GROWTH RESPONSE OF YANKASA RAMS FED DIETS CONTAINING VARYING LEVELS OF SHEA NUT CAKE AT DIFFERENT FEEDING FREQUENCIES

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June, 2018

DECLARATION

I hereby declare that the work in this dissertation entitled "**Growth response of yankasa rams fed diets containing varying levels of shea nut cake at different feeding frequencies"** has been written by me. It is a product of research work executed by me at the Department of Animal Science, Ahmadu Bello University, Zaria, under the supervision of Drs. S.M. Yashim and M.R. Hassan. It has not been accepted for the award of a degree in any university. All literary works cited are indicated and the sources of information are specifically acknowledged by means of references.

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Oladipupo Emmanuel ADEOYE **Date**

CERTIFICATION

This dissertation titled **"GROWTH RESPONSE OF YANKASA RAMS FED DIETS CONTAINING VARYING LEVELS OF SHEA NUT CAKE AT DIFFERENT FEEDING FREQUENCIES"** By Oladipupo Emmanuel ADEOYE, meets the regulations governing the award of Master of Science Degree in Animal Science of the Ahmadu Bello University, Zaria and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

This work is dedicated to God Almighty for seeing me through and to my parents Mr. and Mrs. Adeoye for their love, resources and prayers.

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I am very grateful to God for the rich supply of His Grace from the start to the end of this study. Words are not enough to thank Him.

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ABSTRACT

The study aimed at evaluating the effects of inclusion levels and feeding frequencies of shea nut cake on the growth performance, nutrient digestibility, nitrogen balance, haematological, blood serum and economics of Yankasa rams production. Twenty-four rams averaging 16.4kg were randomly assigned to four treatment diets containing 0, 2.5, 5 and 7.5% inclusion of shea nut cake andtwo feeding frequencies, daily and skip-a-day. The result shows that hay intake, total feed intake, final weight, total weight gain and ADG were significantly ($P<0.05$) affected by the inclusion levels with 7.5% inclusion recording the highest values (292.07g/day, 588.70g/day, 21.02kg, 4.09kg and 51.11g respectively). Feeding frequency affected supplement intake, hay and total feed intake but did not affect on final weight, total weight gain and average daily gain. Animals on daily feeding recorded higher supplement intake (385.93 g/day) and total feed intake (574.90 g/day). Dry Matter digestibility for 7.5% inclusion was higher than the other inclusion levels with a value of 62.84%. The DM digestibility was found to progressively increase as the inclusion increased from 0% to 7.5% and this was observed to follow the same pattern with OM, CP, NFE, and ADF digestibilities. CP and EE digestibilities were affected by feeding frequency. Daily feeding (68.02%) was higher than skip-a-day feeding (58.27%) in CP and EE (71.27% versus 55.39%) digestibility. The digestibility parameters were all affected by the interaction. The percentage of nitrogen retained progressively increased as the inclusion increased from 0% to 7.5%. The daily feeding was higher than the skip-a-day feeding for nitrogen intake, nitrogen retained and percentage of nitrogen retained. All the serum parameters were affected by the inclusion levels. Serum creatinine progressively decreased as the inclusion increased from 0% (2.05mg/dl) to 7.5% (1.36mg/dl). The serum metabolites were not affected by the feeding frequencies. All the haematological parameters were affected by the inclusion levels. The WBC and Neutrophils both progressively decreased as the inclusion increased from 0-7.5% while Lymphocytes increased with increase of inclusion levels. The 0% inclusion was higher for WBC (6.65 (10^9/uL)), Neutrophils (54.00%), Haemoglobin (7.5g/dl), MCH (13.50pg) and MCHC (26.90g/dl) while the 7.5% inclusion was higher for Lymphocytes (63.50%), Monocytes (6.50%) and PCV (31.00%). The WBC count for the daily feeding (3.78 (10^9/uL)) was significantly lower than the skip-a-day feeding (6.98 (10^9/uL)) while the other haematological parameters were not affected by the feeding frequencies. The interaction affected the serum metabolites and the haematological parameters. The Cost of concentrate reduced as the inclusion increased from 0% to 7.5% from N51.25 to N48.20. The cost per gain of N542.48 at 7.5% was significantly ($P < 0.05$) lower than the cost per gain at the other inclusion levels. The feeding frequencies had no impacts on the economics of feeding Yankasa rams. It can be concluded that shea nut cake could be included in concentrate diets up to 7.5% and fed to rams without any negative impact on the growth of rams, and that rams can be supplemented with concentrate diets once in two days without a resultant loss in weight of the animals.

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CHAPTER ONE

1.0 INTRODUCTION

The cost of feed ingredients used in livestock feeding is on the upward trend year after year, and this is due to the ever-increasing demand and reduced supply of such feed ingredients. This increased demand and reduced supply of feed ingredients is due to the increase in competition from other species, especially humans (Kumar, 2015). Meeting nutrient requirement of animals is now recognized as a major constraint for sustainable positive growth in the livestock subsector, hence there is a need to search for and utilize agro industrial by products which will be available throughout the year. These unconventional feed ingredients will help reduce the competition between humans and livestock for the limited supply of the conventional feed ingredients, and hence narrow down the gap between feed stuff demand and availability.

In an effort to address the constraint of meeting livestock nutrient requirements, several unconventional feed ingredients have been incorporated in livestock diets. In recent times, one of the most promising unconventional feed ingredients is the Shea-nut cake. The Shea-nut cake is a by-product of the shea butter industry. Shea butter is the fat extracted from the nut of Africa Shea butter tree (*Butyrospermum parkii*). It is used in cosmetic formulations and as a substitute for cocoa butter in chocolate industries. Shea tree (*Butyrospermum parkii*) is a native of the savannah regions across Africa from Senegal to Ethiopia. It was called by different names in different countries viz., Lulu (Arabic), Bambouk butter tree (English), Karate (French), Okwuma (lgbo) Tango (Spanish) (Kumar, 2015). It is also called ori in Yoruba and kadanya in Hausa. It is edible and used as a cooking fat in Africa. The saponifiable fraction of Shea butter is composed primarily of stearic and oleic acids with lesser amounts of palmitic, linoleic and arachidonic acids while the unsaponifiable fraction of Shea butter is composed of bioactive substances that are responsible for Shea butter's medicinal properties (Malachi, 2014).

Shea-nut cake has been shown to vary in composition depending on whether extraction of fat was by an industrial (expeller and sometimes solvent) or traditional cottage industry method, with the industrial methods tending to be more efficient at fat extraction (Dei *et al*., 2007). The following ranges of nutrient compositions (percentage DM) have been reported: crude protein (8 to 25), ether extract (1.7-36.2), crude fibre (5.3 to 13.8), ash (3.3 to 7.6) and nitrogen-free extract (31.8 to 67.5) (Dei *et al*., 2007). Belewu *et al*., 2004 also reported that Shea-nut cake contains 15.02% CP, 26.00% cellulose, 55.40% acid detergent fibre and 29.30% lignin. The Shea-nut cake which constitutes a nuisance to the environment in some locations has been successfully used in several studies in feeding different species of ruminant animals including but not limited to buffalo calves (Kishan and Kalyani, 2012) as well as small ruminants such as sheep (Prasanna *et al*., 2016 and Konlan, 2010).

Most agricultural residues including Shea-nut cake contain some antinutritional factors which prevent the availability of other nutrients. Shea-nut cake has been found to contain some anti-nutritive factors and the following have been reported: saponins (Gohl, 1981), tannins (Okai, 1990), theobromine (Rhule, 1999), saponins and theobromine (Atuahene *et al*., 1998) and saponins and tannins (Annongu *et al*., 1996). The presence of such anti-nutritional factors like tannins could prevent the availability of some nutrients like protein to the animal if not properly processed. Additionally, the Shea-nut cake has a bitter taste due to the presence of anti-nutritional factors such as saponins making the cake to be unpalatable to livestock (Belewu and Yahaya, 2008).

Feeding diets with lowered protein content reduces input, improves nitrogen utilization efficiency, and reduces nitrogen losses from manure. Reducing dietary protein also benefits the

producer by reducing feed cost and improving overall farm profitability (VanSaun and White, 2011).

1.1 Justification

Shea-nut cake has a metabolizable energy of between 3017 and 3577kcal/kg DM depending on the processing method (Dei *et al.,* 2008) and can be used as energy supplement to replace high cost low energy supplements like deoiled rice bran and as protein supplement to replace groundnut cake and cottonseed cake etc. Shea-nut cake is available at a relatively cheaper rate and so it can be used in the concentrate mixture as one of the unconventional feed ingredient for ruminants to minimize the cost of feeding (Kumar, 2015). Protein from Shea-nut cake might be used as cheap sources of protein supplementation in the feeding of animals. This will greatly reduce the cost of feeding as protein constitutes an expensive feed ingredient especially for low income farmers (Kumar, 2015). Oddoye *et al.* (2012) reported that Shea-nut cake from Shea-nut processing industries in Ghana is a potential feed ingredient due to its high values for protein (11.6 to 17.8%) and crude fat (2.5 to 54.5%). Not much work in the feeding of Shea-nut cake to small ruminants has been reported in this part of the country. This study was aimed at bridging the gap and to assess the efficiency of feeding Shea-nut cake on the growth performance of sheep.

The conservation of nitrogen in animal production must begin by improving the nitrogen use efficiency of the animals. Greater improvements in animal production are generally obtained through strategies that improve protein-feeding efficiency (Rotz, 2004). Decreasing protein concentration in dairy animal diets was found to dramatically decrease manure nitrogen losses without affecting animal production (VanSaun and White, 2011). Studies done by Yashim (2014) indicated that feeding every other day was better than feeding daily terms of in total feed intake, weight gain and decrease in methane nitrogen losses.

The study was also an inquiry into a more efficient strategy of feeding protein supplements. The effects of different feeding frequencies of Shea-nut cake on Yankasa rams were therefore studied in order to investigate animal production with less nitrogen consumed and excreted.

1.2 Objectives

The main objective of the study was to evaluate the nutritive value of Shea-nut cake as a supplement to *Digitaria smutsii* hay fed to Yankasa rams at different levels and frequencies. The specific objectives were to determine:

1.the effects of different inclusion levels and feeding frequencies of Shea-nut cake on the growth performance, nutrient digestibility and nitrogen balance of Yankasa rams fed a basal diet of *Digitaria smutsii* hay

2.the effects of different inclusion levels and feeding frequencies of Shea-nut cake on the blood serum and haematological parameters of Yankasa rams fed a basal diet of *Digitaria smutsii* hay

3.the economic effects of feeding of Shea-nut cake at different inclusion levels and feeding frequencies to Yankasa rams

1.3 Research Hypotheses

1.H_0: Different inclusion levels and feeding frequencies of Shea-nut cake have no effect on the growth performance, nutrient digestibility and nitrogen balance of Yankasa rams.

H_a: Different inclusion levels and feeding frequencies of Shea-nut cake have effects on the growth performance, nutrient digestibility and nitrogen balance of Yankasa rams.

2.H_0: Different inclusion levels and feeding frequencies of Shea-nut cake have no effect on the nutrient digestibility and nitrogen balance of Yankasa rams.

H_a: Different inclusion levels and feeding frequencies of Shea-nut cake have effects on the nutrient digestibility and nitrogen balance of Yankasa rams.

3.H_0: Different inclusion levels and feeding frequencies of Shea-nut cake have no effect on the economics of production of Yankasa rams.

H_a: Different inclusion levels and feeding frequencies of Shea-nut cake have effects on the economics of production of Yankasa rams.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Sheep Production in Nigeria

Sheep (*Ovis aries*) are quadrupedal ruminant animals typically kept as livestock. Like all ruminants, sheep are members of the order *Artiodactyla*, the even-toed ungulates. Although the name "sheep" applies to many species in the genus *Ovis*, in everyday usage it almost always refers to *Ovis aries*. Numbering a little over one billion in the world, domestic sheep are also the most numerous species of sheep. A male sheep is called a ram and a female sheep is called an ewe while a young sheep is called lamb. Sheep husbandry is practiced throughout the world, and has been fundamental to many civilizations. In the modern era, Australia, New Zealand, the Southern and Central South American nations, and the British Isles are most closely associated with sheep production (Wellington Consevation Center, 2017).

There are four main breeds or races of sheep native to Nigeria, the Balami, Uda, Yankasa and West African Dwarf (WAD) (Adu and Ngere, 1979) Nigeria has a population of about 8 to 13.2 million sheep out of which about 3.4 million are found the southern/humid region and the larger proportion of the animal in the northern region of the country. Out of these four major breeds of sheep in the country, the WAD breed is common to southern region against the widespread of Balami, Uda and Yakansa breeds in the northern region of the country (Lawal-Adebowale, 2012).

Yankasa is a meat breed found in North and North central Nigeria. The Yankasa breed has been the most extensively studied in Nigeria. The body colour is white with black patches around the eyes and sometimes on the feet. The muzzle and ears are usually black too. Rams have curved

horns and a hairy white mane, and ewes are polled. Yankasa sheep have been recorded in all parts of Nigeria, though the populations attenuate towards the northern border. Some tentative studies have been made of its ecological adaptations. Yankasa sheep do not need daily watering in the wet season and watering once a day suffices in the dry season (Aganga *et al*., 1988).

Sheep are kept both in villages and by pastoralists in the north, and along the northern borders of Nigeria, there are occupationally specialized pastoralists who depend on very large herds of sheep for subsistence. Sheep are more prestigious than goats in Islamic ceremonies and substantial changes in price within the ritual year encourage sheep-production. In the south, the traditional purpose of sheep was for use in animal sacrifices at social and religious ceremonies, and they do not form a regular source of protein in human diet (Roger, 1999)Sheep are kept for generating family income, for use during religious/traditional rites, and for meat and milk (Ahmed and Egwu, 2014).

