingredient Composition of Neem Supplements for Acceptability Trial**

| | SUPPLEMENTS | | | |
|---|---|---|---|---|
| **Ingredients (g/kg)** | **1** | **2** | **3** | **4** |
| Maize | 370 | 370 | 370 | 330 |
| Soybean | 200 | 100 | 0 | 0 |
| Wheat bran | 380.0 | 268.5 | 156.5 | 0 |
| **Neem leaf meal** | **0** | **200** | **400** | **600** |
| Salt | 20 | 20 | 20 | 17 |
| Oyster shell grit | 10 | 10 | 10 | 10 |
| Dicalcium phosphate | 10 | 10 | 10 | 10 |
| Urea | 10 | 21.5 | 33.5 | 33.0 |
| Total | 1000 | 1000 | 1000 | 1000 |
| Calculated CP (g/kg) | 209.1 | 208.9 | 209.4 | 209.1 |

**Table 3.2: Composition of Supplements for the Intake and Growth Study**

| | SUPPLEMENTS | | | |
|---|---|---|---|---|
| **Ingredients (g/kg)** | **1** | **2** | **3** | **4** |
| Maize | 370 | 370 | 370 | 370 |
| Soybean | 200 | 100 | 50 | 0 |
| Wheat bran | 380.0 | 268.5 | 212.0 | 156.5 |
| **Neem leaf meal** | **0** | **200** | **300** | **400** |
| Salt | 20 | 20 | 20 | 20 |
| Oyster shell grit | 10 | 10 | 10 | 10 |
| Dicalcium phosphate | 10 | 10 | 10 | 10 |
| Urea | 10 | 21.5 | 28 | 33.5 |
| Total | 1000 | 1000 | 1000 | 1000 |
| Calculated CP (g/kg) | 209.1 | 208.9 | 209.0 | 209.4 |

### 3.4 Feed intake and growth study

Twenty West African Dwarf sheep (12 males and 8 females) with an average initial body weight of 14.6 ± 1.50 kg were randomly allotted to four dietary treatments of five animals each. They were offered a basal diet of rice straw *ad libitum* and either of the four NLM-based supplements shown in Table 3.2 as below;

$T_1$= Rice straw + soy bean meal concentrate

$T_2$= Rice straw + 20% NLM concentrate

$T_3$= Rice straw + 30% NLM concentrate

$T_4$ = Rice straw + 40% NLM concentrate

Each treatment consisted of 5 animals in a completely randomized design. The sheep were penned individually in a well-ventilated shed. The size of each shed was 1.94 m by 1.46 m with a concrete floor.

A daily supplement allowance of 1.3% of each animal's body weight (approximately 25% of voluntary intake) was offered as single meal at 08:00 hour and rice straw was then offered *ad libitum*, after ensuring that the sheep have consumed all the concentrates. The sheep had free access to water. Orts of rice straw were weighed 24 hour post feeding to ascertain daily feed consumption. The sheep were allowed 14 days to adjust to their diet followed by 84 days of measurements. Feed intake was determined daily and body weights were recorded fortnightly throughout the study.

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

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

Feed Conversion Efficiency was calculated as: $\frac{\text{Feed Intake}}{\text{Weight Gained}}$

### 3.5 Digestibility Study

Twelve male sheep (3 animals per treatment in a completely randomized design) were used for this study. Faecal bags were fixed on each sheep and faeces were collected for seven days. A daily supplement allowance of 1.3% of each animal's body weight was offered as single meal at 08:00 hour and rice straw was then offered *ad libitum*, after ensuring that the sheep have consumed all the supplements. Orts of rice straw were weighed 24 hour post feeding to ascertain daily feed consumption. The adjustment period before the collection of faeces was two weeks. The faecal samples were bulked for each animal and stored in the refrigerator. After the trial the faecal samples were oven dried at 60 $^{0}$C for ten days to a constant weight for dry matter (DM) determination. The dried faeces were ground and labelled respectively for analysis.

Digestibility (%) was calculated as: $\frac{\text{(DM Intake – Faeces DM) x 100}}{\text{DM intake}}$

### 3.6 Chemical Analysis

Stored feed and faecal samples were dried in an oven at 60 $^{o}$C to a constant weight for dry matter determination. They were then ground using a laboratory mill through a 1 mm sieve and subsequently analysed. Dry matter, crude protein, and ash for the feed and faeces were determined using the method of AOAC (1995). Neutral detergent fibre (NDF), acid detergent fibre (ADF), lignin, cellulose, hemicellulose and silica were determined using the method of Van Soest (1991).

### 3.7 Blood Sampling

About 10 millilitres of blood sample was collected from the jugular vein of each sheep using a disposable syringe and needle between 07:00 and 08:00 hours and transferred into a glass vacutainer tube containing the anticoagulant tripotassiumethelyne diamine tetra acetic acid ($K_3$.EDTA). The tubes were placed in a cold box containing ice packs and transported immediately to the Laboratory for haematological analyses.

#### 3.7.1 PCV (Haematocrit) Determination

The PCV was determined by the Microhaematocrit method (Samour, 2006) using the Hawksley Micro-haematocrit Reader (Hawksley, London; Plate 3.1). The blood sample from each sheep after proper mixing was sucked into plain micro-capillary tube to about three-quarters full. One end of each filled tube was sealed with plasticine.

The filled micro-capillary tubes were subsequently arranged in the numbered grooves of the microhaematocrit rotor with the sealed ends facing the rim gasket (Plate 3.2). The microhaematocrit tubes were spun at 12,000g for 5 minutes using the micro-capillary centrifuge (Plate 3.3).

