COMPARATIVE STUDY ON THE UTILIZATION OF GROUNDNUT HAULMS AND COWPEA HUSKS BY LACTATING RED SOKOTO DOES FED DIGITARIA SMUTSII BASAL DIET.

BY

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A THESIS SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES, AHMADU BELLO UNIVERSITY, ZARIA IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF A MASTER DEGREE IN ANIMAL SCIENCE.

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DECLARATION

I declare that the work in the dissertation entitled "Comparative study on the utilization of Groundnut haulms and Cowpea husks by lactating Red Sokoto does fed *Digitaria smutsii* basal diet" has been performed by me in the Department of Animal Science under the supervision of Professor C.A.M Lakpini and Dr. (Mrs) G.E. Jokthan. The information derived from the literature has been duly acknowledged in the text. No part of this Research work has previously been presented for another degree at any university.

Name of student	**Signature**	**Date**

CERTIFICATION

This Thesis entitled "Comparative study on the utilization of groundnut haulms and cowpea husks by lactating Red Sokoto Does fed *Digitaria smutsii* basal diet" by Jonathan Nuwam, meets the regulations governing the award of the degree of Masters in Animal Science, Ahmadu Bello University Zaria and is approved for its contribution to acknowledge the literacy presentation.

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DEDICATION

This Thesis is dedicated to my late parents, Mr. and Mrs. Nuwamshong Baidi and my late siblings, Pascalina Peter, Barrister David Baidi and Grace Baidi. May God give them eternal life.

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My profound gratitude and appreciation goes to my humble supervisor, Professor C.A.M Lakpini for his suggestions, guidance and valuable contributions since the commencement of this study. I wish to also sincerely thank Dr. (Mrs) G.E. Jokthan for her contributions towards ensuring that this work comes out with good quality. Her constructive critism of the draft dissertation, have no doubt enriched the quality of this study. I am grateful to Dr S.B. Abdu for taking time out of his tight schedule to analyse my data which in no small measure contributed immensely to the success of this work. I wish to recognize Professor C.U Osuhor for the assiduous vetting of the draft of this dissertation. I also wish to appreciate Dr. S. M. Yashim and Dr. M. R. Hassan for their contributions and suggestions to this study.

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ABSTRACT

The efficacy, acceptability and utilization of groundnut haulms (GH) and cowpea husks (CH) as feed resources for Red Sokoto does (RSD) were investigated. The experiment, in a randomized complete block design involved growth and digestibility trials using twenty pregnant RSD in their last trimester and twelve Red Sokoto bucks (RSB) for the respective trials. The RSD (average liveweight, 27.52± 1.74kg) were aged 2-3 years old while, the RSB (average liveweight, 19.84± 1.4kg) were aged 1½ year old. The trials were used to determine voluntary feed intake, nutrient digestibility and nitrogen balance, milk yield, milk composition and weight gain. There were four treatment groups and both trials lasted for 90 and 21 days respectively. Diet 1, the conventional concentrate diet, cotton seed cake (CSC) was used as control. Diets 2 (GH), 3 (CH), and 4 (GH+CH) were the crop residue test diets. Each of the supplementation diet was fed at 1.8% of body weight (BWT). *Digitaria smutsii* hay was fed at 2.7% BWT. There was no significant ($P>0.05$) difference in dry matter and crude protein intake while, nutrient digestibility and nitrogen balance were statistically ($P>0.05$) similar across treatments. The results of the experiment showed that supplementation significantly ($P<0.05$) influenced milk yield and weight gain of dams and kids. Results also indicated that stage of lactation significantly ($P<0.05$) influenced moisture and total solid constituents of milk. Stage of lactation did not significantly influenced ($P>0.05$) milk fat, milk protein, solids-not-fat and lactose in goat milk. It was concluded that supplementation with GH, CH or GH+CH enhanced the intake of dry matter and crude protein, milk yield and weight gain of Red Sokoto goats. Combination of GH+CH gave better performance and reduce cost of production.

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CHAPTER ONE

1.0 INTRODUCTION

Livestock play a very important role in Nigerian agriculture contributing about 10144×10^3 metric tones to the world milk production (FAO, 1996). The livestock population comprises about 14 million cattle, 34 million goats, 22 million sheep and about 100 million poultry (FAO, 1996). The Red Sokoto , is the most important goat breed in Nigeria, accounting for about 70% of the estimated 34.5 million goats in Nigeria (Osuhor *et al.,* 1998). The livestock sub-sector is dominated by traditional systems of production, processing and marketing. Transhumance pastoralists in the north of the country rear a very high proportion of the cattle herd and many sheep and goats.

The two major problems facing small ruminant production are nutrition and health. Energy and protein supplies are the essential components in animal nutrition and, in many tropical countries (Nigeria inclusive), these components are often the critical limiting factors to ruminant production. Feed resources for ruminants are mainly from native rangelands complemented by crop residues from farmlands after harvest.

Crop residues are important ruminant feed in most parts of the sub-humid zone (Alhassan 1989). About 50 million tones of crop residues are available annually from the seven major crops in Nigeria (Alhassan and Buvanendran 1985). Despite their availability in large quantities, they are high in ligno cellulose and low in readily available carbohydrate and nitrogen (Leng, 1990). The utilization of crop residues depends largely on their nutritive values, method of processing, feeding strategies and eating behaviour of the animal. There is need therefore, to search for better methods and

optimal level of utilization of stored crop residues. Cowpea husks and groundnut haulms are used as supplements in animal production (Manyuchi *et al*., 1997; Savadogo *et al*., 2000).