Sheep are kept everywhere in Nigeria, with a broad distinction between their importance and ubiquity in the north, and the more dispersed populations in the humid zone. Sheep and goats are seen as having secondary importance in relation to crops.

2.2 Significance of Sheep Production

Nigeria is home to about 22.1 million sheep and about 70% of the small ruminants are found in the semi-arid zones of Nigeria and these belong to the agro-pastoral farmers utilizing extensive and semi-intensive management systems (Ajala *et al*. 2003; Mbilu 2007). Whilst, majority of the sheep population in the country are owned by small-holder rural livestock farmers, a few are still in the urban areas (Sanni *et al*. 2004; Mbilu 2007). The indigenous breeds of sheep in order of importance are Yankasa (60%), West African Dwarf (20%), Uda (10%) and Balami (10%). The

vast majority of these small ruminants (about 70%) are found in the Northern part of the country (RIMS, 1992). Even now, these propotions have not changed significantly. Sheep are estimated to contribute 11% of the meat supplied from slaughter houses in the nation and that the contribution of sheep is greater if rural unregistered slaughters are considered (Oni *et al.*, 2001). This suggests the relative importance of small ruminants within the livestock economy of Nigeria. This figure also suggests that small ruminants are a source of meat products which if improved upon would augment the existing supply of meat.

Small ruminants play significant roles in the nutrition, social and economic life of many Nigerians. In most cases, the small ruminants are not kept strictly to provide meat for the household, or as a regular source of cash income. The importance of scavenging sheep and goats is rather as a savings account or insurance policy, that is, they are sold when extra cash is needed. They also play a specific role in social life, like at weddings and other festivities they are presented as gifts or slaughtered as ceremonial meat (Ajala *et al.*, 2008).

2.3 Small Ruminant Production Systems

2.3.1 Extensive or Traditional system

This is a system of production where animals are allowed to graze or browse on large areas of land that are marginal in nature and not suitable for agricultural use. Usually, large number (50-200) of animals are involved on the land and what the animals benefit from grazing depends on the carrying capacity of the land. The carrying capacity may be defined as the amount of forage available to sustain a set number of animals in a given area, or the number of animals that can live on an area of land with given types of biomass (or forages) over a set time period. In this type of system, houses are not provided for the animals and they stay in the open at night. Owing

to the fact that they depend completely on the rangeland they are migratory, moving from one part of the country to another in search of places with better vegetation to graze on. This migratory movement is of two types: - Nomadism and Transhumance. Nomads (Pastoralists – the Tauregs in West Africa, Masai in East Africa and Fulanis in Nigeria) are people without permanent homes and move from one place to another with their herds and flocks. Trans-humans are those with permanent homes or settlements to which they return every year after spending a large proportion of the year elsewhere with their animals in search of feeds and water. This system is under threat because of increasing human population and urbanization (Otaru, 2015).

2.3.2 Semi-intensive System

The semi-intensive management system is the intermediate between intensive and traditional management system. The system involves grazing of the animals on any available herbage during the day and housing them during the night. On the other hand, the sheep is still fed in the morning and in the evening (Otaru, 2015)**.** In this system of production, the animals are released for grazing or scavenging on rubbish dumps, unguarded gardens, and when they return in the evening to their owner's homes, they are fed household wastes. The number of animals kept is usually small, less than 10. During cropping seasons, the movement of the animals is restricted to prevent damage to crops. They are kept in an enclosure (corrals) or tethered to a tree or peg and fed on cut and carry basis with cut grasses and browse supplemented and household wastes. This system is common among villages in most parts of Nigeria where the flock owners keep them to complement their main or primary occupation – usually crop farming. The attention given to the animals in terms of housing, feeding and veterinary care is poor, but better than what obtains in the extensive system (Otaru, 2015).

2.3.3 Intensive system

This is a system of sheep and goat production where the animals are confined and not allowed to search for food by themselves. Good housing and veterinary care are usually provided for them and are fed cut grasses and legumes, grass hay and purchased concentrates, vitamins and minerals. Intensive system of production usually involves an increase in inputs so as to increase the total output from the system. This system is usually associated with high costs of inputs (e.g. high labour cost, expensive quality feeds, high cost of land and cost of good foundation stock). It can only be successful i.e. profitable if high output is achieved or the product produced is highly valued at high price. Generally, management of animals in intensive system of production is better than the other two systems. Due to confinement of large numbers of animals in an area, meticulous health care is necessary to prevent diseases and problems of parasites. Increase in human population and urbanization with decreasing or shrinking area available for grazing either in extensive or semi-intensive system of production, is gradually making the intensive system an option for the future (Otaru, 2015).

The greatest advantages of this system are effective conversion of crop residues or supplement to products of high biological value such as milk and meat. There is control of reproduction, improved performance and hygienic conditions, collection and use of faecal materials as farm yard manures, reduction in cases of parasitic diseases (Otaru, 2014).

2.3.4 Tethering

Suitable for small size flocks of 2–10 animals. This is a subsistence family system and the animals live on kitchen remnants crop residues, grazing near inhabited areas and other supplementary feed (Economides, 1985).

2.4 Constraints to Small Ruminant Production in Nigeria

2.4.1 Disease and parasitism

One of the most serious diseases of small ruminants, *peste des petits ruminants* (PPR) in 1930 was first recognized as a contagious "rinderpest-like" condition in goats in Nigeria. The disease has been difficult to quantify due to the lack of precise statistical records. However, it has been stated that it is the most destructive viral disease among small ruminants (Bourdin, 1983). Goats are more susceptible to PPR than sheep and young animals are more susceptible than adult ones. The use of tissue-culture rinderpest vaccine (TCRV) has been effective in the control of PPR.

Parasitism ranks high among the factors that limit the productivity of small ruminants although its effect is often underestimated. Akerejola *et al* (1979) have estimated that the losses from parasitic diseases in Nigeria's sub-humid zone are higher than those attributable to PPR. Helminthiasis was the most prevalent condition encountered. Assoku (1980) studied the helminths of sheep and goats on the Accra plains of Ghana. He found out that 80% of the sheep and 88.3% of the goats were infected. The problem of parasitism is compounded by the fact that, under the traditional system, livestock are usually reared extensively. This increases infestation and makes control measures difficult. Young animals are the most affected and parasitism could aggravate other conditions such as nutritional stress and susceptibility to disease (Ademosun, 1999).

2.4.2 Reproductive problems

The major reproductive problems of confined or free-roaming small ruminants include: abortions, still births, agalactia, mastitis, metritis, dystocia and perinatal mortality (Falade and Sellers 1976; Smith and van Houtert 1988).

Many of the above problems are associated with systemic diseases that lower the overall performance of the animal, while others specifically cause foetal mortality, abortion or male infertility. Foetal mortality and abortion can be caused by vibriosis (due to *Camphylobacter fetus intestanalis*), salmonellosis (due to *Salmonella abortus-ovis*and *S. dublin*), *Listeria monocytogenes, Chlamydia*, sheep ticks (*Ixodes ricinus*) carrying tick-borne fever, Border disease, mycotic abortion, Q' fever (*Coxiella burnetti*) and *Toxoplasma gondii*. It is noteworthy that *Brucella abortus* is not a major cause of abortion in sheep. Infertility in male animals may arise from infectious epididymitis (caused by *B. ovis* and *Actinobacillus seminis*) (Mukasa, 1999)

2.4.3 Nutritional constraints

Inadequate feeding is a major limiting factor to small ruminant production in tropical Africa. Fodder is of poor nutritional value for most of the year due to the rainfall pattern. In the arid and semi-arid zones, rainfall is less than 600 mm and between 600-1000 mm per year, respectively. The management system is nomadic or transhumant pastoralism. Animals have to trek great distances in search of fodder and water. The quality of available forage is low and browse species which can provide higher levels of proteins and carbohydrates are sparsely dispersed. In the humid and sub-humid zones, up to six months of the year can be rainless, resulting in poor quality forages. The rapid buildup of cell-wall materials and decline in crude protein CP) content at maturity reduces the nutritional value of the forages (Ademosun *et al*, 1985).

Tropical grasses are generally low in crude protein content. As they grow, the lignin content and other cell-wall materials build up rapidly, adversely affecting digestibility. Studies have shown that the use of a grass such as *Panicum maximum* (Guinea grass) or *Cynodon nlemfuencis* (African Bermuda-grass) alone is not adequate to allow optimum production in sheep and goats

(Ademosun *et al*, 1985). The use of browse plants in addition to other feed sources has proven satisfactory. Browses such as *Gliricidia sepium* (Gliricidia) and *Leucaena leucocephala* (Leucaena) have been successfully used for small ruminant production systems in alley farms (Sumberg, 1985) and intensive feed gardens (Ademosun, 1988).

During the dry season, the quality of available herbage is so low that, unless the animals have access to supplementary feeds, they lose weight. These supplementary feeds can be obtained from agro-industrial by-products such as residues of oil extracted from oil bearing seeds groundnuts, coconut, palm kernels, cotton seed, soyabean etc), by-products of grain processing (maize, rice, wheat, sorghum, millet etc), peelings of crops (yams, cassava, potatoes, plantains etc) and industrial by-products (brewers' dried grains, fruit cannery by-products, molasses etc). The types and quantities available tend to be location and season specific (Ademosun, 1999).

Gatenby (1982) has indicated that the major factors limiting the productivity of small ruminants in Africa are poor nutrition in the semi-arid areas and diseases in more humid areas. Water can be a problem in some dry areas. Contrary to popular belief, the genotypes of breeds in Africa are not the primary limiting factors especially where nutrition, disease and marketing problems have been adequately handled.

The nutrient content in the form of metabolizable energy, digestible protein and minerals may be poor in arid and semi-arid regions, even when vegetation appears to be adequate. The dry season poses serious feed problems in semi-arid areas. There are three aspects of the feed problem, namely, the issue of increasing the efficiency with which the available feed is utilised (e.g. forages, crop residues, agro-industrial by-products and nonconventional feeds), the inability to

make maximum use of the limited total feed resources and the inadequate supplies of feed (Devendra, 1987) and water.

Strategies for ensuring adequate nutrition of small ruminants must be based on optimizing overall agricultural and livestock productivity from available resources, improving existing technologies and integrating technology that employs multipurpose crops and animals and recycling of crop residues and by-products as nutrients for both animals and plants.

Components of such strategies may include matching livestock production systems to available resources, selection of crops and cropping systems that will maximize biomass production and nitrogen fixation and thus minimize use of inputs. These may also involve developing simple processing techniques to optimize the use of different components of crops for different end purpose, recycling of livestock wastes, making more efficient and widespread use of agricultural and industrial by-products as sources of ruminant feed and incorporation into the production system of non-ruminant species that are well adapted to use of farm resources, by-products and wastes. An in-depth analysis of each strategy is worthwhile **(**Njwe, 1992).

2.4.4 Health Constraints

A serious constraint to small ruminant production in Africa has been the high prevalence of diseases and parasites, particularly in the more humid areas. This causes high mortality amongst kids and lambs, diminishing the benefits of their high reproductive performance.

Pre-weaning mortality of up to 40% has been recorded with kids and lambs in Nigeria (Ademosun, 1999). However, pre-weaning mortality under the extensive system of management may be underestimated. Births which occur when animals are grazing in the bush and result in the death of the offspring usually go unnoticed. In addition, further losses are caused by abortions and stillbirths.

About 46% of tropical Africa is infested by tsetse flies, with the highest infestation in the humid (90%) and sub-humid (68%) zones. It has generally been believed that small ruminant breeds adapted to the humid zones are trypano-tolerant. However, cases of trypanosomiasis have been recorded amongst indigenous breeds in these zones (Ademosun, 1999)**.** In a village survey of south west Nigeria, trypanosomiasis was responsible for most of the diseases recorded than any other (ILCA, 1982)

2.5 Feed Resources of the Tropics and Feeding of Small Ruminants

2.5.1 Feed intake of small ruminants

The aim of sheep and goats feeding is to feed as much forage as possible and satisfy the largest part of their nutrient requirements. The quantity and quality of roughage available will determine the amount and type of supplement to be fed. The higher the quality of the roughage, the higher the intake and performance of the sheep or goats on the roughage diets. The voluntary intake of lactating ewes and goats is 50 to 100% higher than dry animals (Peart, 1982). Small amounts of nitrogen (soya bean meal or urea) and energy (grains) improve both the roughage and the total digestible energy intake (Economides, 1985).

2.5.2 Grasses and legumes and their seasonal availability

Small ruminants in rural areas often roam around freely and eat a variety of grasses, legumes and kitchen wastes which are available in quality and quantity in wet season (Onwuka *et al.,* 1989). In Nigeria, rangelands for animals to graze only blossom in the rainy season while in dry season they become standing hay. Thus, animals will have abundant feed in the wet season and a shortage of feed in the dry season. Uneven rainfall distribution leads to wide fluctuations in the

quantity and quality of forage available to animals. Natural pastures grow on uncultivated land to which these ruminants have access for grazing. They are found along roadsides and on fallow lands in the coastal forest belt of humid West Africa. They assume more important proportions in the open derived savannah. According to Atta-Krah and Reynolds (1989), natural pastures consist of a mixture of grasses such as *Panicum maximum* (Guinea grass), *Imperata cylindrical* (spear grass), *Andropogon gayanus* (Gamba grass), *Pennisetum spp* (Elephant grass) and *Hyparrhenia spp* (Thatching grass). These grasses grow rapidly during the wet season, becoming fibrous and coarse during the dry season, and are undergrazed because of the large amounts that become rapidly available. Their quality declines further during the dry season when they become standing hay and are subject to overgrazing. A review of published nutrient contents of these grasses showed that during the period of rapid growth (wet season) they contain, on average, about 25 % dry matter, made up of 10 % crude protein, 6 % ash and a crude fibre content of 32 % and 43 % acid detergent fibre (Smith *et al* 1989). As the dry season advances and weather conditions become harsh, their nutritional quality declines to the extent that crude protein could fall to as low as 2 %. Ash values decline to about 3-4 % as a result of translocation to the root system, while fibre content increases in response to the process of lignification, sometimes up to 50 % crude fibre or 60 % ADF. In other words, these grasses cannot meet the nutrient requirements of small ruminants for most part of the year. Even during the rains they can only satisfy maintenance requirements (Smith *et al* 1989). Ademosun *et al* (1988) also affirmed that unless well fertilized and harvested young, tropical grasses alone cannot supply small ruminants with the nutrients required for a reasonable production level. The production of high quality forages requires inputs and management know-how not yet available to the small ruminant producers within the farming system (free range system).