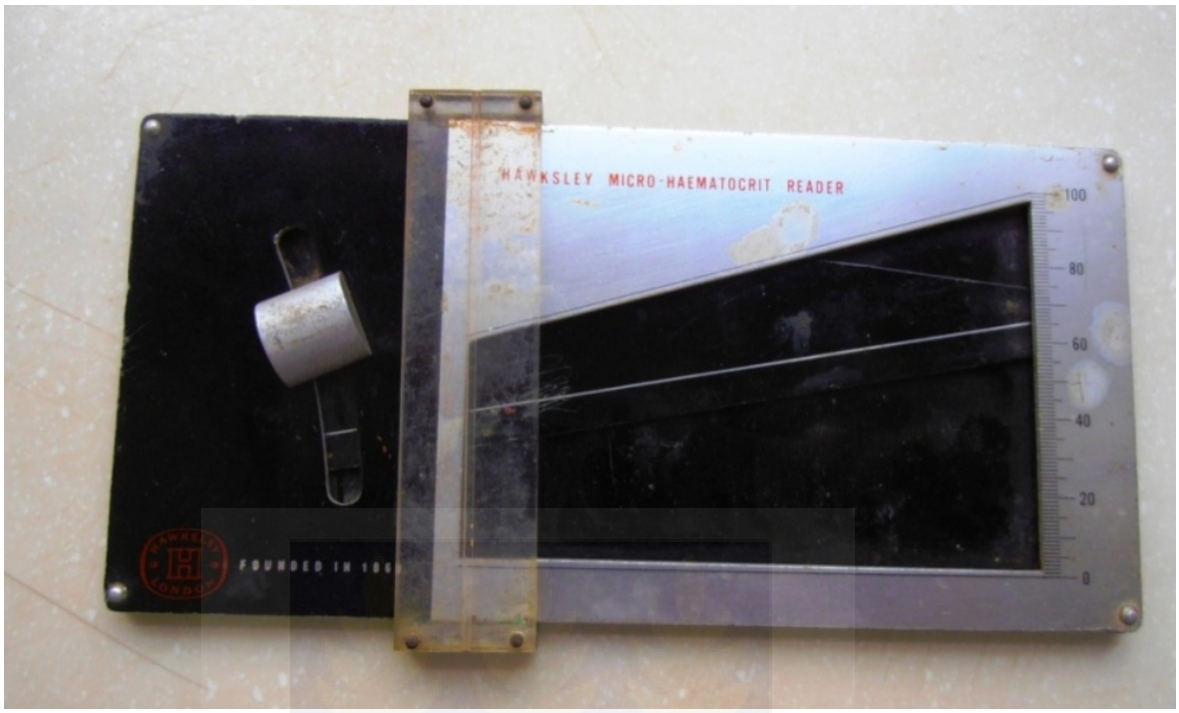


**Plate 3.1: Hawksley Micro-haematocrit Reader (Hawksley, London)**

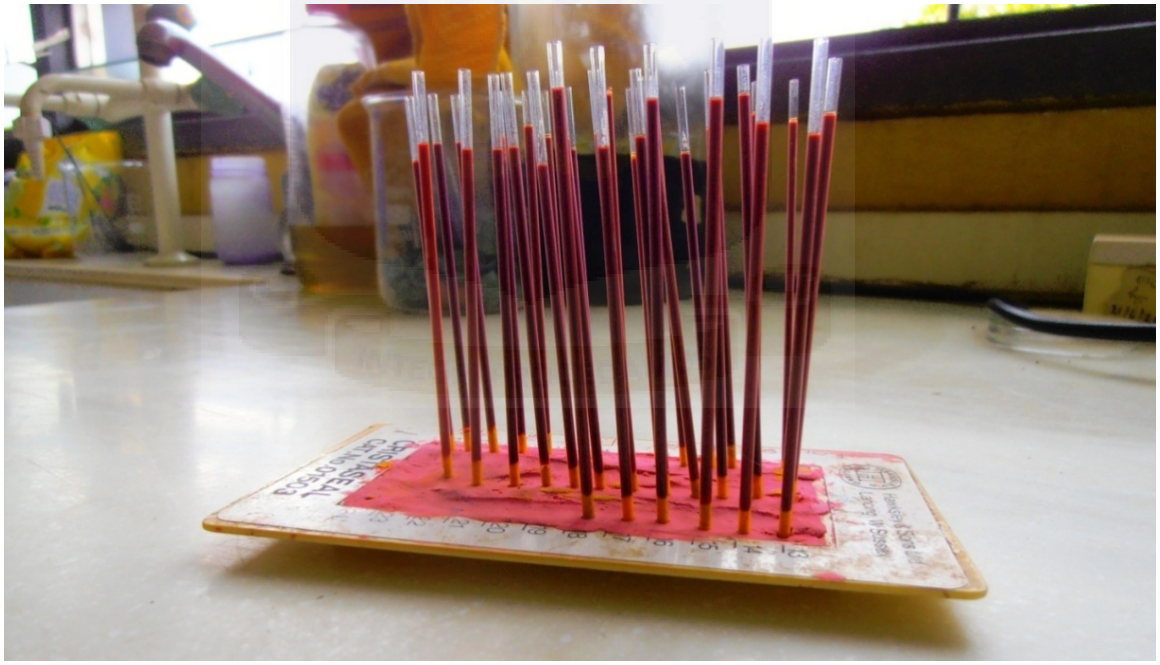

**Plate 3.2: Whole blood in microhaematocrit tubes before spinning**

**Field Data**


**Plate 3.3: Micro-capillary centrifuge (Model MB, International Equipment Company, Boston, U.S.A)**

**Filled data**

After spinning, three distinct layers were observed in the tubes; the plasma layer, the buffy coat and the red cell column (Plate 3.4). Each tube was carefully positioned in the slider slot such that the demarcation between the sealant and the red column was on the zero mark (base line). The tube holder was slid until the mark on top the plasma column was in line with the top line (100 marks). The knob was adjusted until the middle line passed through the top of the RBC column. The PCV was read on the scales on the right corresponding to the middle line on the Hawksley Micro-haematocrit reader (Hawksley, London).

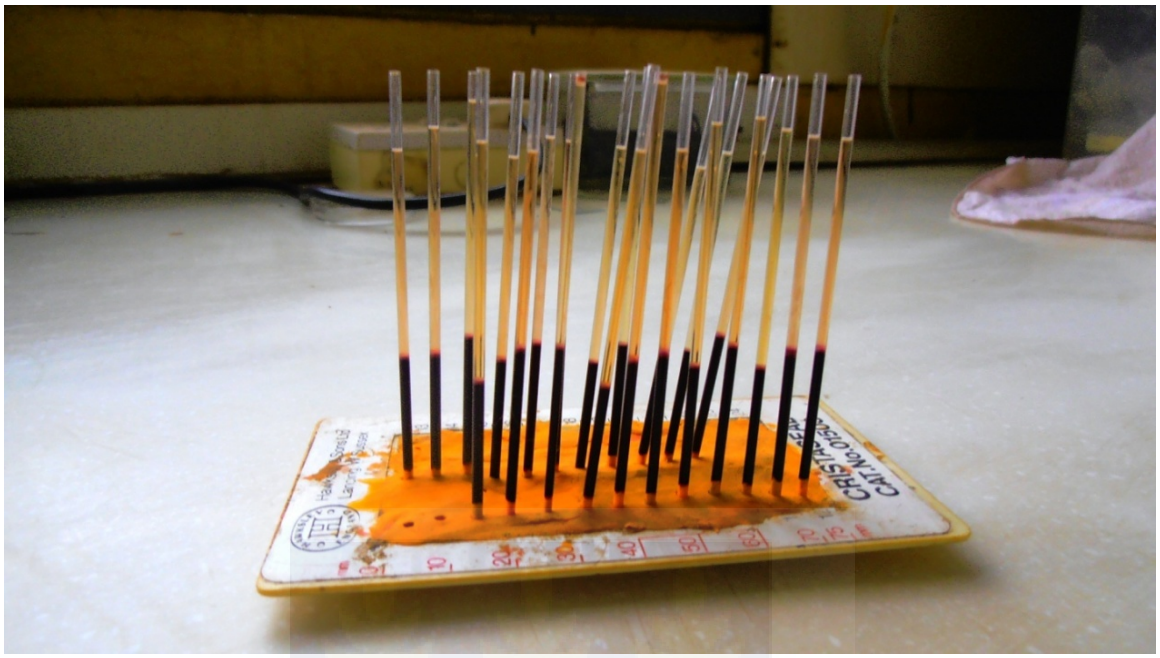

**Plate 3.4: Microhaematocrit tubes after centrifugation**

**Field data**

### 3.7.2 Hb estimation

The Cyamethaemoglobin method (Gillet *et al.*, 2009) was used to determine Hb concentration. Drabkin's solution having a pH 9.6 was used. Five millilitres of the Drabkin's solution was measured using a pipette into a labelled empty test tube. 20 µL of whole blood was pipetted and added to the test tube containing the Drabkin's solution to give a 1:250 dilution. The mixture was mixed thoroughly and allowed to stand for about 5 minutes and centrifuged at 3500 rpm for 3 minutes to allow the sedimentation of RBC nuclei. A blank was used to zero the spectrophotometer and the absorbance values of the supernatant read on a CECIL1000 Series Spectrophotometer (Cecil Instruments, England; Plate 3.5) at a wavelength of 540 nm. The haemoglobin was estimated from a standard calibration curve.

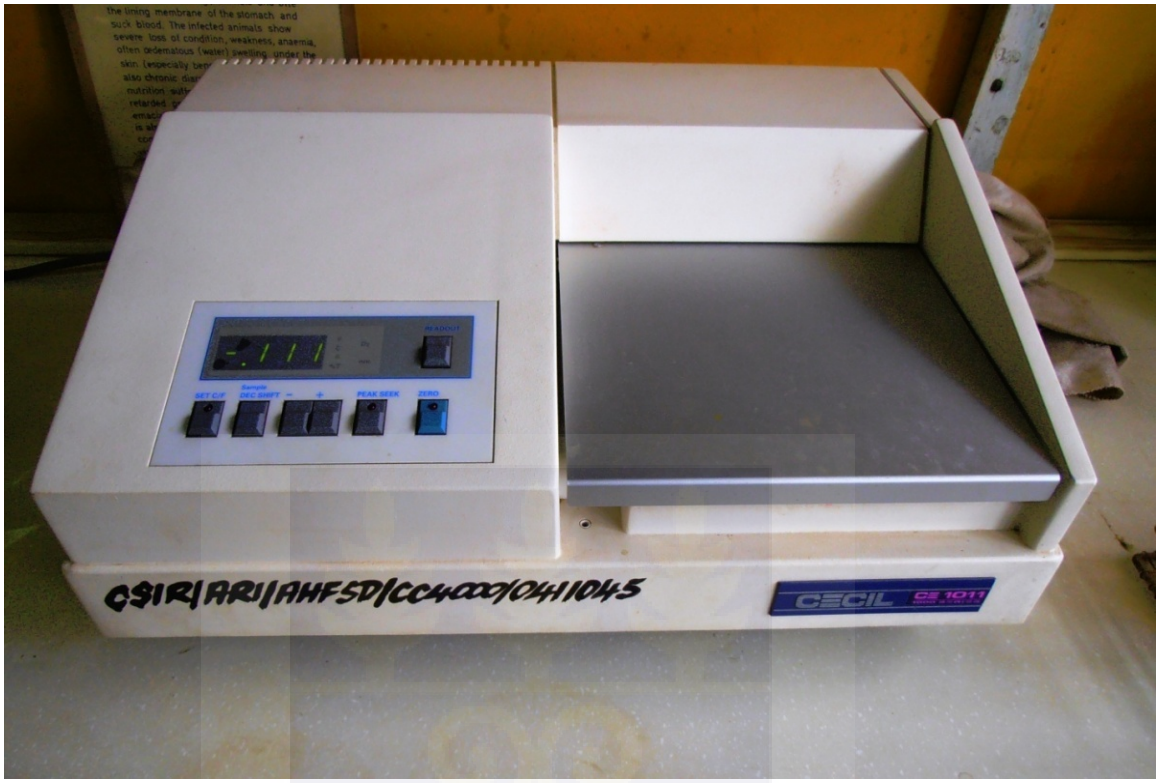


**Plate 3.5: Spectrophotometer (Cecil Instruments, England)**

**Field data**

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

Absorbance values were plotted against haemoglobin concentration and the blood haemoglobin concentrations (g/dL) determined.

### 3.7.3 Total cell counts (RBC and WBC) estimation

The total cell counts were estimated using the Nat and Herrick's method (1952). A Nat and Herrick's reagent is a solution containing NaCl, $Na_2SO_4$, $Na_2HPO_4.12H_2O$, $KH_2PO_4$, formaldehyde, methyl violet 2B and distilled water (Samour, 2006).

Four (4) mL of Nat and Herrick's solution was pipetted and transferred into clean labelled empty test tube. 20 µL of whole blood was aspirated using micropipette and dispensed into the tubes containing the Nat and Herrick's solution to make a dilution of 1:200. A small aliquot of the diluted sample was withdrawn, using a pipette; the chambers of the improved Neubauer haemocytometer (Plate 3.6) were carefully filled and allowed to stand for five minutes so that the cells can settle down. The counting was done using a light compound microscope at x40 objective magnification. The nuclei of the large oval RBCs stained violet, and the cytoplasm stained light. The RBCs were counted in the four squares at the corners of the haemocytometer.

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

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

Where

L= litre, N = number of cells counted in 160 small squares

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

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

Where

L= litre, N= number of cells counted in 9 small squares

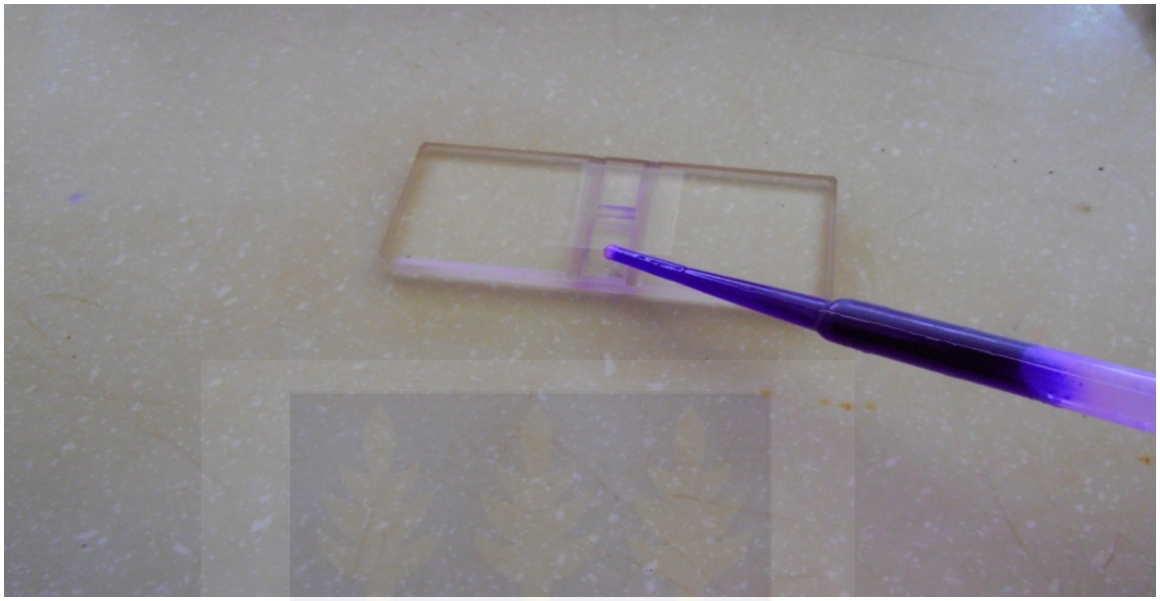

**Plate 3.6: Improved Neubauer haemocytometer counting chamber (Camlab, UK)**

**Field data**

### 3.8 Statistical Analysis

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

# CHAPTER FOUR

## 4.0 RESULTS

### 4.1 Chemical Composition of Neem Leaf Meal and Rice straw

The chemical composition of neem leaf meal and rice straw are presented in Table 4.1. The neem leaf meal had a high dry matter, crude protein, and lower NDF and ADF than the rice straw.