2.5.3 Browse plants

Browse plants, in form of fodder trees and shrubs, form an integral part of the farming systems in humid West Africa (Atta-Krah *et al,* 1986). As their establishment and management require little effort, labour, time, technical know-how or resources, it should be easy to promote and intensify their use as animal feed. The multipurpose nature of browses as fuel wood, shade, food (fruits), poles, etc. as well as their potential to improve soil fertility and conservation, are added incentives (Atta-Krah *et al* 1986).

In terms of utilization as animal feed, browses currently play an important, albeit non-strategic role as animals under confinement often receive one type or another of browse, from fallow lands or around homesteads. Efficient utilization in a complementary way with grass forages and crop residues is what needs to be worked out through research, in order to exploit their potential nutritive value (Smith, 1992).

These browse plants are evergreen and possessed the ability to maintain a relatively high feed nutrient value in the dry season. Therefore, browses such as *Gliricidia sepium* (Gliricidia), *Gmelina arborea* (Gmelina tree), *Moringa oleifera* (Moringa) and *Leucaena leucocephala* (Leucaena) have been used either as supplements to tropical forages or as sole feeds and it is a viable feeding system in humid West Africa (Ademosun *et al* 1988).

2.6 Origin, Distribution and Forage Yield of *Digitaria smutsii* (Woolly finger grass)

Digitaria smutsii belongs to the family Poaceae and is commonly referred to as digitaria grass or crab grass. It is said to be native to Southern Africa (Hacker *et. al.,* 1993). *Digitaria smutsii* is indigenous to Africa and grows well in the dry part of tropical and subtropical climates. The grass was first introduced into Nigeria from South Africa in 1956. *Digitaria* performs well in

areas with annual rainfall ranging from 600-1800mm, but best rainfall optimum is 900mm per annum. Well-drained sandy-loam soil is preferable for the successful establishment of *D. smutsii*, which is by means of stem cuttings or stolons because no viable seeds are produced. *D. smutsii* is tolerant to acidic or alkaline soils and withstands limited-water logging.

The genus *Digitaria* has world-wide distribution in tropical areas (Hanard 1950). It is found in areas characterized by fertile soil, seasonal rainfall and generally high temperature (Osbourn, 1969). It is easily established, and is vigorous and adaptable. It persists under intensive grazing and is palatable to livestock (Osbourn, 1969). Its stoloniferous habits make vegetative propagation relatively easy in that both stolons and mature stems will be productive. The plant covers the ground within 6-8 weeks, even when only 3 plants take root per square yard (Rooney, 1961).

Dry-matter yields obtained in grass pasture OF *Digitaria smutsii* (Wooly finger grass) under rain-fed conditions are lower than those from both the fertilized and unfertilized irrigated grass pastures with an average yield of 5-8 metric tons dry matter per hectare (Agishi, 1984 and Ariba, 1987). Okeagu *et al* (1985) reported that cattle can be stocked on *Digitaria smutsii* for 154 days in the wet season at 2.4 Tropical Livestock Units (TLU)/ha before they start to lose weight.

2.6.1 Chemical composition of *Digitaria smutsii* (Woolly finger grass)

Digitaria grass comprises of a number of different species (*D. eriantha, D. umfolozi, D. smutsii, D. setivalva, D. peitzii, D. polevansii, D. decumbens* etc.) and they differ in their chemical composition. Minson *et al.* (1984) attributed such differences to the genetic make-up of the plant which controls morphological characteristics such as proportion of leaf to stem, and also to different management practices during growth or harvest of the crop.

Minson *et al* (1990) reported the dry matter content of six species to range from 56.1 to 70.9%, neutral detergent fibre to range from 13 - 14%, hemicelluloses 26.5 - 38.2% on DM basis. This is lower than values of hemicelluloses (59.6 - 66.4%), neutral detergent fibre (43.2 - 54.9%) and cellulose (59.0 - 65.9%) reported by Minson (1984).

2.7 Origin, Distribution and Utilization of Shea Butter Tree

Butyrospermum parkii is a small to medium-sized tree (min. 7) 10-15 (max. 25) m high; much branched, dense, spreading, round to hemispherical crown. In mature trees the bole is short, usually 3-4 m but exceptionally 8 m, with a diameter ranging from 0.3 to 1 m, but most frequently 0.6 m. Bark conspicuously thick, corky, horizontally and longitudinally deeply fissured; protects older trees against bush fires. The shea tree is a light-demanding species of open sites and parkland savannah; forming extensive pure stands in some areas but often also associated with other trees, such as *Parkia biglobosa* (nere). (Orwa *et al.,* 2009). The shea tree grows naturally in the wild in the dry savannah belt of West Africa from Senegal in the west to Sudan in the east, and on to the foothills of the Ethiopian highlands (Neumann, 1998). Shea trees grow across 4 million km^2 of sub-Saharan Africa. Shea parklands provide a sustainable source of edible fat (shea butter) that, in terms of volume, is currently second only to cocoa butter as a vegetal source of stearic acid in the multi-billion dollar chocolate and cosmetic sectors (Julia *et al.,* 2015).

Today, Shea-nuts are important internationally and are sold to European and Japanese food industries. The refined fat is sold as baking fat, margarine and other fatty spreads under various trade names and finds increasing use in various foodstuffs (Orwa *et al.,* 2009). In the western world, it is mostly used for cosmetics as an emollient. Throughout Africa it is used extensively for food, is a major source of dietary fat, and for medicinal purposes (Neumann, 1998).

Shea butter has a fatty composition similar to that of cocoa butter, so is often used as a substitute for cocoa, and in pastries because it makes highly pliable dough. Traditionally prepared unpurified, shea butter is sold in 'loaves' in markets and, if properly prepared and wrapped in leaves, is resistant to oxidative rancidity and will keep for years if not exposed to air and heat. Nuts that have been cleaned and lightly sun dried without previous maceration yield a tasteless, odourless fat. Traditionally prepared shea butter, after refining, is also tasteless and odourless. (Orwa *et al.,* 2009).

Shea collection, post-harvest processing, butter extraction and the first stages of commercialization are still exclusively a female activity. The beginning of the shea value chain involves rural women collecting from the parklands and processing the nuts in their homesteads, before the derivative materials leave the continent. Afterwards, the shea goes into the international marketplace, where the downstream shea is used as a mono-product or an ingredient in the multi-billion dollar cosmetic and food industries. This is because shea stearin (the high melting point fraction of shea butter) is usually cheaper than cocoa butter and is an important functional ingredient when formulated into cocoa butter equivalents (Julia *et al.*, 2015).

2.7.1 Processing and chemical composition of Shea-nut cake

Asante (1987) stated that, two methods of processing Shea-nut into butter and cake exist. These are traditional and industrial methods. The traditional method consists of the following procedure; crushing the nut, roasting, milling, kneading, boiling, stirring, decanting and collecting the oil (Irvine, 1974).

The dry kernels are crushed by placing one or two nuts at a time on a flat stone or concrete floor and hitting hard with a specially made pestle. The crushed nuts are roasted or fried in an oven or pan. This process continuous till it turns brown, splits and shine with oil. The roasted mass is milled manually with a grinding stone or by using corn mill (Asante, 1987). The milled mass is kneaded with cold or warmed water until it becomes thick to work with. More water is then added and the process continuous until fat rises to the surface of the water. The crude fat is skimmed and boiled again. The milled oil floats on the surface and is gradually collected into a calabash or any suitable storage container and stored as shea butter. The remaining residue after skimming the fat and after the last boiling of the crude fat is dried to obtain Shea-nut cake (Irvine 1974). The traditional method of shea butter extraction yields 25 – 30% shea butter and the cake is generally oily (Dalzich 1955). Asante (1987) reported that, the industrial Shea-nut processing yields more oil (shea butter) than the traditional method and thus produces less oily cake. This process also produces two kinds of SNC with varying levels of fat content; 22 – 24% and 10 – 12% for midway cake and final cake respectively (Asante, 1987).

In a trial carried out by to Asante (1987), the industrial shea butter extraction process uses the screw press method. This involves preheating of the nut at 90°C by means of steam and passing the nut through a screw press machine for the first stage extraction which removes the fat and leaves the cake with a fat content of 22 – 24%. The cake is heated again and passed through a second stage of fat extraction, leaving the cake with a fat content of 10 – 12%. This cake is disposed off as a by-product, which is referred to as Shea-nut cake (Konlan, 2010).

Shea-nut cake has been shown to vary in composition depending on whether extraction of fat was by an industrial (expeller and sometimes solvent) or traditional cottage industry method, with the industrial methods tending to be more efficient at fat extraction (Dei *et al*., 2007). The

following range of nutrient compositions (percentage DM): crude protein (8 to 25), ether extract (1.7-36.2), crude fibre (5.3 to 13.8), ash (3.3 to 7.6) and nitrogen-free extract (31.8 to 67.5) have been reported (Dei *et al*. 2007). Belewu *et al*., 2004 also reported that Shea-nut cake contains 15.02% CP, 26.00% cellulose, 55.40% acid detergent fibre and 29.30% lignin.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Location of the Study

The experiment was carried out at the Department of Animal Science Teaching and Research Farm, Ahmadu Bello University, Zaria. Zaria is located within the Northern Guinea Savanna Zone of Nigeria, with a latitude of 11° 14' 14"N and Longitude 7° 38' 65"E at an altitude of 610m above sea level (Ovimaps, 2016).The climate is relatively dry with a mean annual rainfall of 700-1400mm. The rain starts between late-April and early-May to mid-October. The dry season begins around the middle of October, with cold weather that ends in February. This is followed by a relatively hot-dry weather between March and April just before the rain begins. The mean maximum daily temperature ranges from 14 °C to 24 °C during the cold season while the mean maximum daily temperature ranges from 19 °C to 36 °C during the hot season. The mean relative humidity during dry and wet seasons is 21% and 72% respectively (IAR, 2016).

3.2 Source of Animals and Experimental Diets

The experimental animals were sourced from Kaffur in Kastina State while the Shea-nut cake was sourced from Minna, Niger State. The basal diet *Digitaria smutsii* hay was sourced from the National Animal Production Research Institute, Shika, Zaria, Kaduna State.

3.3 Experimental design and treatments

Table 3.1 shows four iso-nitrogenous supplementary diets of 16% crude protein containing 0, 2.5, 5 and 7.5% of Shea-nut cake were formulated as treatments T1, T2, T3 and T4, respectively. The animals were randomly assigned to the four dietary treatments with six (6) animals per Treatment and each Treatment was further divided in two feeding frequencies with three animals

per feeding frequency in a 4x2 factorial arrangement and designed in a completely randomized design (CRD). The experimental animals were housed individually in the experimental pens with concrete floors.

3.4 Growth Trial

Twenty four (24) yearling Yankasa ram lambs with an average live weight of 16.4kg were used for the growth trial. The animals were quarantined for three weeks during which the animals were dewormed against internal parasites using Albendazole® 10% suspension and external parasites by dipping in Acaricide (*Amitics*®). The animals were also administered with *Tetraamycine*® long acting antibiotics.

All the animals were fed concentrate diets containing varying levels of Shea-nut cake at 2.5 percent of their body weight and a basal diet of *Digitaria smutsii* hay *ad libitum*. The concentrate diet was offered once as a single meal each morning at 8.00am, and thereafter, *Digitaria smutsii* hay was offered *ad libitum.* The animals on the skip-a-day feeding frequency across the four treatments were however only fed the concentrate diet once in two days and they were exclusively fed *Digitaria smutsii* hay on the days the concentrate diet was withdrawn. Fresh water was also offered *ad libitum.* The growth trial lasted for a period of 90 days. Measurements were taken daily for feed intake before feeding each morning throughout the growth trial. During the trial, body weight of the rams was also measured and recorded fortnightly.

3.5 Digestibility Study

At the end of the growth trial, all rams from each treatment group were housed in metabolic crates for total faecal and urine collection for the determination of nutrient digestibility. The animals were allowed 7 days adjustment period in the metabolic crates and the same feed and feeding procedure used during the growth trial was applied during the digestibility study.

Afterwards, the collection period lasted for another 7 days. The animals were fed the experimental diets as they were fed during the feeding trial based on their individual treatment.

Daily faecal output was weighed and 10% of each day's collection was sub sampled and oven dried for DM determination and subsequent laboratory analysis. Daily urine output was collected in a container containing 0.1M concentrated H_2SO_4 placed under the metabolic crates, while 10% of the daily urine output were collected from each ram and stored in the refrigerator. At the end of the 7-day collection period, 10% of the urine taken from each ram was bulked and sub sampled and used for nitrogen determination.

3.6 Blood Sample Collection

At the end of the growth trial, blood samples were taken from each of the animals sample tubes. Blood samples were analyzed for glucose (Folin and Wu, 1920), serum protein (Lowry *et al.*, 1951) serum urea and creatinine (Brod and Sirota, 1948). Blood samples were also taken separately for determination of haematological parameters such as packed cell volume (Bull *et al.*, 2000), total erythrocyte count and haemoglobin (Kokholm, 1991). Ethylene di-amine tetra acetic acid (EDTA) was used as anticoagulant (5mg/tube).