**Table 4.1: Chemical Composition of Neem Leaf meal**

| Parameter (%) | Neem leaf meal | Rice Straw |
|---|---|---|
| Dry matter | 88.34 | 87.93 |
| Crude Protein | 18.11 | 9.55 |
| Ash | 12.0 | 18.1 |
| Neutral Detergent Fibre | 49.67 | 57.5 |
| Acid Detergent Fibre | 30.6 | 42.3 |

### 4.2 Chemical Composition of Supplements Used in Growth and Digestibility Study

The nutrient composition of the supplements used in the growth and digestibility studies are shown in Table 4.2. Supplement 1 had DM, CP, Ash, NDF and ADF values of 86.14%, 28.4%, 10.5%, 35.39% and 22.4%. Supplement 2 had 86.7%, 26.6%, 16.5% 37.45% and 26.8% of DM, CP, Ash, NDF and ADF. Supplements 3 and 4 had 85.78%,

25.8%, 18.2%, 40.41%, 28.4% and 86.14%, 25.6%, 18.6%, 43.61% and 28.7% respectively.

**Table 4.2 Chemical Composition of the Experimental Supplement**

| Nutrients (%) | SUPPLEMENTS | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| Dry matter | 86.14 | 86.7 | 85.78 | 86.14 |
| Crude Protein | 28.4 | 26.6 | 25.8 | 25.6 |
| Ash | 10.5 | 16.5 | 18.2 | 18.6 |
| Neutral Detergent Fibre | 35.39 | 37.45 | 40.41 | 43.61 |
| Acid Detergent Fibre | 22.4 | 26.8 | 28.4 | 28.7 |

### 4.3: Acceptability of Supplements

The effect of NLM inclusion on the acceptability of the supplements by the sheep is shown in Table 4.3. Supplement 1 (0% neem) had the highest consumption ($P<0.05$) followed by Supplements 2 (20%), 3 (40%) and 4 (60%) NLM respectively but there was no significant difference ($P>0.05$) between Supplements 3 and 4. The acceptability of the supplement decreased with increased level of NLM inclusion.

**Table 4.3: Acceptability of neem leaf meal supplements fed to West African Dwarf sheep**

| Supplements | Mean of average intake (g) |
|---|---|
| 1(0% neem) | 196.0[a] |
| 2(20% neem) | 90.5[b] |
| 3(40% neem) | 15.1[c] |
| 4(60% neem) | 3.6[c] |
| *LSD* | *12.31* |
| *SEM* | *4.42* |
| *P- value* | *<.001* |

Means in the same column with different superscript are significantly different (P<0.05); SEM = standard error of means; LSD= Least significant difference

### 4.4: Effect of NLM-based supplement on Feed Intake by sheep

The total intakes of dry matter, crude protein, ash, neutral detergent fibre and acid detergent fibre are shown in Table 4.4. The dry matter intake was higher (P<0.05) in sheep on Treatments 2 and 3 than those on Treatments 1 and 4. Feed intake decreased with increasing levels of NLM from Treatments 2 to 4. The total dry matter intake of the rice straw ranged from 478.30 to 455.93 g/day. The crude protein intake ranged from 153.71 to 135.50 g/day. Sheep on Treatment 1 had higher (P<0.05) crude protein intake than those on Treatments 2, 3 and 4. The crude protein intake decreased significantly (P<0.05) with increasing levels of NLM in the diet. The ash intake was in the range of 101.48 to 56.83 g/day with the highest recorded by sheep on Treatment 3 and the lowest

for those on the control (Treatment 1). The NDF intake was higher (P<0.05) in sheep on Treatments 3, 4, 1 and 2. The NDF intake ranged from 233.96 to 124.86 g/day. The ADF intake was in the range of 118.64 to 154.30 g/day. ADF intake was significantly (P<0.05) higher in sheep on Treatment 3 than their counterparts on Treatments 4, 2 and 1. Sheep on Treatment 1 had the lowest ADF intake.

**Table 4.4: Intake of dry matter (DMI), Crude Protein (CPI), Neutral detergent fibre (NDFI), and Acid detergent fibre (ADFI) in sheep fed basal diet of rice straw and NLM supplements**

| | TREATMENTS | | | | | | |
|---|---|---|---|---|---|---|---|
| Parameter | 1 | 2 | 3 | 4 | *LSD* | *SEM* | *P-Value* |
| Total DMI(g/day) | 466.21$^{b}$ | 482.20$^{a}$ | 478.30$^{a}$ | 455.93$^{c}$ | *5.226* | *1.884* | *<.001* |
| CP Intake(g/day) | 153.71$^{a}$ | 147.94$^{b}$ | 143.86$^{c}$ | 135.50$^{d}$ | *1.593* | *0.574* | *<.001* |
| Ash (g/day) | 56.83$^{d}$ | 91.77$^{c}$ | 101.48$^{a}$ | 98.45$^{b}$ | *1.042* | *0.376* | *<.001* |
| NDF Intake (g/day) | 191.54$^{c}$ | 124.86$^{d}$ | 233.69$^{a}$ | 204.47$^{b}$ | *2.256* | *0.0813* | *<.001* |
| ADF Intake (g/day) | 121.23$^{d}$ | 149.05$^{c}$ | 158.36$^{a}$ | 151.91$^{b}$ | *1.667* | *0.601* | *<.001* |

Means in the same row with different superscript are significantly different (P<0.05); SEM = standard error of mean; LSD= Least significant difference

### 4.5 Digestibility of Nutrients by West African Dwarf sheep

The digestibility of dry matter, crude protein, ash, detergent fibre and components of fibre in sheep supplemented with NLM are shown in Table 4.5. Dry matter digestibility ranged from 79.33 to 88.79%. Sheep on Treatment 2 had significantly (P<0.05) higher dry matter digestibility than those on Treatments 1, 3 and 4. Dry matter digestibility was similar (P>0.05) in sheep fed supplements 3 and 4. Crude protein digestibility in sheep on

Treatments 1 and 2 were significantly (P<0.05) higher than those on Treatments 3 and 4. The crude protein digestibility generally decreased with increasing levels of NLM in the supplements fed. Crude protein digestibility in this study ranged from 40.35 to 57.13%. Crude protein digestibility was similar (P>0.05) in sheep fed Supplements 3 and 4. Ash digestibility was significantly (P<0.05) higher in sheep on Treatment 1 (control) than the sheep on the NLM Treatments 2, 3 and 4. Also sheep on Treatment 2 had higher ash digestibility than those on Treatments 3 and 4. However, ash digestibility for sheep on Treatments 3 and 4 were similar. Ash digestibility ranged from 18.77 to 22.08%. NDF digestibility was similar (P>0.05) for sheep on Treatments 2, 3 and 4. Sheep on Treatments 2 and 3 were significantly higher (P<0.05) than Treatment 1. NDF digestibility for Treatments 4 and 1 were similar (P>0.05). ADF digestibility for sheep fed on NLM Treatments 2, 3 and 4 were however significantly higher (P<0.05) than control (Treatment 1). The digestibility of ADF ranged from 26.18 to 29.43%. The digestibility of lignin was highest for sheep on Treatment 4 and lowest for sheep on Treatment 1 (control). Lignin digestibility was similar (P>0.05) for sheep on Treatments 2 and 3. Lignin digestibility in this study ranged from 9.10 to 13.85%. The digestibility of cellulose was highest (P<0.05) for sheep on Treatment 2 and lowest for those on Treatment 4, whiles sheep on Treatments 1 and 3 recorded similar (P>0.05) digestibility. Also sheep on Treatments 2 and 3 recorded similar (P>0.05) digestibilities. The cellulose digestibility recorded in this study ranged from 14.85 to 17.85%. Although hemicellulose digestibility was similar (P>0.05) for sheep on the treatments, they tended to be significantly higher in sheep on Treatment 1 (control). Hemicellulose digestibility ranged from 13.16 to 14.63%. The digestibility for silica ranged from 11.04 to 13.04%. The

digestibility for cellulose was similar (P>0.05) for sheep on Treatments 1 and 3 but higher (P<0.05) for sheep on Treatments 2 and 4. Sheep fed on Treatments 2 and 4 also had similar (P>0.05) cellulose digestibility.