3.7 Chemical Analysis

The dry matter content of shea-nut cake, *Digitaria* hay, concentrate diets and fecal samples were determined by drying the samples to a constant weight in an oven at 50-60 degree Celsius and 25mmHg for about 5 hours. Kjeldahl nitrogen analyses using the method of AOAC (2005) were used in duplicate on the samples and Crude protein was calculated as N x 6.25. Crude fibre content was determined by means of Foss Tecator Analyzer, ether extract content by Sohxlet extractor and ash content through combustion in a Muffle furnace. Neutral detergent fibre (NDF)

and acid detergent fibre (ADF) were determined by the Method of Van Soest and Robertson (1988). Antinutritional factors such as tannins, phytate, oxalate, hydrocyanide and saponin were analysed by the method of Wheeler *et al.* (1994).

3.8 Cost-benefit Analysis

Cost analysis was carried out to determine the profitability of varying the inclusion levels of Shea-nut cake in concentrate diets of Yankasa rams. Parameters considered included cost of concentrate, total concentrate intake, cost of hay, total hay intake, total feed cost per ram, live weight gain and cost per gain. All calculations of feed cost and output were based on averages per head, and at the prevailing prices.

3.9 Statistical Analysis

Analysis of variance was carried out on all the data collected using the GLM procedure of SAS (SAS, 2008). Means separation was carried out Duncan's Multiple Range Test (Duncan, 1955).The following model was used:

$Y_{ijk} = \mu + A_i + B_j + (AxB)_{ij} + e_{ijk}$

Where:μ = overall mean

A_i = effects of inclusion levels (i = 1-4)

B_j = effects of feeding frequencies (j = 1-2)

$(AxB)_{ij}$ = interaction between feeding frequencies and inclusion levels

e_{ijk} = random error

Table 3.1: Ingredient composition of supplemented diets

	Shea-nut Cake inclusion levels (%)			
Ingredients	0	2.5	5	7.5
Corn bran	20.45	17.65	14.85	12.05
Cotton seed cake	14.05	14.35	14.15	14.95
Rice bran	35.0	35.0	35.0	35.0
BDG	25.0	25.0	25.0	25.0
Shea butter cake	0.0	2.5	5.0	7.5
Molasses	2.5	2.5	2.5	2.5
Bone meal	2.5	2.5	2.5	2.5
Salt	0.5	0.5	0.5	0.5
Total	100	100	100	100
Calculated analysis (%)				
CP	16.00	16.00	16.00	16.00

BDG = Brewer's Dry Grain; CP = Crude Protein

Table 3.2: Antinutritional factors of Shea-nut cake

Parameters	Composition (mg/100g)	Toxic levels (Lethal dose)
Phytate	2.48	< 25.20mg/g DM (Okoli *et al.*, 2003)
Oxalate	1.12	< 20g/kg (Acamovic *et al.*, 2004)
Tannins	3.15	60–100g/Kg DM (Barry and Duncan, 1984)
HCN	2.10	2.0- 4.0mg/Kg body weight (Njidda, 2010)
Saponin	1.04	<2.55 mg/g DM (Njidda, 2010)

CHAPTER FOUR

4.0 RESULTS

4.1 Chemical composition of experimental diets

The chemical composition of *Digitaria smutsii* hay, Shea-nut cake and the concentrate diets containing inclusion levels of Shea-nut cake are shown in Table 4.1. The results showed that *Digitaria* hay and Shea-nut cake used in the study had crude protein contents of 5.36 and 11.44 awhile NDF contents of 69.23 and 42.28%, respectively. The dry matter, Ether extract and lignin content increased from the 0-5% inclusion levels.

4.2 Main effects of inclusion levels of Shea-nut cake on feed intake and weight gain of Yankasa rams fed *D. smutsii* hay basal diet.

Table 4.2 shows the effects of inclusion levels of Shea-nut cake on feed intake and weight gain of Yankasa rams fed a basal diet of *D. smutsii* hay. The inclusion of Shea-nut cake in the experimental diet significantly ($P<0.05$) affected *D. smutsii* intake, total feed intake, final weight, total weight gain and average daily gain. Total feed intake was significantly ($P<0.05$) influenced by the inclusion of Shea-nut cake with 7.5% inclusion recording the highest values (588.70g/day) while 0% and 5% were the least (554.58 and 551.34g/day, respectively). Final weight was significantly ($P<0.05$) higher in 7.5% inclusion (21.02kg) and the lowest final weight (20.40) was observed at 5% inclusion level. Total weight gain was affected by the inclusion level with the highest values of 4.69kg observed at 7.5% and the least values recorded at 5% inclusion (3.99kg) which was statistically similar to 0 and 2.5%. The results of the total weight gained by the animals and the average daily gain (ADG) followed the same pattern as the final weight gain. The supplement intake and the feed-gain ratio were not significantly ($P>0.05$) influenced by different inclusion levels.

Table 4.1: Chemical composition of supplemented diets, Shea-nut cake and *Digitaria smutsii* hay

	Shea-nut Cake inclusion levels (%)					
Parameters	0	2.5	5	7.5	SNC	Digitaria hay
DM	92.56	93.19	94.50	93.70	92.00	90.04
CP	12.06	12.31	11.96	13.04	11.44	5.36
EE	3.76	3.95	4.18	3.52	3.19	0.54
CF	8.52	9.15	8.78	7.95	4.78	30.05
NFE	62.31	60.78	61.39	62.31	75.37	61.50
ASH	7.29	7.00	8.19	6.88	5.22	2.65
ADF	31.55	32.60	29.77	34.63	27.50	38.88
NDF	52.48	50.88	53.69	49.98	42.28	69.23
Lignin	15.97	16.52	16.54	15.39	14.78	20.40

DM = Dry Matter, CP = Crude Protein, EE= Ether Extract, CF= Crude Fibre, NFE= Nitrogen Free Extract, ADF= Acid Detergent Fibre, NDF= Neutral Detergent Fibre

Table 4.2: Main effects of inclusion levels of Shea-nut cake on feed intake and weight gain of Yankasa rams fed *D. smutsii* hay basal diet

Parameters	Shea-nut Cake inclusion levels (%)				SEM
	0	2.5	5	7.5	
Dry matter intake (g/d)					
Supplement	293.88	285.20	280.40	296.63	12.4
D. smutsii	260.70 [b]	283.20 [ab]	270.94 [ab]	292.07 [a]	14.77*
Total intake	554.58 [c]	568.41 [b]	551.34 [c]	588.70 [a]	6.21*
Initial weight (kg)	16.42	16.42	16.42	16.33	1.05
Final weight (kg)	20.74 [ab]	20.74 [ab]	20.40 [b]	21.02 [a]	0.30*
Total weight gain (kg)	4.32 [ab]	4.32 [ab]	3.99 [b]	4.69 [a]	0.29*
ADG (g)	48.00 [ab]	48.00 [ab]	44.28 [b]	51.11 [a]	2.32*
Feed-gain ratio	11.55	11.84	12.45	11.52	0.62

[abc*]Means with different superscripts within rows differed significantly (P<0.05), SEM = Standard Error of Means, ADG= Average Daily Gain

4.3 Main effects of feeding frequencies of feeding concentrates containing Shea-nut cake on feed intake and weight gain of Yankasa rams fed *D. smutsii* hay basal diet.

Table 4.3 shows the effects of feeding frequencies of feeding concentrates containing Shea-nut cake on feed intake and weight gain of Yankasa rams fed a basal diet of *D. smutsii* hay. Supplement intake, *D. smutsii* and Total intake were significantly ($P<0.05$) affected by feeding frequencies. The results showed both the supplemented intake (385.93g/day) and the total feed (574.90g/day) intake to be significantly ($P<0.05$) higher in the daily feeding frequency while the skip-a-day frequency had a significantly ($P<0.05$) higher *D. smutsii* hay intake (364.49g/day). Feeding frequencies had no significant ($P>0.05$) effect on the final weight, total weight gain and average daily gain, however, the daily feeding frequency had numerically higher values in these parameters. The feed-gain ratio showed no significant ($P>0.05$) difference between the two feeding frequencies even though skip-a-day (12.65) feeding was numerically higher.

Table 4.3: Main effects of feeding frequencies of Shea-nut cake on feed intake and weight gain of Yankasa rams fed *D. smutsii* hay basal diet

Parameters	Feeding frequency		SEM
	Daily feeding	Skip-a-day	
Dry matter intake (g/d)			
Supplement	385.93 [a]	192.12 [b]	24.86*
D. smutsii	188.97 [b]	364.49 [a]	29.54*
Total intake	574.90 [a]	556.62 [b]	8.78*
Initial weight (kg)	16.38	16.42	0.74
Final weight (kg)	21.07	20.38	0.41
Total weight gain (kg)	4.70	3.96	0.42
ADG (g)	52.22	44.00	4.60
Feed-gain ratio	11.01	12.65	0.88

[ab*]Means with different superscripts within rows differed significantly ($P<0.05$), SEM = Standard Error of Means, ADG = Average Daily Gain

4.4 Interaction effects of inclusion level and feeding frequencies of feeding Concentrates containing Shea-nut cake on feed intake and weight gain of Yankasa rams fed a basal diet of *D. smutsii* hay.

The interaction effects of inclusion level and feeding frequencies of feeding concentrates containing Shea-nut cake on feed intake and weight gain of Yankasa rams fed a basal diet of *D. smutsii* hay is shown on Table 4.4. All the parameters measured were significantly ($P<0.05$) affected by the interaction between the inclusion levels and feeding frequencies. The result shows that the supplement intake was significantly ($P<0.05$) higher in daily feeding across all the inclusion levels (0, 2.5, 5.0 and 7.5%, respectively). On the contrary, the result showed that *D. smutsii* hay intake at skip-a-day frequency was significantly ($P<0.05$) higher than daily feeding across the inclusion levels. The total intake was also significantly ($P<0.05$) affected by the interaction. The animals fed daily at 0% had a significantly ($P<0.05$) higher total intake. The animals fed daily at 0% and 7.5% inclusion were comparable and significantly ($P<0.05$) higher than other levels in final weight, total weight gained, ADG and Feed-gain ratio. On the other hand, the animals fed with the skip-a-day feeding frequency at 0% and 5% interaction were the least significant ($P<0.05$) for most of the same parameters.

Table 4.4: Interaction effects of inclusion level and feeding frequencies of Shea-nut cake on feed intake and weight gain of Yankasa rams fed *D. smutsii* hay basal diet

	Shea-nut Cake inclusion levels and Feeding Frequency interaction								
	0		2.5		5		7.5		
Parameters	Daily	Skip-a-day	Daily	Skip-a-day	Daily	Skip-a-day	Daily	Skip-a-day	SEM
DM intake (g/d)									
Supplement	400.36^{a}	187.40^{b}	378.32^{a}	192.08^{b}	367.92^{a}	192.89^{b}	397.12^{a}	196.13^{b}	6.22*
D. smutsii	198.08^{b}	323.32^{a}	191.03^{b}	375.38^{a}	171.37^{b}	370.50^{a}	195.39^{b}	388.76^{a}	7.38*
Total intake	598.44^{a}	510.73^{d}	569.35^{c}	567.46^{c}	539.29^{d}	563.39^{c}	592.51^{ab}	584.89^{b}	4.39*
Initial weight (kg)	16.50	16.33	16.33	16.50	16.33	16.50	16.33	16.33	0.74
Final weight (kg)	21.57^{a}	19.90^{d}	20.57^{bc}	20.90^{b}	20.40^{c}	20.40^{c}	21.73^{a}	20.31^{cd}	0.22*
Total weight gain(kg)	5.07^{a}	3.57^{c}	4.24^{bc}	4.40^{b}	4.07^{bc}	3.90^{c}	5.40^{a}	3.98^{bc}	0.21*
ADG(g)	56.33^{a}	39.67^{c}	47.11^{b}	48.89^{b}	45.22^{bc}	43.33^{c}	60.00^{a}	42.22^{c}	2.38*

Feed-gain ratio	10.62 [a]	12.87 [c]	12.09[bc]	11.61 [b]	11.93 [b]	13.00 [cd]	9.88 [a]	13.85 [d]	0.44*

[abcd*]Means with different superscripts within rows differed significantly (P<0.05), SEM = Standard Error of Means, ADG = Average Daily Gain

4.5 Main effects of inclusion levels of feeding concentrates containing Shea-nut cake on nutrient digestibility of Yankasa rams fed *D. smutsii* hay basal diet.

Table 4.5 shows the effects of inclusion levels of feeding concentrates containing Shea-nut cake on nutrient digestibility of Yankasa rams fed a basal diet of *D. smutsii* hay. Fibre and Ether Extract were affected by the inclusion levels while the other parameters were not affected. DM, OM, CP, NFE, NDF and ADF digestibilities were significantly ($P<0.05$) influenced by the inclusion levels of Shea-nut cake. The digestibility coefficients of these parameters (DM, OM, CP, NFE, NDF and ADF) significantly ($P<0.05$) increased progressively with increase from 0% to 7.5% inclusion level. Inclusion levels of 2.5% and 5.0% were comparable and similar ($P>0.05$) with values of 59.07% and 59.43% respectively.