**Table 4.5: Digestibility of Components of feed as influenced by NLM supplementation**

| | TREATMENTS | | | | | | |
|---|---|---|---|---|---|---|---|
| Fraction (%) | 1 | 2 | 3 | 4 | *LSD* | *SEM* | *P-Value* |
| Dry matter | 84.11$^{b}$ | 88.79$^{a}$ | 80.06$^{cd}$ | 79.33$^{d}$ | *3.658* | *1.29* | *<.001* |
| Crude Protein | 57.13$^{a}$ | 54.43$^{a}$ | 42.41$^{bc}$ | 40.35$^{c}$ | *2.99* | *1.05* | *<.001* |
| Ash | 22.08$^{a}$ | 21.09$^{b}$ | 18.77$^{d}$ | 19.09$^{cd}$ | *0.85* | *0.302* | *<.001* |
| NDF | 40.81$^{bc}$ | 42.99$^{a}$ | 42.62$^{a}$ | 41.85$^{ac}$ | *1.604* | *0.566* | *0.044* |
| ADF | 26.18$^{b}$ | 29.43$^{a}$ | 28.92$^{a}$ | 28.69$^{a}$ | *0.989* | *0.351* | *<.001* |
| Lignin | 9.10$^{d}$ | 11.57$^{bc}$ | 11.23$^{c}$ | 13.85$^{a}$ | *0.717* | *0.255* | *<.001* |
| Cellulose | 17.08$^{bc}$ | 17.85$^{a}$ | 17.69$^{ac}$ | 14.85$^{d}$ | *0.699* | *0.248* | *<.001* |
| Hemicellulose | 14.63 | 13.56 | 13.70 | 13.16 | *1.361* | *0.483* | *0.182* |
| Silica | 13.04$^{a}$ | 11.04$^{b}$ | 13.56$^{a}$ | 11.33$^{b}$ | *1.528* | *0.542* | *0.002* |

Means in the same row with different superscript are significantly different (P<0.05); SEM = standard error of mean; LSD= Least significant difference

### 4.6 Daily weight gain and FCE of sheep fed basal diet of rice straw and supplemented with NLM concentrate

The daily weight gain and feed conversion efficiency of the West African Dwarf Sheep are shown in Table 4.6. The initial weights of the sheep ranged from 13.20 to 15.00 kg. The average daily weight gain of sheep on the basal diet (Treatment 1) and Treatment 3 were similar ($P>0.05$) but significantly ($P<0.05$) higher than sheep on the Treatments 2 and 4 diets. Average daily weight gain of sheep on Treatments 2 and 3 were similar ($P>0.05$). Also sheep on Treatments 2 and 4 were similar ($P>0.05$). The average daily weight gain ranged from 18.37 to 28.57g. The feed conversion efficiency of sheep on the basal diet (Treatment 1) and Treatment 4 were similar ($P>0.05$) but significantly ($P<0.05$) higher than sheep on Treatments 2 and 3 diets. Sheep on Treatments 2 and 3 were however similar ($P>0.05$).

**Table 4.6: Initial weights, Final weights, Average daily gain, Average daily feed intake and Feed conversion efficiency for West African Dwarf sheep**

| | TREATMENT | | | | | | |
|---|---|---|---|---|---|---|---|
| PARAMETER | 1 | 2 | 3 | 4 | *LSD* | *SEM* | *P-Value* |
| Initial weight (kg) | 13.20 | 15.00 | 14.70 | 14.20 | *2.283* | *0.762* | *0.388* |
| Final weight (kg) | 16.00 | 17.00 | 17.10 | 16.00 | *2.151* | *0.718* | *0.556* |
| Average daily gain (g/day) | $28.57^{a}$ | $20.41^{bce}$ | $24.49^{ac}$ | $18.37^{de}$ | *5.723* | *1.909* | *0.008* |
| FCE | $0.515^{a}$ | $0.477^{b}$ | $0.482^{b}$ | $0.507^{a}$ | *0.011* | *0.004* | *<.001* |

Means in the same row with different superscript are significantly different (P<0.05); SEM = standard error of mean; LSD= Least significant difference

The growth pattern of sheep is shown in Figure 1.0. There was an increase in the growth of the sheep across all the treatments. However, animals on the control diet (Treatment 1) had the fastest (P<0.05) growth. There was a decrease in growth from week 10 to week 12 for sheep on Treatment 4.

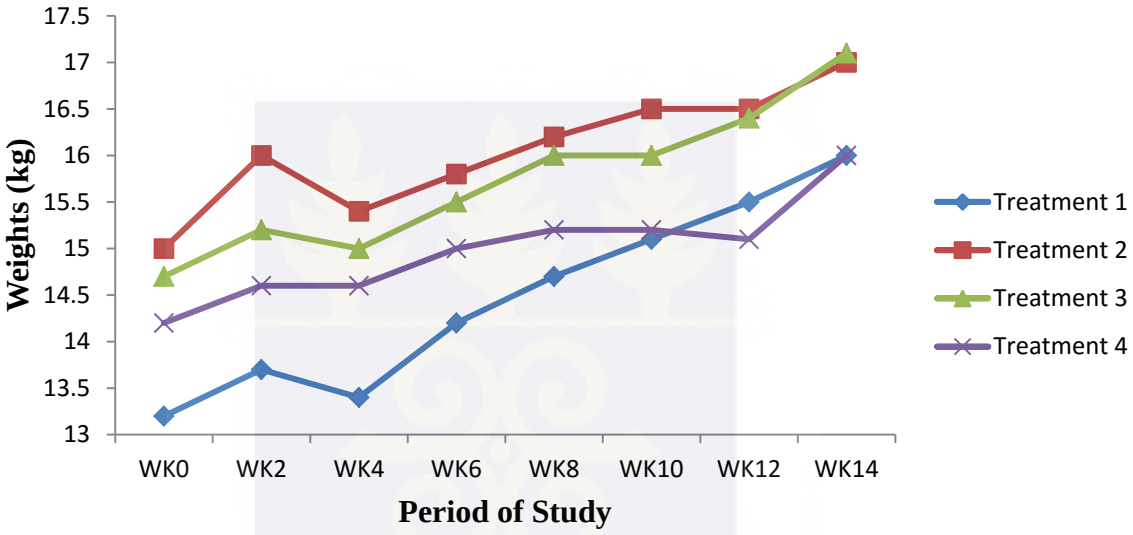


**Figure 1.0 Growth pattern of sheep on NLM-based supplements**

### 4.7 Haematological indices in West African Dwarf sheep

The levels of haemoglobin, PCV, RBC and WBC counts are shown in Table 4.7. Haemoglobin concentration ranged from 11.94 to 12.46 g/dL. Dietary treatments did not significantly (P>0.05) affect haemoglobin concentration or PCV across the treatments. Packed cell volume ranged from 27.15 to 29.91% in this study. The RBC counts ranged from 8.26 to 8.96 x $10^{12}$ /L. Dietary treatment did not significantly (P>0.05) affect RBC counts. Similarly, WBC counts were similar (P>0.05) across the dietary treatments.

**Table 4.7: Blood haematological indices in sheep**

| | TREATMENT | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Parameter | 1 | 2 | 3 | 4 | Overall Means | *LSD* | *SEM* | *P-Value* |
| Hb (g/dL) | 12.46 | 11.99 | 12.11 | 11.94 | 12.13 | *1.810* | *0.604* | *0.927* |
| PCV (%) | 29.91 | 27.15 | 29.46 | 28.00 | 28.63 | *2.873* | *0.958* | *0.191* |
| RBC ( x $10^{12}$ /L) | 8.96 | 8.26 | 8.62 | 8.85 | 8.67 | *0.762* | *0.254* | *0.256* |
| WBC (x $10^{9}$ / L) | 7.97 | 8.48 | 7.60 | 8.05 | 8.03 | *1.520* | *0.507* | *0.680* |

# CHAPTER FIVE

# 5.0 DISCUSSION

## 5.1 Chemical Composition of Experimental Diets

The dry matter composition of the neem leaves was lower than the value 93.50% reported by Paengkoum (2010). Raghuvansi *et al*. (2007) reported a dry matter content of 95.16% for neem leaves which were higher than the current study. The difference in dry matter content can be attributed to method of drying the leaves and stage of harvesting the leaves. The dry matter content of neem leaves in the present study compares favourably with other tree leaves and browses. For example, Akinjagunla *et al*. (2007) and Abdu *et al*. (2012b) reported dry matter contents of 80.58% and 92.7% for Gmelina. Also similar dry matter contents ranging from 91.23 to 91.6% have been reported for *Acacia albida*, *Acacia seyal* leaves and other mixtures (Gebreselassie *et al*., 2015). The high dry matter content of neem leaves makes it a good source of feed for animals in the dry season. The high dry matter of the diet will help the animal to take in more of the diet which will lead to nutrient intake. This will also lead to increase in productivity.

The Crude protein concentration of the Neem leaves was higher than the 9.7% reported by Ramana *et al*. (2000) but comparable to the values of 20.9% reported by Ogbuewu *et al*. (2011). The difference in crude protein values can be attributed to differences in the variety of the neem plant. The crude protein value of neem leaves in this study compares favourably with other tree leaves and browses. For example, Ogundipe and Akinlade (2016) reported a crude protein content of 19.68% for gliricidia (*gliricidia sepium*)

leaves. High levels of crude protein in the Neem leaf supplement means there will be more protein made available to the rumen microbes which should lead to increase in digestibility of the feed resulting in increase in productivity especially when fed to sheep in the dry season.

The Ash content of neem leaves was 12.0% which were higher than the value of 7.1% reported by Ogbuewu *et al*. (2011). High ash content is an indication of high concentration of minerals (Kwabiah *et al*., 2003). Thus the differences in ash content could be attributed to the soil in which the plants grew. The ash content of neem leaves in the present study was comparable to other tree leaves such as Gmelia (*Gmelina arborea*) Leaf which has an ash content of 11.30% (Abdu *et al*., 2012b). The importance of the high level of ash in the NLM means many minerals will be made available to the sheep which will help increase productivity of the sheep.

The NDF and ADF content for neem leaves were 49.67% and 30.6% respectively. These were higher than the values of 38.0% and 27.0% respectively reported by Ramana *et al*. (2000) for the neem leaf. The variation could be attributed to differences in maturity of the neem leaves used. The values obtained in the present study were within the ranges 27.40 to 55.23% for NDF and 18.87 to 46.30% for ADF for leaves for 15 tropical fodder trees. The NDF and ADF levels for the neem leaf were comparable to the values 41.50% and 28.70% reported for gliricidia (Mpairwe *et al*., 1998). It was however lower than the values 28.5% and 18.1% reported for *Moringa Oleifera* leaves (Babeker and Abdalbagi, 2015).

### 5.2 Acceptability of Neem leaves

Although neem leaves have bitter taste, it was acceptable by the sheep. However, acceptability by sheep decreased with increasing level of inclusion of NLM. This suggests that the sheep were not used to the taste. There is a perception that ruminants do not accept neem leaves due to its bitter taste. The bitter taste is attributed to the presence of triterpenoids, especially azadirachtin (Nanang *et al*., 1997). Ruminants can tolerate bitter taste because they are able to detoxify the secondary compounds in plants in an allelochemical type of reaction in their system (Lu, 1988). Other studies have reported that neem leaves were palatable to sheep (Chandrawathani *et al*., 2006) and goats (Seresinhe and Marapana, 2011).

### 5.3 Influence of dietary inclusion of NLM on intakes

The dry matter intake of sheep on Treatments 2 and 3 compared to Treatments 1 and 4 could be due to the higher levels of NLM in the diets which affected the palatability of diet. This also means that more rice straw will be consumed and this will lead to an increase in growth of the sheep.

In the current study, crude protein intake significantly decreased from Treatment 1 to Treatment 4. This could be attributed to the decreasing crude protein level with increasing NLM concentrate in the supplements fed (Table 4.4). This is so because the soy bean meal has higher crude protein content than the NLM. Also, as the level of NLM increased it decreased the palatability of the diet which affected intake. According to Mattewman (1977) an animal's feed intake is highly affected by the palatability and

digestibility of the feed. Also, decrease in crude protein intake due to reduced palatability of the diet have been reported when West African Dwarf goats fed supplements containing increasing levels of wild sunflower (*Tithonia Diversifolia Hemsl., A. Gray*) as reported by Odedire and Oloidi (2014).

The general increase in the ash contents with increasing NLM inclusion could partly account for the trend observed in Ash intake. The importance of the high level of ash in the NLM means more minerals will be made available to the sheep which will help increase the productivity of the sheep.

The high intake of NDF for Treatment 3 followed by Treatments 4, 1 and 2 can be attributed to bulky nature of the rice straw consumed. This means that more of the rice straw was consumed.

Acid detergent fibre intake was highest for Treatment 3 followed by Treatments 4, 2 and 1. This trend can be attributed to the increasing ADF values of NLM supplements. Similarly, Sultana *et al*. (2015) reported significant increasing levels of ADF intake for goats supplemented on Moringa (*Moringa Oleifera*) foliage as replacement to conventional concentrate diet with straw. The high ADF intakes in Treatments 3 and 4 could be attributed to the NLM to affect rumen microbes that will aid in digesting more of the ADF there by increasing ADF intake.

### 5.4 Influence of dietary inclusion of NLM on digestibility

The trend observed in the dry matter digestibility was positively related to NDF (Table 4.4) intake as high NDF intake reduced dry matter digestibility. The high dry matter digestibility of the diets fed to sheep in the current study could be attributed to the ability of the NLM supplements to have had an influence on the rumen microbes to increase digestion. Other studies have indicated significant increase (57.24%, 59.71%, 65.11%, 66.14% and 68.83%) in dry matter digestibility between goats fed graded levels of cassava leaf meal with corn bran based diet (Yousuf *et al*., 2007).

The digestibility of crude protein decreased with increasing level of NLM supplements fed. The level of crude protein in the supplements increased from Treatment 1 to Treatment 4 (Table 4.1c) suggesting a direct relationship between crude protein level and digestibility in the diet. The supplementation of the West African breed of sheep or goat with graded levels of other leaf meals having decreased crude protein digestibility have been reported in other studies (Yousuf *et al*., 2007; Abdu *et al*., 2012a). For example Abdu *et al*. (2012a) reported of decreasing levels of crude protein digestibility for West African Dwarf Sheep lambs fed on graded levels of zizyphus (*Zizyphus mauritiana*) leaf meal with maize stover as a basal diet. The digestibilities were 58.29%, 50.40%, 48.74%, 46.59% and 38.18% for CP.