Table 4.5: Main effects of inclusion levels of Shea-nut cake on nutrient digestibility of Yankasa rams fed *D. smutsii* hay basal diet

	Shea-nut Cake inclusion levels (%)				
Parameters (%)	0	2.5	5	7.5	SEM
Dry Matter	56.69 [b]	59.07 [ab]	59.43 [ab]	62.84 [a]	2.17*
Organic Matter	63.23 [b]	65.81 [ab]	66.60 [ab]	68.01 [a]	1.88*
Crude Protein	59.99 [b]	62.63 [ab]	63.38 [ab]	66.60 [a]	3.16*
Crude Fibre	63.35	63.45	63.42	64.12	0.90
Ether Extract	59.47	64.87	67.01	61.98	4.77
NFE	51.40 [b]	53.21 [ab]	53.77 [ab]	58.02 [a]	2.51*
NDF	62.63 [b]	64.61 [ab]	66.51 [a]	66.46 [a]	1.73*
ADF	55.36[b]	58.94[ab]	58.32[ab]	63.46[a]	2.75*

[ab*]Means with different superscripts within rows differed significantly (P<0.05), SEM = Standard Error of Means, NFE= Nitrogen Free Extract, ADF= Acid Detergent Fibre, NDF= Neutral Detergent Fibre

4.6 Main effects of feeding frequencies of feeding concentrates containing Shea-nut cake on nutrient digestibility of Yankasa rams fed *D. smutsii* hay basal diet.

Table 4.6 shows the effects of feeding frequencies of feeding concentrates containing Shea-nut cake on nutrient digestibility of Yankasa rams fed a basal diet of *D. smutsii* hay. CP and EE were significantly ($P<0.05$) affected by feeding frequencies. The digestibility in daily feeding frequency (68.02%) was significantly ($P<0.05$) higher than skip-a-day feeding (58.27%) for Crude Protein digestibility. Daily feeding frequency was also higher for EE (71.27%) compared to skip-a-day (55.39%). Daily feeding frequency was numerically higher in OM digestibility while it was numerically lower for Crude Fibre, NFE, NDF and ADF.

Table 4.6: Main effects of feeding frequencies of Shea-nut cake on nutrient digestibility of Yankasa rams fed *D. smutsii* hay basal diet

	Feeding frequency		
Parameters (%)	Daily feeding	Skip-a-day	SEM
Dry Matter	58.72	60.29	3.07
Organic Matter	66.94	64.88	2.66
Crude Protein	68.02[a]	58.27[b]	4.47*
Crude Fibre	62.67	64.49	1.27
Ether Extract	71.27[a]	55.39[b]	6.75*
NFE	52.65	55.55	3.55
NDF	63.45	66.65	2.44
ADF	56.74	61.30	3.89

[ab*]Means with different superscripts within rows differed significantly (P<0.05), SEM = Standard Error of Means, NFE= Nitrogen Free Extract, ADF= Acid Detergent Fibre, NDF= Neutral Detergent Fibre

4.7 Interaction effects of inclusion level and feeding frequencies of feeding Concentrates containing Shea-nut cake on nutrient digestibility of Yankasa rams fed *D. smutsii* hay basal diet.

Table 4.7 shows the Interaction effects of inclusion level and feeding frequencies of feeding concentrates containing Shea-nut cake on nutrient digestibility of Yankasa rams fed a basal diet of *D. smutsii* hay. All parameters measured were significantly ($P<0.05$) influenced by the interaction between the feeding frequencies and inclusion levels. The animals fed daily at 7.5% inclusion were significantly ($P<0.05$) higher for Dry Matter, Organic Matter, Crude Protein and NFE digestibility. This was followed by the animals at 2.5% daily feeding for the same set of parameters. The interaction between the 5% inclusion level and the skip-a-day feeding frequency were significantly ($P<0.05$) higher for Crude Fibre (61.38%), NDF (72.08%) and ADF (66.46%), while the interaction between the 0% inclusion level and the daily feeding frequency had the least significant ($P<0.05$) values of 49.58%, 60.95% and 51.98% digestibility respectively for the same set of parameters.

Table 4.7: Interaction effects of inclusion level and feeding frequencies of Shea-nut cake on nutrient digestibility of Yankasa rams fed *D. smutsii* hay basal diet

	Shea-nut Cake inclusion levels and Feeding Frequency interaction								
	0		2.5		5		7.5		
Parameters (%)	Daily	Skip-a-day	Daily	Skip-a-day	Daily	Skip-a-day	Daily	Skip-a-day	SEM
Dry Matter	55.33 ^{c}	58.05^{bc}	59.97 ^{b}	58.16^{bc}	53.24 ^{c}	65.62 ^{a}	66.34 ^{a}	59.34^{bc}	1.54*
Organic Matter	63.54 ^{c}	62.91 ^{c}	68.34 ^{b}	63.29 ^{c}	63.07 ^{c}	70.12 ^{b}	72.82 ^{a}	63.21 ^{c}	1.33*
Crude Protein	63.19 ^{c}	56.78 ^{d}	69.00 ^{b}	56.25 ^{d}	64.39 ^{c}	62.36 ^{c}	75.50 ^{a}	57.70 ^{d}	2.24*
Crude Fibre	62.13 ^{c}	64.59 ^{a}	63.15 ^{b}	63.74 ^{ab}	61.401 ^{c}	65.43 ^{a}	64.01 ^{ab}	64.20 ^{ab}	0.63*
Ether Extract	66.81 ^{b}	52.13 ^{c}	74.00 ^{ab}	55.73 ^{c}	69.04 ^{b}	64.98 ^{b}	75.22 ^{a}	48.73 ^{c}	3.38*
NFE	49.58 ^{c}	53.22 ^{b}	53.41 ^{b}	53.00 ^{b}	46.16 ^{c}	61.38 ^{a}	61.45 ^{a}	54.58 ^{b}	1.77*
NDF	60.95 ^{d}	64.30 ^{c}	64.22 ^{c}	65.00 ^{c}	60.93 ^{d}	72.08 ^{a}	67.71 ^{b}	65.20 ^{c}	1.22*
ADF	51.98 ^{c}	58.74 ^{b}	59.20 ^{b}	58.68 ^{b}	50.17 ^{c}	66.46 ^{a}	65.60 ^{a}	61.32 ^{b}	1.95*

^{abcd*}Means with different superscripts within rows differed significantly (P<0.05), SEM = Standard Error of Means, NFE= Nitrogen Free Extract, ADF= Acid Detergent Fibre, NDF= Neutral Detergent Fibre

4.8 Effects of inclusion levels of feeding concentrates containing Shea-nut cake on nitrogen balance of Yankasa rams fed *D. smutsii* hay basal diet.

Table 4.8 shows the effects of inclusion levels of feeding concentrates containing Shea-nut cake on nitrogen balance of Yankasa rams fed a basal diet of *D. smutsii* hay. All the parameters measured were significantly ($P<0.05$) affected by the inclusion except nitrogen intake and nitrogen retained. Fecal nitrogen at 0% inclusion level was significantly higher ($P<0.05$) than others which were comparable and similar. Urinary nitrogen at 7.5% inclusion level was significantly higher ($P<0.05$) than 2.5% inclusion. The percentage of nitrogen retained progressively increased significantly ($P<0.05$) as the inclusion level increased from 0 to 7.5%.

Table 4.8: Main effects of inclusion levels of Shea-nut cake on nitrogen balance of Yankasa rams fed *D. smutsii* hay basal diet

	Shea-nut Cake inclusion levels (%)				
Parameters (g/day)	0	2.5	5	7.5	SEM
Nitrogen intake	12.04	11.76	12.31	12.45	1.12
Fecal N	5.18 [a]	4.26[b]	4.47[b]	3.94 [b]	0.28*
Urinary N	1.20 [ab]	1.08 [b]	1.21[ab]	1.30 [a]	0.07*
N retained	5.66	6.42	6.64	7.22	1.14
N retained as % of intake	47.01[b]	54.78 [ab]	53.93[ab]	57.99[a]	5.16*

[ab*]Means with different superscripts within rows differed significantly (P<0.05), SEM = Standard Error of Means

4.9 Main effects of feeding frequencies of feeding concentrates containing Shea-nut cake on nitrogen balance of Yankasa rams fed *D. smutsii* hay basal diet.

Table 4.9 shows the effects of feeding frequencies of feeding concentrates containing Shea-nut cake on nitrogen balance of Yankasa rams fed a basal diet of *D. smutsii* hay. Nitrogen intake, nitrogen retained and nitrogen retained as percentage of intake were significantly ($P<0.05$) affected by the feeding frequencies .The daily feeding frequencies was significantly ($P<0.05$) higher for nitrogen intake (14.28g/day), nitrogen retained (8.56g/d) and percentage of nitrogen retained (59.92%) when compared to the skip-a-day feeding frequency (10.00g/d, 4.41g/d and 43.73% respectively). In addition, the daily feeding frequency was also numerically higher than the skip-a-day frequency for fecal nitrogen but lower for Urinary nitrogen.

Table 4.9: Main effects of feeding frequencies of Shea-nut cake on nitrogen balance of Yankasa rams fed *D. smutsii* hay basal diet

	Feeding frequency		
Parameters (g/day)	Daily feeding	Skip-a-day	SEM
Nitrogen intake	14.28 [a]	10.00 [b]	1.58*
Fecal N	4.53	4.39	0.40
Urinary N	1.19	1.20	0.09
N retained	8.56 [a]	4.41 [b]	1.62*
N retained as % of intake	59.94 [a]	44.41 [b]	7.30*

[ab*]Means with different superscripts within rows differed significantly (P<0.05), SEM = Standard Error of Means

4.10 Interaction effects of inclusion level and feeding frequencies of feeding concentrates containing Shea-nut cake on nitrogen balance of Yankasa rams fed *D. smutsii* hay basal diet.

Table 4.10 shows the Interaction effects of inclusion level and feeding frequencies of feeding concentrates containing Shea-nut cake on nitrogen balance of Yankasa rams fed a basal diet of *D. smutsii* hay. All the parameters measured were significantly ($P<0.05$) influenced by the interactions. For all the inclusion levels, the daily feeding frequency was significantly ($P<0.05$) higher than the skip-a-day in nitrogen intake, nitrogen retained and percentage nitrogen retained. The 7.5% inclusion and daily feeding frequencies significantly ($P<0.05$) recorded the highest values in nitrogen intake (14.80g/day), nitrogen retained (9.83g/day) and nitrogen retained as percentage of intake (66.42%). For the same set of parameters, the 0% inclusion level and skip-a-day feeding frequency recorded significantly ($P<0.05$) lowest values of 9.34d/day, 2.95g/day and 31.58% respectively. For the Fecal nitrogen and Urinary nitrogen, the variations between the means were significant ($P<0.05$) but not uniformly distributed.

Table 4.10: Interaction effects of inclusion level and feeding frequencies of Shea-nut cake on nitrogen balance of Yankasa rams fed *D. smutsii* hay basal diet

	Shea-nut Cake inclusion levels and Feeding Frequency interaction								
	0%		2.5%		5%		7.5%		
Parameters (g/day)	Daily	Skip-a-day	Daily	Skip-a-day	Daily	Skip-a-day	Daily	Skip-a-day	SEM
Nitrogen intake	14.74 [a]	9.34 [b]	13.50 [a]	10.02 [b]	14.07 [a]	10.55 [b]	14.80 [a]	10.09 [b]	0.79*
Fecal N	5.35 [a]	5.01 [a]	4.17 [b]	4.35 [b]	4.97 [a]	3.96 [bc]	3.62 [c]	4.25 [b]	0.20*
Urinary N	1.02 [d]	1.38 [a]	1.10 [cd]	1.06 [cd]	1.29 [ab]	1.13 [c]	1.35 [a]	1.24 [b]	0.05*
N retained	8.37 [ab]	2.95 [d]	8.23 [ab]	4.61 [c]	7.81 [b]	5.46 [c]	9.83 [a]	4.60 [c]	0.81*
N retained as % of intake	56.78 [b]	31.58 [d]	60.96 [ab]	46.01 [c]	55.51 [b]	51.75 [bc]	66.42 [a]	45.59 [c]	3.65*

[abcd*]Means with different superscripts within rows differed significantly (P<0.05), SEM = Standard Error of Means

4.11 Main effects of inclusion levels of feeding concentrates containing Shea-nut cake on serum metabolites of Yankasa rams fed *D. smutsii* hay basal diet.

Table 4.11 shows the effects of inclusion levels of feeding concentrates containing Shea-nut cake on serum metabolites of Yankasa rams fed *D. smutsii* hay basal diet. All the parameters measured were significantly ($P<0.05$) affected by the inclusion levels of Shea-nut cake in the concentrate. Serum Urea at 7.5% inclusion (33.36mg/dl) was significantly ($P<0.05$) higher than the other inclusion levels which were statistically similar ($P<0.05$). Serum Creatinine showed a significant ($P<0.05$) progressive decrease in value as the inclusion increased from 0 (2.05mg/dl) to 7.5% (1.36mg/dl). Serum Glucose at 5% inclusion level (41.58%) was significantly ($P<0.05$) higher than the other inclusion levels while the least values were observed at 0% (29.87%) and 2.5% (35.12%). Total protein at 2.5% (6.16mg/dl) was higher ($P<0.05$) higher than the other inclusion levels while the other inclusion levels were comparable at the same level of significance.

Table 4.11: Main effects of inclusion levels of Shea-nut cake on serum metabolites of Yankasa rams *D. smutsii* hay basal diet

	Shea-nut Cake inclusion levels (%)				
Parameters	0	2.5	5	7.5	SEM
Serum Urea (mg/dl)	18.92 [b]	25.47 [b]	24.91 [b]	33.36 [a]	3.43*
Serum Creatinine (mg/dl)	2.05 [a]	1.68 [ab]	1.57 [ab]	1.36 [b]	0.27*
Serum Glucose (mg/dl)	29.87 [b]	35.12 [b]	41.58 [a]	40.25 [ab]	3.04*
Total protein(Mg/dl)	4.62 [b]	6.16 [a]	5.07 [b]	5.18 [b]	0.44*

[abc]*Means with different superscripts within rows differed significantly (P<0.05), SEM = Standard Error of Means

4.12 Main effects of feeding frequencies of feeding concentrates containing Shea-nut cake on serum metabolites of Yankasa rams fed *D. smutsii* hay basal diet.