Significant difference in ash digestibility for sheep on Treatment 1 (control) as compared to Treatments 2, 3 and 4 can be attributed to anti nutritional factors that were not making the ash available in the NLM to be digested.

Significant differences in NDF could be attributed to the neem leaf meal to have improved the rumen environment which aided in the digestion of NDF in the rumen. This means that the high NDF digestibility of the rice straw will lead to increase in dry matter intake (Table 4.4). Increase in dry matter intake also means that more nutrients in the feed will be made available to the sheep to improve on productivity. However, there was no significant difference in NDF digestibility (50.54% and 48.69%) observed when 50% of soy bean meal was replaced with a leaf mixture of *Leucaena leucocephala, Morus alba* and *Azadirachta indica* with wheat straw as basal diet in West African Dwarf Sheep (Patra *et al*., 2002).

Acid detergent fibre digestibility had significant difference and this could be attributed to the neem leaf meal to have improved the rumen environment which aided in the digestion of ADF in the rumen. The higher ADF digestibility of the sheep on Treatments 2, 3 and 4 compared to Treatment 1 could be attributed to the high ADF contents of the supplements containing the NLM. This means that there was more dry matter intake which will lead to intake of more nutrients to improve on the productivity of the sheep.

The high lignin digestibility in Treatment 4 followed by Treatments 2, 3 and Treatment 1 in the current study could be attributed to the ability of NLM to have improved the rumen environment to aid the digestion of the lignin in the rice straw.

The significant differences of cellulose digestibility for Treatment 2 followed by Treatments 3 and 1 in the current study can be attributed to the ability of the NLM to have improved the rumen environment to aid the digestion of cellulose in the rice straw. However, Treatment 4 which had the lowest cellulose digestibility could be that NLM at 40% level inhibits rumen microbes from effectively digesting cellulose.

The significant difference of silica digestibility for Treatments 3 followed by Treatment 1 in the current study can be attributed to the ability of the NLM to have improved the rumen environment to aid the digestion of silica in the rice straw.

**5.5 Growth and Feed conversion Efficiency of West African Dwarf Sheep**

The initial and final body weights of the sheep were similar. Sheep on the control Treatment 1 (0% Neem) had better daily weight gains than those on NLM treatments. The control treatment of 0% neem had a higher percentage of soy bean meal (Table 3.2) which elicited higher crude protein intake (Table 4.4) for the sheep on that treatment thus improving growth rate.

Significant difference of FCE for Treatments 1 and 4 followed by Treatments 3 and 2 can be attributed to the higher crude protein intake (Table 4.4) for sheep on that treatment. Also the neem leaves could have improved the rumen environment which helped in quicker digestion of diet for sheep on Treatment 4 which helped them make better use of their diet. It means that the sheep on Treatments 1 and 4 better utilised their feed to gain weight (Table 4.6)

### 5.6 Blood haematology of West African Dwarf Sheep

In the present study Hb, PCV, RBC and WBC levels were not significantly different in the dietary treatments indicating no deleterious effects of the NLM on the haematology of the sheep. The range of values obtained for Hb, PCV, RBC and WBC (Table 4.7) were comparable to those reported by Obese *et al*. (1994) and Baiden and Obese (2010) for the same breed of sheep. Furthermore, they fell within the normal ranges of 9-13 g/L, 27-45%, 9-15 x $10^{12}$ /L and 4-12 x $10^{9}$ / L for Hb, PCV, RBD and WBC respectively in sheep (The Merck Veterinary manual, 2010).

# CHAPTER SIX

## 6.0 CONCLUSION AND RECOMMENDATION

### 6.1.0 CONCLUSION

1. Supplements containing up to 30% Neem leaf meal can be fed to West African Dwarf sheep without deleteriously affecting their dry matter intake, digestibility and physiology.

2. Neem leaf meal-based supplement can be used to achieve moderate growth in West African Dwarf sheep in the dry season.

### 6.2 RECOMMENDATION

1. I recommend that supplement containing up to 30% neem leaf meal may be used to feed sheep in the dry season.

2. Further research should be conducted to determine the effect of neem leaf meal on rumen microbial population and intestinal helminthis

3. Further research should also be conducted to determine the effect of neem leaf meal on meat quality.

4. In addition, the determination of the effect of neem leaf meal on the biochemical parameters of ruminants is being suggested.

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# APPENDICES

## ANALYSIS OF VARIANCE

### Appendix 1: Acceptability

| Source of variation | d.f. | s.s. | m.s. | v.r. | F pr. |
|---|---|---|---|---|---|
| Diet | 3 | 1318826. | 439609. | 402.60 | <.001 |
| Residual | 220 | 240224. | 1092. | | |
| Total | 223 | 1559050. | | | |

### Appendix 2: Total Dry Matter Intake

| Source of variation | d.f. | s.s. | m.s. | v.r. | F pr. |
|---|---|---|---|---|---|
| TRT | 3 | 179861. | 59954. | 40.22 | <.001 |
| Residual | 1676 | 2498528. | 1491. | | |
| Total | 1679 | 2678389. | | | |

### Appendix 3: Total Crude Protein Intake

| Source of variation | d.f. | s.s. | m.s. | v.r. | F pr. |
|---|---|---|---|---|---|
| TRT | 3 | 73833.4 | 24611.1 | 177.60 | <.001 |
| Residual | 1676 | 232255.3 | 138.6 | | |
| Total | 1679 | 306088.7 | | | |

**Appendix 4: Total Ash Intake**

| Source of variation | d.f. | s.s. | m.s. | v.r. | F pr. |
|---|---|---|---|---|---|
| TRT | 3 | 534985.04 | 178328.35 | 3008.19 | <.001 |
| Residual | 1676 | 99355.01 | 59.28 | | |
| Total | 1679 | 634340.05 | | | |

**Appendix 5: Total Neutral Detergent Fibre Intake**

| Source of variation | d.f. | s.s. | m.s. | v.r. | F pr. |
|---|---|---|---|---|---|
| TRT | 3 | 2669526.2 | 889842.1 | 3201.51 | <.001 |
| Residual | 1676 | 465834.3 | 277.9 | | |
| Total | 1679 | 3135360.4 | | | |

**Appendix 6: Total Acid Detergent Fibre Intake**

| Source of variation | d.f. | s.s. | m.s. | v.r. | F pr. |
|---|---|---|---|---|---|
| TRT | 3 | 339050.4 | 113016.8 | 745.42 | <.001 |
| Residual | 1676 | 254108.0 | 151.6 | | |
| Total | 1679 | 593158.4 | | | |

**Appendix 7: Dry Matter Digestibility**

| Source of variation | d.f. | s.s. | m.s. | v.r. | F pr. |
|---|---|---|---|---|---|
| TRT | 3 | 1193.20 | 397.73 | 11.36 | <.001 |
| Days | 6 | 382.56 | 63.76 | 1.82 | 0.111 |
| TRT.Days | 18 | 186.35 | 10.35 | 0.30 | 0.997 |
| Residual | 56 | 1960.58 | 35.01 | | |
| Total | 83 | 3722.69 | | | |

**Appendix 9: Crude Protein Digestibility**

| Source of variation | d.f. | s.s. | m.s. | v.r. | F pr. |
|---|---|---|---|---|---|
| Days | 6 | 132.19 | 22.03 | 0.94 | 0.473 |
| TRT | 3 | 4478.17 | 1492.72 | 63.81 | <.001 |
| Days.TRT | 18 | 88.62 | 4.92 | 0.21 | 1.000 |
| Residual | 56 | 1310.06 | 23.39 | | |
| Total | 83 | 6009.04 | | | |