Table 4.12 shows the effects of feeding frequencies of feeding concentrates containing Shea-nut cake on serum metabolites of Yankasa rams fed *D. smutsii* hay basal diet. It was observed from the trial that none of the parameters analyzed were significantly ($P<0.05$) influenced by feeding frequency. However, the daily feeding frequency had numerically higher values than the skip-a-day feeding frequencies in serum urea, serum creatinine and serum glucose.

Table 4.12: Main effects of feeding frequencies of Shea-nut cake on serum metabolites of Yankasa rams *D. smutsii* hay basal diet

	Feeding frequency		
Parameters	Daily feeding	Skip-a-day	SEM
Serum Urea (mg/dl)	25.84	25.48	4.86
Serum Creatinine (mg/dl)	1.70	1.63	0.39
Serum Glucose (mg/dl)	37.82	35.59	4.30
Total protein(mg/dl)	5.24	5.27	0.62

SEM = Standard Error of Means

4.13 Interaction effects of inclusion level and feeding frequencies of feeding concentrates containing Shea-nut cake on serum metabolites of Yankasa rams fed *D. smutsii* hay basal diet.

Table 4.13 shows the interaction effects of inclusion level and feeding frequencies of feeding concentrates containing Shea-nut cake on serum metabolites of Yankasa rams fed *D. smutsii* hay basal diet. All parameters analyzed were significantly ($P<0.05$) influenced as the inclusion level interacted with feeding frequency. The concentration of serum urea was significantly ($P<0.05$) higher (38.89%) as 7.5% inclusion level interacted with skip-a-day feeding while the least value of 13.83% was observed when 0% inclusion interacted with skip-a-day feeding frequency. Serum creatinine had values ranging from 1.05mg/dl as 5% inclusion interacted with skip-a-day feeding to 2.73 mg/dl when 2.5% inclusion interacted with skip-a-day feeding.

Serum glucose had a range of 27.87mg/dl (5% inclusion interaction with skip-a-day feeding) to 42.90mg/dl (7.5% inclusion interaction with skip-a-day feeding). The values for Total protein varied from 7.14mg/dl as 5% inclusion interacted with skip-a-day feeding to 4.17mg/dl as 2.5% inclusion interacted with skip-a-day feeding.

Table 4.13: Interaction effects of inclusion level and feeding frequencies of Shea-nut cake on serum metabolites of Yankasa rams fed *D. smutsii* hay basal diet

	Shea-nut Cake inclusion levels/Feeding Frequency								
	0%		2.5%		5%		7.5%		
Parameters	Daily	Skip-a-day	Daily	Skip-a-day	Daily	Skip-a-day	Daily	Skip-a-day	SEM
Serum Urea (mg/dl)	24.00 ^{c}	13.83 ^{d}	29.08 ^{b}	21.85 ^{c}	22.47 ^{c}	27.35^{bc}	27.82^{bc}	38.89 ^{a}	2.43*
Serum Creatinine (mg/dl)	1.36 ^{cd}	2.73 ^{a}	2.31 ^{b}	1.05 ^{d}	1.57 ^{c}	1.57 ^{c}	1.57 ^{c}	1.15 ^{d}	0.19*
Serum Glucose (mg/dl)	28.42 ^{b}	31.32 ^{b}	42.37 ^{a}	27.87 ^{b}	40.26 ^{a}	42.90 ^{a}	40.23 ^{a}	40.26 ^{a}	2.15*
Total protein(mg/dl)	5.06 ^{c}	4.17 ^{d}	5.18^{bc}	7.14 ^{a}	5.74 ^{b}	4.39 ^{d}	4.98 ^{c}	5.38^{bc}	0.31*

^{abcd}*Means with different superscripts within rows differed significantly (P<0.05), SEM = Standard Error of Means

4.14 Main effects of inclusion levels of feeding concentrates containing Shea-nut cake on haematological changes of Yankasa rams fed *D. smutsii* hay basal diet.

Table 4.14 shows the effects of inclusion levels of feeding concentrates containing Shea-nut cake on haematological changes of Yankasa rams fed *D. smutsii* hay basal diet. All the parameters were influenced by the inclusion level. White Blood Cell (WBC) had a progressive but significant ($P<0.05$) decrease in value as the inclusion level increased from 0% inclusion level (6.65×10^9/uL) to 7.5% inclusion level (4.11×10^9/uL). The same trend was observed for Neutrophils.

The monocytes observed at 7.5% inclusion level were higher significantly ($P<0.05$) than the other inclusion levels, while 0, 2.5 and 5% inclusion levels were statistically ($P<0.05$) similar. Packed Cell Volume was significantly higher at 7.5% inclusion level and ranged from 26.50% to 31.00%. Red Blood Cells ranged from 5.28×10^6/uL to 7.32×10^6/uL and the 0% inclusion level was significantly lower than the inclusion levels containing Shea-nut cake. Haemoglobin decreased from the 0% inclusion level to 7.5% inclusion level and ranged from 6.00g/dl to 7.15g/dl. Mean Corpuscular Volume ranged from 37.95fL to 50.20fL. Mean Corpuscular Haemoglobin (MCH) and Mean Corpuscular Haemoglobin Concentration (MCHC) were both significantly ($P<0.05$) higher at 0% inclusion level (13.5pg and 26.90g/dl respectively) than other inclusion levels which were statistically ($P<0.05$) similar. The 7.5% inclusion level had the lowest platelets count and the values ranged from ranged from 452.30^{10^3}/uL to 548.95^{10^3}/uL.

Table 4.14: Main effects of inclusion levels of Shea-nut cake on haematological changes of Yankasa rams fed *D. smutsii* hay basal diet

	Shea-nut Cake inclusion levels (%)				
Parameters	0	2.5	5	7.5	SEM
WBC (10^9/uL)	6.65 [a]	5.25 [ab]	5.50 [ab]	4.11 [b]	1.13*
Neutrophils (%)	54.00 [a]	38.00 [ab]	37.00 [ab]	30.00 [b]	8.79*
Lymphocytes (%)	45.50 [b]	60.00 [ab]	61.00 [ab]	63.50 [a]	8.12*
Monocytes (%)	0.50 [b]	2.00 [b]	1.50 [b]	6.50 [a]	1.20*
Eosinophils(%)	0.00 [b]	0.00 [b]	0.50 [a]	0.00 [b]	0.17*
PCV (%)	26.50 [b]	29.00 [ab]	27.00 [b]	31.00 [a]	1.20*
RBC (10^6/uL)	5.28 [b]	6.95 [a]	7.32 [a]	6.36 [ab]	0.65*
Haemoglobin (g/dL)	7.15 [a]	6.30 [ab]	6.00 [b]	6.20 [b]	0.45*
MCV (fL)	50.20 [a]	44.50 [ab]	37.95 [b]	49.05 [a]	4.51*
MCH (pg)	13.50 [a]	9.20 [b]	8.20 [b]	10.00 [b]	1.24*
MCHC (g/dL)	26.90 [a]	22.00 [b]	22.30 [b]	20.20 [b]	2.21*
Platelets (10^3/uL)	548.95 [a]	494.50 [ab]	533.90 [a]	452.30 [b]	37.10*

[ab]*Means with different superscripts within rows differed significantly (P<0.05), SEM = Standard Error of Means, WBC = White Blood Cell, PCV = Packed Cell Volume, RBC = Red Blood Cell, MCV = Mean Corpuscular Volume, MCH = Mean Corpuscular Haemoglobin, MCHC = Mean Corpuscular Haemoglobin Concentration

4.15 Main effects of feeding frequencies of feeding concentrates containing Shea-nut cake on haematological changes of Yankasa rams fed *D. smutsii* hay basal diet.

Table 4.15 shows the effects of feeding frequencies of feeding concentrates containing Shea-nut cake on haematological changes of Yankasa rams fed *D. smutsii* hay basal diet. White Blood Cell (WBC) was significantly ($P<0.05$) affected by feeding frequency. The WBC in daily feeding frequency (3.78×10^9/uL) was significantly ($P<0.05$) lower than the skip-a-day feeding frequency (6.98×10^9/uL). The other parameters showed no significant ($P<0.05$) differences. However, skip-a-day feeding frequency was numerically higher for Lymphocytes, Monocytes, Eosinophils, Haemoglobin, MCH, and MCHC, while the skip-a-day feeding frequency was numerically higher for Neutrophils, PCV, RBC, MCV, and Platelets.

Table 4.15: Main effects of feeding frequencies of Shea-nut cake on haematological changes of Yankasa rams fed *D. smutsii* hay basal diet

	Feeding frequency		
Parameters	Daily feeding	Skip-a-day	SEM
WBC (10^9/uL)	3.78 [b]	6.98 [a]	1.59*
Neutrophils (%)	28.50	51.00	12.44
Lymphocytes (%)	68.25	46.75	11.49
Monocytes (%)	3.00	2.25	1.69
Eosinophils(%)	0.25	0.00	0.24
PCV (%)	27.50	29.25	1.69
RBC (10^6/uL)	6.38	6.57	0.92
Haemoglobin (g/dL)	6.45	6.38	0.64
MCV (fL)	44.55	46.30	6.38
MCH (pg)	10.38	10.08	1.75
MCHC (g/dL)	23.45	22.25	3.12
Platelets (10^3/uL)	488.78	526.05	52.46

[ab]*Means with different superscripts within rows differed significantly (P<0.05), SEM = Standard Error of Means, WBC = White Blood Cell, PCV = Packed Cell Volume, RBC = Red Blood Cell, MCV = Mean Corpuscular Volume, MCH = Mean Corpuscular Haemoglobin, MCHC = Mean Corpuscular Haemoglobin Concentration

4.16 Interaction effects of inclusion level and feeding frequencies of feeding concentrates containing Shea-nut cake on haematological changes of Yankasa rams fed *D. smutsii* hay basal diet.

Table 4.16 shows the interaction effects of inclusion level and feeding frequencies of feeding concentrates containing Shea-nut cake on haematological changes of Yankasa rams fed *D. smutsii* hay basal diet. All parameters analyzed were significantly ($P<0.05$) influenced as the inclusion level interacted with feeding frequency. The interaction between feeding frequency and inclusion level was significantly ($P<0.05$) higher at 0% inclusion level and skip-a-day feeding frequency for WBC, Neutrophils, Haemoglobin, MCH, MCHC and Platelets. The interaction between frequency and inclusion level was significantly ($P<0.05$) lower than others at 0% inclusion level and skip-a-day feeding frequency for Lymphocytes and Monocytes. The Packed Cell Volume was significantly ($P<0.05$) higher as 7.5% inclusion interacted with skip-a-day feeding with a value of 33.00%.

Table 4.16: Interaction effects of inclusion level and feeding frequencies of Shea-nut cake on haematological changes of Yankasa rams fed *D. smutsii* hay basal diet

Parameters	Shea-nut Cake inclusion levels/Feeding Frequency								SEM
	0%		2.5%		5%		7.5%		
	Daily	Skip-a-day	Daily	Skip-a-day	Daily	Skip-a-day	Daily	Skip-a-day	
WBC (10^9/uL)	4.20^{bc}	9.10^{a}	5.10^{b}	5.40^{b}	2.40^{c}	8.60^{a}	3.40^{c}	4.80^{bc}	0.80*
Neutrophils (%)	32.00^{cd}	76.00^{a}	42.00^{bc}	34.00^{c}	21.00^{d}	53.00^{b}	19.00^{d}	41.00^{bc}	6.22*
Lymphocytes (%)	67.00^{ab}	24.00^{d}	56.00^{bc}	64.00^{b}	76.00^{a}	46.00^{c}	74.00^{ab}	53.00^{bc}	5.74*
Monocytes (%)	01.00^{bc}	0.00^{c}	2.00^{b}	2.00^{b}	2.00^{b}	1.00^{bc}	7.00^{a}	6.00^{a}	0.85*
Eosinophils (%)	0.00^{b}	0.00^{b}	0.00^{b}	0.00^{b}	1.00^{a}	0.00^{b}	0.00^{b}	0.00^{b}	0.12*
PCV (%)5	26.00^{d}	27.00^{d}	27.00^{d}	31.00^{b}	28.00^{cd}	26.00^{d}	29.00^{c}	33.00^{a}	0.85*
RBC (10^6/uL)2.5	5.24^{c}	5.31^{c}	8.47^{a}	5.42^{c}	6.20^{bc}	8.43^{a}	5.60^{c}	7.12^{b}	0.46*
Haemoglobin (g/dL)	6.40^{c}	7.90^{a}	7.20^{b}	5.40^{d}	5.30^{d}	6.70^{bc}	6.90^{bc}	5.50^{d}	0.32*

MCV (fL)	49.60 [b]	50.80 [b]	31.80 [c]	57.20 [a]	45.10 [b]	30.80 [c]	51.70 [ab]	46.40 [b]	3.19*
MCH (pg)	12.20 [b]	14.80 [a]	8.50 [cd]	9.90 [c]	8.50 [cd]	7.90 [d]	12.30 [b]	7.70 [d]	0.88*
MCHC (g/dL)	24.60 [b]	29.20 [a]	26.60 [ab]	17.40 [c]	18.90 [c]	25.70 [b]	23.70 [b]	16.70 [c]	1.56*
Platelets (10^3/uL)	475.40 [c]	622.50 [a]	567.80 [b]	421.20 [d]	465.70 [cd]	602.10 [ab]	446.20 [cd]	458.40 [cd]	26.23*

[abcd]*Means with different superscripts within rows differed significantly (P<0.05), SEM = Standard Error of Means, WBC = White Blood Cell, PCV = Packed Cell Volume, RBC = Red Blood Cell, MCV = Mean Corpuscular Volume, MCH = Mean Corpuscular Haemoglobin, MCHC = Mean Corpuscular Haemoglobin Concentration

4.17 Main effects of inclusion levels of feeding concentrates containing shea nut cake on economics of production of Yankasa rams fed D. smutsii hay basal diet

Table 4.17 shows the effects of inclusion levels of feeding concentrates containing Shea-nut cake on economic analysis of Yankasa rams fed *D. smutsii* hay basal diet. Cost of Concentrate and Cost/gain were significantly (P<0.05) affected by the inclusion levels. The Cost of concentrate reduced as the inclusion levels increased from 0% (₦51.25) to 7.5% (₦48.20). The cost per gain of ₦592.52 at 5% was significantly higher (P<0.05) than the cost per gain of ₦542.48 at 7.5% inclusion level. Although the Total Feed Cost per Ram showed no significant (P<0.05) difference, the result showed the cost at 7.5% inclusion level to be numerically higher than the cost at the other inclusion levels.