**Appendix 10: Ash Digestibility**

| Source of variation | d.f. | s.s. | m.s. | v.r. | F pr. |
|---|---|---|---|---|---|
| TRT | 3 | 159.277 | 53.092 | 27.73 | <.001 |
| Residual | 80 | 153.165 | 1.915 | | |
| Total | 83 | 312.442 | | | |

**Appendix 11: NDF Digestibility**

| Source of variation | d.f. | s.s. | m.s. | v.r. | F pr. |
|---|---|---|---|---|---|
| Days | 6 | 98.224 | 16.371 | 2.43 | 0.037 |
| TRT | 3 | 58.174 | 19.391 | 2.88 | 0.044 |
| Days.TRT | 18 | 45.717 | 2.540 | 0.38 | 0.987 |
| Residual | 56 | 377.090 | 6.734 | | |
| Total | 83 | 579.205 | | | |

**Appendix 12: ADF Digestibility**

| Source of variation | d.f. | s.s. | m.s. | v.r. | F pr. |
|---|---|---|---|---|---|
| TRT | 3 | 132.295 | 44.098 | 17.05 | <.001 |
| Days | 6 | 44.836 | 7.473 | 2.89 | 0.014 |
| Residual | 74 | 191.354 | 2.586 | | |
| Total | 83 | 368.484 | | | |

**Appendix 13: Lignin Digestibility**

| Source of variation | d.f. | s.s. | m.s. | v.r. | F pr. |
|---|---|---|---|---|---|
| TRT | 3 | 237.991 | 79.330 | 58.31 | <.001 |
| Days | 6 | 7.107 | 1.185 | 0.87 | 0.521 |
| Residual | 74 | 100.679 | 1.361 | | |
| Total | 83 | 345.778 | | | |

**Appendix 14: Cellulose digestibility**

| Source of variation | d.f. | s.s. | m.s. | v.r. | F pr. |
|---|---|---|---|---|---|
| TRT | 3 | 121.443 | 40.481 | 31.29 | <.001 |
| Days | 6 | 16.278 | 2.713 | 2.10 | 0.064 |
| Residual | 74 | 95.743 | 1.294 | | |
| Total | 83 | 233.464 | | | |

**Appendix 15: Hemicellulose Digestibility**

| Source of variation | d.f. | s.s. | m.s. | v.r. | F pr. |
|---|---|---|---|---|---|
| TRT | 3 | 24.500 | 8.167 | 1.67 | 0.182 |
| Days | 6 | 10.367 | 1.728 | 0.35 | 0.906 |
| Residual | 74 | 362.591 | 4.900 | | |
| Total | 83 | 397.458 | | | |

**Appendix 16: Silica Digestibility**

| Source of variation | d.f. | s.s. | m.s. | v.r. | F pr. |
|---|---|---|---|---|---|
| TRT | 3 | 97.707 | 32.569 | 5.28 | 0.002 |
| Days | 6 | 8.702 | 1.450 | 0.23 | 0.964 |
| Residual | 74 | 456.882 | 6.174 | | |
| Total | 83 | 563.291 | | | |

**Appendix 17: Initial Weight**

| Source of variation | d.f. | s.s. | m.s. | v.r. | F pr. |
|---|---|---|---|---|---|
| TRMT | 3 | 9.338 | 3.113 | 1.07 | 0.388 |
| Residual | 16 | 46.400 | 2.900 | | |
| Total | 19 | 55.737 | | | |

**Appendix 18: Final Weight**

| Source of variation | d.f. | s.s. | m.s. | v.r. | F pr. |
|---|---|---|---|---|---|
| TRMT | 3 | 5.538 | 1.846 | 0.72 | 0.556 |
| Residual | 16 | 41.200 | 2.575 | | |
| Total | 19 | 46.737 | | | |

**Appendix 19: Average Daily Gain**

| Source of variation | d.f. | s.s. | m.s. | v.r. | F pr. |
|---|---|---|---|---|---|
| TRMT | 3 | 307.16 | 102.39 | 5.62 | 0.008 |
| Residual | 16 | 291.55 | 18.22 | | |
| Total | 19 | 598.71 | | | |

**Appendix 21: Feed Conversion Efficiency**

| Source of variation | d.f. | s.s. | m.s. | v.r. | F pr. |
|---|---|---|---|---|---|
| TRt | 3 | 0.0864 | 0.0288 | 20.89 | <.001 |
| Residual | 332 | 0.4581 | 0.0014 | | |
| Total | 335 | 0.5446 | | | |

**Appendix 22: Haemoglobin**

| Source of variation | d.f. | s.s. | m.s. | v.r. | F pr. |
|---|---|---|---|---|---|
| Subject stratum | | | | | |
| TRT | 3 | 5.841 | 1.947 | 0.15 | 0.927 |
| Residual | 16 | 204.178 | 12.761 | 2.64 | |
| Subject.Time stratum | | | | | |
| d.f. correction factor 0.4929 | | | | | |
| Time | 6 | 139.397 | 23.233 | 4.81 | 0.005 |
| Time.TRT | 18 | 139.231 | 7.735 | 1.60 | 0.143 |
| Residual | 96 | 463.807 | 4.831 | | |
| Total | 139 | 952.454 | | | |

**Appendix 23: Packed Cell Volume**

| Source of variation | d.f. | s.s. | m.s. | v.r. | F pr. |
|---|---|---|---|---|---|
| Subject stratum | | | | | |
| TRT | 3 | 171.73 | 57.24 | 1.78 | 0.191 |
| Residual | 16 | 514.14 | 32.13 | 2.03 | |
| Subject.Time stratum | | | | | |
| d.f. correction factor 0.5105 | | | | | |
| Time | 6 | 1072.93 | 178.82 | 11.30 | <.001 |
| Time.TRT | 18 | 495.71 | 27.54 | 1.74 | 0.104 |
| Residual | 96 | 1518.93 | 15.82 | | |
| Total | 139 | 3773.43 | | | |

**Appendix 24: Red Blood Cells**

| Source of variation | d.f. | s.s. | m.s. | v.r. | F pr. |
|---|---|---|---|---|---|
| Subject stratum | | | | | |
| TRT | 3 | 10.098 | 3.366 | 1.49 | 0.256 |
| Residual | 16 | 36.190 | 2.262 | 1.43 | |
| Subject.Time stratum | | | | | |
| d.f. correction factor 0.7616 | | | | | |
| Time | 6 | 102.236 | 17.039 | 10.76 | <.001 |
| Time.TRT | 18 | 21.405 | 1.189 | 0.75 | 0.714 |
| Residual | 96 | 151.998 | 1.583 | | |
| Total | 139 | 321.926 | | | |

**Appendix 25: White Blood Cells**

| Source of variation | d.f. | s.s. | m.s. | v.r. | F pr. |
|---|---|---|---|---|---|
| Subject stratum | | | | | |
| TRT | 3 | 13.797 | 4.599 | 0.51 | 0.680 |
| Residual | 16 | 143.951 | 8.997 | 2.28 | |
| Subject.Time stratum | | | | | |
| d.f. correction factor 0.6977 | | | | | |
| Time | 6 | 199.111 | 33.185 | 8.40 | <.001 |
| Time.TRT | 18 | 135.334 | 7.519 | 1.90 | 0.047 |
| Residual | 96 | 379.441 | 3.953 | | |
| Total | 139 | 871.634 | | | |