Table 4.17: Main effects of inclusion levels of feeding concentrates containing shea nut cake on economics of production of Yankasa rams fed D. smutsii hay basal diet

Parameters	Shea-nut Cake inclusion levels (%)				SEM
	0	2.5	5	7.5	
Cost of conc. (₦/kg)	51.25 [a]	50.23 [ab]	49.22 [b]	48.20 [b]	0.58*
Total conc. intake(kg)	26.45	25.67	25.24	26.70	1.12
Cost of hay (₦/kg)	45.85	45.85	45.85	45.85	0.00
Total hay intake(kg)	23.47	25.49	24.39	26.29	4.13
Total Feed cost/ram(₦)	2430.97	2457.38	2359.63	2491.57	66.17
Live weight gain(kg)	4.32 [ab]	4.32 [ab]	3.99 [b]	4.69 [a]	0.29*
Cost/gain (₦)	570.57 [ab]	569.21 [ab]	592.52 [a]	542.48 [b]	24.95*

[ab]*Means with different superscripts within rows differed significantly (P<0.05), SEM = Standard Error of Means. Cost of concentrate = a; Total concentrate intake = b; Cost of Hay = c; Total Hay intake = d; Total feed cost/ram = [(a * b) + (c * d)] ; Cost/gain(₦) = Total Feed Cost / Weight gain

4.18 Main effects of feeding frequencies of feeding concentrates containing shea nut cake on economics of production of Yankasa rams fed D. smutsii hay basal diet

Table 4.18 shows the effects of feeding frequencies of feeding concentrates containing Shea-nut cake on economic analysis of Yankasa rams fed *D. smutsii* hay basal diet. Total concentrate intake and total hay intake were significantly (P<0.05) affected by feeding frequencies. The daily feeding frequency had a significantly (P<0.05) higher total concentrate intake (34.74kg) while the skip-a-day feeding frequency had a significantly (P<0.05) higher total hay intake (32.81kg). Also, the daily feeding frequency had a numerically higher total feed cost per ram (₦2506.76) and a numerically lower cost per gain (₦539.23).

Main effects of feeding frequencies of feeding concentrates containing shea nut cake on economics of production of Yankasa rams fed D. smutsii hay basal diet

Parameters	Feeding frequency		SEM
	Daily feeding	Skip-a-day	
Cost of conc. (₦/kg)	49.73	49.73	0.82
Total conc. intake(kg)	34.74 [a]	17.29 [b]	6.86*
Cost of hay (₦/kg)	45.83	45.83	0.00
Total hay intake(kg)	17.01 [b]	32.81 [a]	5.84*
Total Feed cost/ram(₦)	2506.76	2363.02	93.59
Live weight gain(kg)	4.70	3.96	0.42
Cost/gain (₦)	539.23	598.16	35.28

[ab]*Means with different superscripts within rows differed significantly (P<0.05), SEM = Standard Error of Means. Cost of concentrate = a; Total concentrate intake = b; Cost of Hay = c; Total Hay intake = d; Total feed cost/ram = [(a * b) + (c * d)] ; Cost/gain = Total Feed Cost / Weight gain

4.19 Interaction effects of inclusion level and feeding frequency of shea nut cake on economic analysis of Yankasa rams fed D. smutsii hay basal diet

Table 4.19 shows the interaction effects of inclusion level and feeding frequencies of feeding concentrates containing Shea-nut cake on economic analysis of Yankasa rams fed *D. smutsii* hay basal diet. With the exception of the Cost of Hay, all the economic parameters analyzed were significantly ($P<0.05$) affected by the interaction. The cost of concentrate decreased progressively as the inclusion level increased. For each of the inclusion level 0% to 7.5%, the total concentrate intake was significantly ($P<0.05$) higher for daily feeding frequency than for skip-a-day feeding frequency. The reverse of this was observed for the total hay intake where the skip-a-day feeding frequency values were significantly ($P<0.05$) higher than the daily feeding frequency in the same inclusion level.

The interaction between skip-a-day feeding frequency and 0% inclusion was significantly ($P<0.05$) lower (₦2198.24) while the interaction between 0% inclusion and daily feeding frequency was significantly ($P<0.05$) higher (₦2663.69) than others. The least cost per gain of ₦468.30 was obtained as 7.5% inclusion interacted with daily feeding frequency while the highest cost per gain of ₦616.66 was obtained as 7.5% inclusion interacted with skip-a-day feeding.

Table 4.19: Interaction effects of inclusion level and feeding frequency of shea nut cake on economic analysis of Yankasa rams fed D. smutsii hay basal diet

	Shea-nut Cake inclusion levels/Feeding Frequency								
	0%		2.5%		5%		7.5%		
Parameters	Daily	Skip-a-day	Daily	Skip-a-day	Daily	Skip-a-day	Daily	Skip-a-day	SEM
Cost of conc. (₦/kg)	51.25 [a]	51.25 [a]	50.23 [b]	50.23 [b]	49.22 [c]	49.22 [c]	48.20 [d]	48.20 [d]	0.41*
Total conc. intake(kg)	36.03 [a]	16.87 [b]	34.05 [a]	17.29 [b]	33.11 [a]	17.36 [b]	35.74 [a]	17.65 [b]	3.43*
Cost of Hay (₦/kg)	45.83	45.83	45.83	45.83	45.83	45.83	45.83	45.83	0.00
Total Hay intake(kg)	17.83 [c]	29.10 [b]	17.19 [c]	33.78 [ab]	15.42 [c]	33.35 [ab]	17.59 [c]	34.99 [a]	2.92*
Total Feed cost/ram(₦)	2663.69 [a]	2198.24 [d]	2498.15[bc]	2416.61 [c]	2336.37 [c]	2382.89 [c]	2528.82 [b]	2454.32[bc]	46.79*
Live weight gain(kg)	5.07 [a]	3.57 [c]	4.24[bc]	4.40 [b]	4.07[bc]	3.90 [c]	5.40 [a]	3.98[bc]	0.21*
Cost/gain (₦)	525.38 [c]	615.75 [a]	589.19 [a]	549.23[bc]	574.04 [b]	611.00 [a]	468.30 [d]	616.66 [a]	17.64*

[abcd]*Means with different superscripts within rows differed significantly (P<0.05), SEM = Standard Error of Means. Cost of concentrate = a; Total concentrate intake = b; Cost of Hay = c; Total Hay intake = d; Total feed cost/ram = [(a * b) + (c * d)] ;

Cost/gain = Total Feed Cost / Weight gain

CHAPTER FIVE

5.0 DISCUSSION

5.1 Chemical composition of supplementary diets, Shea nut cake and *Digitaria smutsii* hay

The chemical composition of *Digitaria smutsii* offered as basal diet was comparable to values earlier reported by Yashim (2014). The chemical composit-ion of Shea-nut cake obtained in this study for Dry matter, CP, Ether extract and Ash were similar to the values obtained by Dei *et al.* (2007) for traditionally extracted shea cake. The CP content of 11.4% obtained in this study was slightly higher than the value of 10.3% reported by Dei *et al.* (2007) but lower than 12.24% (Adam *et al.,* 2015) and 15.02% (Belewu *et al.,* 2004) for locally processed Shea-nut cake. The Ether extract of 3.19% obtained was however very much lower than the 28.79 percent obtained by Adam *et al.* (2015). The CP and EE of the shea-nut cake used in this study were similar to that of shea-nut processed industrially even though it was obtained locally.

The Crude fibre and the fibre fractions obtained were lower than those reported by Oddoye *et al.* (2012). Shea-nut cake has been shown to vary in composition depending on whether extraction of fat was by an industrial (expeller and sometimes solvent) or traditional cottage industry method, with the industrial methods tending to be more efficient at fat extraction (Dei *et al*., 2007).

5.2 Voluntary feed intake and weight gain of Yankasa rams fed of *D. smutsii* hay basal diet

5.2.1 Main effects of inclusion level of Shea-nut cake on voluntary intake and weight gain of Yankasa rams fed *D. smutsii* hay basal diet

The inclusion level of Shea-nut cake in the diet had no effect on supplement intake. This disagrees with the results obtained by Yusuf *et al.* (2009) who reported an increase in supplement intake when Shea-nut fat were included in the diet of Yankasa rams. Belewu *et al.*

(2004) worked with goats and stated that the inclusion of Shea-nut cake could reduce intake due to its unpleasant taste. The increase in total feed intake with increase in the inclusion level observed in this study is in agreement with the findings of Konlan *et al.* (2012), who reported a higher feed intake with higher inclusion level of Shea-nut cake fed to West African Dwarf rams.

The higher total weight gained (4.069kg) and the average daily gain (51.11g) of the 7.5% inclusion level agrees with the report of Konlan *et al.* (2012). However, the average daily weight gained by the animals was much higher than those obtained when fed up to 23% inclusion and this difference could be due to the assertions of Belewu *et al.* (2004) that higher inclusion levels of Shea-nut cake above 7.5% could have a negative impact on growth and other related parameters.

5.2.2 Main effects of feeding frequency of Shea-nut cake on voluntary intake and weight gain of Yankasa rams fed *D. smutsii* hay basal diet

The animals on daily supplemental feeding had higher total dry matter intake and this agrees with Ayman *et al.* (2017) who worked with Nadji ram lambs and reported lower dry matter intake for the animals on restricted feeding. However, the findings disagree with the result obtained by Fadel (2004) who stated that intake of dry matter was not influenced by feeding frequency of protein supplement. Yashim (2015) reported a higher total dry matter intake at skip-a-day feeding frequency when *Ficus sycomorus* leaf meal was fed to Yankasa rams.

Feeding frequencies did not significantly affect the total weight gain nor the average daily gain and this disagrees with Zali and Ganjkhanlou (2007) who concluded that increase of feeding frequency in varaminni ram lambs (fat tailed lambs) resulted in decreased fat reservoirs. It also disagrees with Yashim (2014) who obtained a higher ($P<0.05$) weight gain and the average daily gain for skip-a-day frequency when *Ficus sycomorus* leaf meal was fed to Yankasa sheep.

5.2.3 Interaction effects of inclusion level and feeding frequency of Shea-nut cake on voluntary intake and weight gain of Yankasa rams fed *D. smutsii* hay basal diet

The interaction between the inclusion level and feeding frequencies affected the feed intake of the animals. This agrees with the report by Robbles *et al.* (2007), who reported a change in dry matter intake of steers due to the interaction between inclusion level and feeding frequency leading to a higher weight gain. The observed effects of the interaction on the total weight gain in this study might be as a result of a change in the fermentation rate and the rumen environment affecting the growth parameters (Rotger *et al.*, 2006).

5.3 Nutrient digestibility by Yankasa rams fed of *D. smutsii* hay basal diet

5.3.1 Main effects of inclusion level of Shea-nut cake on nutrient digestibility of Yankasa rams fed *D. smutsii* hay basal diet

A significant ($P<0.05$) increase in percentage digestibility of DM, OM, CP, NFE, NDF and ADF with increased inclusion was observed in this study and the inclusion level at 7.5% was found to be higher than others for all parameters measured. Higher intake often leads to a faster rate of passage of ingested feed through the digestive tract of the animal and this could affect efficient degradation and hence the digestibility of feed (Swan and Lamming, 1967). Therefore, the higher digestibility observed at 7.5% inclusion level may not be due to its equally higher total dry matter intake. This result however agrees with the findings of Kumar *et al. (*2016) who reported higher nutrient digestibility for higher inclusion levels of Shea-nut cake up to 18.5%. It agrees with Konlan *et al. (*2012) who also reported that Shea-nut cake concentrate supplementation improved DM and CP digestibility of West African dwarf rams.

5.3.2 Main effects of feeding frequency of Shea-nut cake on nutrient digestibility of Yankasa rams fed *D. smutsii* hay basal diet

The percentage digestibility of crude protein and ether extract were influenced by the feeding frequencies and the animals on daily feeding frequency recorded a better digestibility of both nutrients. This corroborates earlier findings that higher feeding frequency led to a more stable rumen environment and thereby a more efficient digestion (Abouheif *et al.,* 2010). Greater frequency of feeding has been reported to have a positive impact on digestibility of DM, OM and CP due to increased number of protozoa (Weimer, 1998; Atkinson *et al.,* 2010).

5.3.3 Interaction effects of inclusion level and feeding frequency of Shea-nut cake on nutrient digestibility of Yankasa rams fed *D. smutsii* hay basal diet

There was a high level of interaction between inclusion level and feeding frequency which cut across all parameters measured. This finding is supported by earlier reports that a change in feed composition and frequency of feeding influences digestibility of nutrients in feed (Rotger *et al.,* 2006; Yashim, 2014). Cecava *et al.* (1990) however, observed a lack of interaction between energy level and feeding frequency in their experiment on steers and attributed it to the level of DM intake and nature of the diets fed.

5.4 Nitrogen balance of Yankasa rams fed by *D. smutsii* hay basal diet

5.4.1 Main effects of inclusion level of Shea-nut cake on nitrogen balance of Yankasa rams fed *D. smutsii* hay basal diet

The similarity in nitrogen intake across all the treatments could indicate that the animals were able to obtain their required nourishment from all of the treatments. Likewise, the similar nitrogen retained could mean that similar amount of nitrogen was supplied to the animals by each of the treatment due to the iso-nitrogenous nature of the diet. These findings disagree with

the result obtained by Yousuf *et al.* (2014) who reported that urinary nitrogen excretion was reduced in goats placed on shea butter leaf extracts treatments, when compared with the control group and resulted in higher nitrogen retention. The highest nitrogen retention and percent nitrogen retention in the animals fed at 7.5% inclusion could however be attributed to better synchrony of dietary protein and energy than in other treatments (Longo *et. al.*, 2008).

The 7.5% inclusion level had higher urinary nitrogen output than others and this could be due to the protective influence of the increased levels of tannins in the diet on dietary protein, thereby encouraging the escape rate from rumen microbial fermentation (Yousuf *et. al.*, 2014). The range of nitrogen retained as percentage of intake obtained in this study was similar to the range of 44.9-63.59% reported by Lakpini *et al.* (2015) for Yankasa rams.

5.4.2 Main effects of feeding frequency on of Shea-nut cake nitrogen balance of Yankasa rams fed *D. smutsii* hay basal diet

The higher nitrogen intake and nitrogen retained in the daily feeding frequency is directly attributable to the higher CP in the diets of the animals due to daily supplementation. The lower percentage of nitrogen retained as percentage of intake observed in the skip-a-day feeding frequency could be due to poor synchrony of dietary protein and energy (Longo *et. al.*, 2008) due to lower protein supplementation. Bunting *et al.* (1987) observed that although nitrogen retention was not affected by feeding frequency in wether lambs, increased feeding frequency decreased mean ruminal ammonia-N concentrations. They also noted that both the quantity of total nitrogen reaching the abomasum and the efficiency of microbial crude protein synthesis tended to increase with increased feeding frequency. Fadel (2004) also reported that urinary nitrogen excretion was lower and nitrogen retention was higher in sheep offered supplemental protein twice a day when compared to those on single supplementation.

5.4.3 Interaction effects of inclusion level and feeding frequency of Shea-nut cake on nitrogen balance of Yankasa rams fed *D. smutsii* hay basal diet

Nitrogen balance was higher in animals on daily feeding frequency higher than the animals on skip-a-day feeding frequency for the four inclusion levels in all parameters measured. This may likely be to the fact that the animals on daily supplementation had higher nitrogen intake due to higher frequency of supplementation regardless of the inclusion level. This higher level of nitrogen intake consequently affected the nitrogen retention and nitrogen retained as percentage of intake. In contrast, Yashim (2014) reported an increase in nitrogen intake as the feeding frequency reduces from daily to skip-a-day feeding.

5.5 Serum metabolites of Yankasa rams fed of *D. smutsii* hay basal diet

5.5.1 Main effects of inclusion level of Shea-nut cake on serum metabolites of Yankasa rams fed *D. smutsii* hay basal diet.

The serum urea levels in the Yankasa rams fed at different inclusion levels of Shea-nut cake were within the normal range of 10-35 mg/dl (Radostits *et al.,* 2000). The 7.5% inclusion had higher concentration of urea and this suggests an increase in microbial degradation due to increased protein supplied to the rumen, since serum urea level is an indication of effective rumen degradable protein in the diet (Finangwai, 2014). All but one of the inclusion levels (0%) were within the normal range of 5.0-12.3 g/dl for serum protein (Jawasreh *et al.,* 2010) and 1.2-1.9 mg/dl for serum creatinine (Radostits *et al.,* 2000) reported for sheep. The above normal serum creatinine value in 0% inclusion could be due to the level of energy in the feed. Low energy significantly increases serum creatinine above normal range (Bakshi *et al.,* 1997). High creatinine is indicative of poor protein and amino acid metabolism that can lead to impaired renal function and death of cardiac tissue (Gray and Howorth, 1980). The values of serum glucose at

all the inclusion levels fell below the normal range for serum glucose. This could be due to the poor digestibility of NFE obtained in all the inclusion levels, which had by far the least digestibility among all the proximate fractions. Nayawo *et al.* (2017) suggested that the increase in serum glucose in rams fed diets containing urea treated rice straw could be as a result of increased intake of soluble carbohydrate leading to increase in the level of blood glucose. Abd El Latif (2003) also indicated that values of blood glucose concentration in growing Friesian calves were correlated with energy in the diets.

This study disagrees in part with the result obtained by Konlan *et al.* (2012) because all the indices were affected whereas Konlan *et al.* (2012) reported that supplementation with Shea-nut cake did not affect the serum biochemical indices (Serum creatinine, serum urea and serum glucose) of the rams except total protein and albumin, which two values were significantly high at the higher inclusion level.

5.5.2 Main effects of feeding frequency of Shea-nut cake on serum metabolites of Yankasa rams fed *D. smutsii* hay basal diet

All the serum parameters were within the normal range for healthy sheep except the serum glucose. There was no difference between the daily feeding frequency and the skip-a-day feeding frequency in any of the serum parameters. This would indicate that a lower frequency of protein supplementation had no negative impact on the serum parameters measured. Bakry *et al.* (2014) however reported that restricted feeding resulted in a significant increase in blood urea and a significant decrease in creatinine and total protein concentration in both Barki sheep and Baladi goats. Also, restricting the feeding of clinically healthy female adult Kacang breed of goats for four weeks resulted in a serum calcium and protein concentrations, but in an increase of serum creatinine and inorganic phosphate concentrations (Irkham *et al.,* 2016).

5.5.3 Interaction effects of inclusion level and feeding frequency of Shea-nut cake on serum metabolites of Yankasa rams fed *D. smutsii* hay basal diet

The interaction did not follow any particular pattern. It was generally observed that the skip-a-day feeding frequency had the significantly higher ($P<0.05$) values for urea (at 7.5%), creatinine (at 0%) and total protein (at 2.5%). The higher level of creatinine observed as 0% inclusion interacted with skip-a-day feeding could be a pointer to low energy and poor protein and amino acid metabolism (Bakshi *et al.,* 1997; Gray and Howorth, 1980). Higher level of urea as 7.5% inclusion interacted with skip-a-day feeding did not agree with the suggestion of Finangwai (2014) that serum urea level is linked to rumen degradable protein in the diet as the animals were fed at a reduced supplementation. The higher level of total protein at 2.5% inclusion and skip-a-day feeding may not be due to the effects of interaction but other factors that influence protein utilization such as age, breed and physiological state (Jain, 1993).

5.6 Haematological parameters of Yankasa rams fed *D. smutsii* hay basal diet

5.6.1 Main effects of inclusion level of Shea-nut cake on haematological parameters of Yankasa rams fed *D. smutsii* hay basal diet

The White Blood Cell (WBC) and WBC fractions, viz neutrophils, lymphocytes, eosinophils, and monocytes from all the treatments were within the range obtained by NseAbasi *et al*. (2014) and Fielder (2017) for healthy sheep. The Red Blood Cell was also normal for sheep with the exception of 0% inclusion level (5.28 X 10^6/uL) which was below the normal range. The low RBC counts recorded for the sheep at the 0% inclusion level could mean a higher susceptibility of the animals at 0% inclusion level to anemia-related disease conditions (Merck's Veterinary Manual, 2012).

Packed cell volume (PCV) concentration and platelet counts obtained in this study were within the normal range and the PCV range indicates that the animals did not suffer from anaemia or dehydration in any of the treatments (Aliyu *et al.,* 2012). The haemoglobin concentration was below the normal range reported by Njidda *et al.* (2014) for healthy sheep, but the MCV, MCH and MCHC were however all comparable to the normal ranges reported for healthy sheep by RAR (2009). This study largely agrees with the report of Kumar *et al.* (2016) who noticed that there was no significant difference observed between treatment groups and period of the experiment in all the blood biochemical parameters except for the platelet count, which were also in the normal range only. It is also supported by Konlan *et al.* (2012) that inclusion of Shea-nut cake in rams' concentrate diet did not influence haematological parameters.

5.6.2 Main effects of feeding frequency of Shea-nut cake on haematological parameters of Yankasa rams fed *D. smutsii* hay basal diet

The feeding frequencies affected none of the haematological parameters except the White Blood Cell (WBC) count. This contradicts earlier studies that concluded that restricted feeding affects haematological parameters. Bakry *et al.* (2014) reported that restricted diets showed a significant ($P<0.05$) decrease in hemoglobin, packed cell volume, RBC, and WBC counts in both sheep and goats. Ibrahim (2007) also reported decreased Haemoglobin due to low level of feeding in camels.

The daily feeding frequency had a lower WBC count compared to the skip-a-day frequency of feeding. Hamman (2001) however reported that WBC count of sheep in lower level feeding was lower than those in higher level feeding.

5.6.3 Interaction effects of inclusion level and feeding frequency of Shea-nut cake on haematological parameters of Yankasa rams fed *D. smutsii* hay basal diet

All the parameters measured differed significantly but in no obvious trend. The higher levels for White Blood Cells, haemoglobin and platelets by the 0% inclusion interaction with skip-a-day feeding however may not be due to the effects of the interaction. Blood count for WBC and haemoglobin has been noted to have a marked decrease in sheep on a restricted diet (Ibrahim, 2007; Bakry *et al.* 2014). The observation may however be tied to other factors such as environment, age, breed and physiological state (Jain, 1993).

5.7 Economic analysis of Yankasa rams fed D. smutsii hay basal diet

5.7.1 Main effects of inclusion levels of feeding concentrates containing shea nut cake on economics of production of Yankasa rams fed D. smutsii hay basal diet

The cost of concentrate per kilogram reduced as the inclusion level of Shea-nut cake increased and this is due to the lower cost per kilogram of Shea-nut cake. The 7.5% inclusion level yielded the most efficient cost per gain. This suggests that the cost of feed can be reduced by increasing the level of Shea-nut cake in concentrate diet. Other authors (Orogun *et al.*, 2015; Yusuf *et al.*, 2009) have also reported an increase in profitability due to an increased inclusion of shea butter cake or fat in feeding sheep as well as poultry.

5.7.2 Main effects of feeding frequencies of feeding concentrates containing shea nut cake on economics of production of Yankasa rams fed D. smutsii hay basal diet

The skip-a-day feeding frequency had a numerically lower total feed cost per ram while the daily feeding frequency had a numerically lower cost per gain, however, neither of these was significant ($P<0.05$). Although feeding frequency had no significant ($P<0.05$) effect on economic

benefits in this study, increasing the frequency of feeding have been shown to increase the cost of feeding ruminants (Komwihangilo and Mlela, 2012)

5.7.3 Interaction effects of inclusion level and feeding frequency of shea nut cake on economic analysis of Yankasa rams fed D. smutsii hay basal diet

The economic analysis showed a difference due to interaction. The interaction between the skip-a-day feeding frequency and the 0% inclusion level had the lowest total feed cost per ram. This is because the 0% diet had the highest cost of concentrate per kilogram, hence when fed at a reduced frequency (skip-a-day), it led to great reduction in feed cost. The interaction between the daily feeding frequency and the 7.5% inclusion level had the lowest cost per weight gain. This can be attributed to the cost of the concentrate diet at 7.5% (which was the least) and the sufficiency of the diet to meet the animals' requirement for weight gain irrespective of its lower cost.

CHAPTER SIX

6.0 SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1 Summary

The study was conducted to determine the effects of inclusion levels and feeding frequencies of Shea-nut cake in concentrate diets on the performance, blood parameters and economics of Yankasa rams fed *Digitaria smutsii* hay. Shea-nut cake is readily available and can be obtained at a very cheap rate. Proximate analysis of Shea-nut cake indicates a huge potential as a feed ingredient.

Twenty four Yankasa rams weighing an average of 16.4kg were used for the study. Four iso-nitrogenous concentrate diets containing 0, 2.5, 5 and 7.5% Shea-nut cake were formulated. Each inclusion level served as a treatment (T_1, T_2, T_3 and T_4 respectively). The experimental animals were randomly allotted to the four dietary treatments with six animals per treatment and three animals per feeding frequencies, in a 4x2 factorial arrangement in a completely randomized design.

The growth performance, nutrient digestibility, nitrogen balance, blood serum and haematological parameters were determined. The cost analysis was also carried out. The results showed that the inclusion levels, the feeding frequencies and the interaction between the inclusion levels and the feeding frequencies affected the parameters measured.

6.2 Conclusions

The following conclusions were drawn from the study:

- Inclusion of Shea-nut cake in concentrate diets up to 7.5% inclusion improved dry matter intake and weight gain.

- Feeding Yankasa rams supplements containing Shea-nut cake either daily or every other day resulted in similar weight gained.
- Feeding Shea-nut cake up to 7.5% inclusion boosted the digestibility of dry matter, organic matter, crude protein, nitrogen free extract and acid detergent fibre and led to an increase in the percentage of nitrogen retained in Yankasa rams.
- Daily supplementation of Yankasa rams resulted in better digestibility of crude protein and ether extract and a higher nitrogen retention than every other day supplementation
- Increasing the inclusion of Shea-nut cake in concentrate diets of Yankassa rams up to 7.5% led to a significant ($P<0.05$) decrease in serum creatinine which is a marked pointer to a better protein and energy metabolism.
- Feeding Yankasa rams protein supplements containing Shea-nut cake either daily or every other day had no effect on any of their serum and haematological indices except the White Blood Cells.
- Inclusion of Shea-nut cake in concentrate diets of Yankasa rams reduced the cost of concentrate and the cost/kg weight gained, with a 50.04 Naira reduction in cost/gain at 7.5% inclusion.

6.3 Recommendations

- Farmers can include Shea-nut cake up to 7.5% inclusion in concentrate diets without a negative impact on either feed intake or weight gain of their rams.
- Farmers can supplement their rams with concentrate diets containing Shea-nut cake in order to further reduce the cost of feeding.
- During periods of scarcity, farmers can supplement their rams with concentrate diets containing Shea-nut cake once in two days without a resultant loss in weight of the animals.

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