Groundnut haulms are generally used to fatten animals in Northern Nigeria (Adu and Lakpini, 1983[b]). Several experiments with sheep and goats have shown that performance can be improved by protein supplementation (Mtenga and Nyaky, 1985; Mtenga and Kitaly, 1990). However, most of the supplements used such as cotton seed cake, groundnut cake and fish meal are expensive and not easy to come by. Crop residues such as cowpea husks and groundnut haulms offer cheap alternative sources of protein supplementation. The main by-products from cowpea are remnant of cowpea harvest such as cowpea shell and cowpea haulms. The by-products from groundnuts include groundnut haulms, groundnut cake and groundnut shell. Information on the feeding value of cowpea by-products and groundnut by-products by lactating Red Sokoto does is limited.

Ruminant livestock production could be increased substantially if more efficient feeding strategies can be introduced. Adequate feed resources are potentially available, and so the challenge before animal nutritionist is how to improve their utilization and hence help small holder farmers solve their feed problems.

1.1 Justification

The problem of poor genetic potential of the indigenous animals, high cost of conventional livestock feed and the problem of long dry season resulting in seasonal

scarcity and uneven distribution of good quality forage are constraints to milk production in the tropics.

Dry season also presents the major stress in terms of nutrition. The available grass in the range is poor in quality and quantity and cannot provide sufficient crude protein and energy for maintenance and production. The consequences of these are low milk yield, weight loss, low resistance to diseases, high mortality and anoestrus. A greater sustainability is produced by better feeding.

This informed the use of proteins from plant origin such as groundnut cake, soyabean meal, palm kernel meal and also the use of proteins from animal sources such as fish meal supplements for livestock feeding. But these feedstuffs are expensive and not readily available. The situation is worsened by the direct competition which exists between man and livestock for energy concentrates in most parts of the tropics. Genetic improvement alone might not result in drastic increases in milk production in the tropics but, it is a prerequisite.

In order to overcome these problems, supplementation with legume-rich residues offers cheap sources of dietary protein and better feeding strategy in the dry season can reduce weight losses, increase milk yield and help to prevent nutritional anoestrus (Bayer, 1986; Mani, 1986). It would therefore be appropriate to produce a late maturing high fodder yielding legume in the wet season and conserve the tops to feed animals as supplements. This is towards establishing feeding systems based on the use of these cheaper and more readily available feed resources for maximum returns in ruminants.

1.2 Objectives of the study

1. To determine growth response and lactation performance of Red Sokoto does (RSD), fed groundnut haulms and /or cowpea husks as supplements.
2. To compare the cost effectiveness of feeding cowpea husks and/or groundnut haulms as alternative sources of protein supplement to cottonseed cake for lactating Red Sokoto does.

1.3 Hypothesis

H_A: There is significant difference between the effects of cotton seed cake and groundnut haulms, cowpea husks or groundnut haulms + cowpea husks supplementation on milk yield and weight gain of Red Sokoto goats.

H_0: There is no significant difference in the effects of cotton seed cake and groundnut haulms, cowpea husks or groundnut haulms + cowpea husks supplementation on milk yield and weight gain of Red Sokoto goats.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 The Place of Goats in the World Economy

Goats are kept in most countries of the world for meat, hides, fibre and milk production. It was estimated that in 1985 there were 485 million goats globally and that goat milk production totaled eight million tones. Of the total world population of goats, 94 percent are said to be found in developing countries, supplying 73 percent of the milk produced by goats (FAO,1990). Tropical Africa contains one-third of the world's goats, but "they have been neglected politically and scientifically" (Mathewman, 1995). In most circumstances goats are kept in small herds by poor people and may run with other animals such as sheep or cattle. They contribute a significant amount to the daily welfare of the very poor, like the 123 million landless poor of India. They are seldom kept for one type of production alone. For example, they may be mainly kept for meat production, but higher-yielding goats may be milked as the opportunity arises on a seasonal basis (Mathewman, 1995).

Leather production from goats has become a major industry in India and other Asian countries in recent years. Cashmere production is a significant contributor to small-farmer income in China. Mohair production is important for commercial farmers in south Africa. However, most production from goats is utilized in the small farm context, where its impact and value is often not measurable (Mathewman, 1995).

Variability in body size and in geographic distribution among breeds of goats exceeds that of any other farm animal (Donkin, 1988). Goats are particularly well adapted to hot

climates (Singh and Ludri, 2002). They are often unfairly accused of causing environmental deterioration and even desertification, but they can form an important part in the ecology of rural areas and can even be used to control bush encroachment. Goats are usually not of specific breeds in the formal sense, although many types can be distinguished (Donkin, 1988). Some have a greater potential for milk production and are known to be kept primarily for this purpose (Gall, 1996).

Goats are usually kept extensively and this may mean that there are severe nutritional constraints on their ability to produce milk. Such constraints may also apply in urban or peri-urban areas where "town goats" are kept under circumstances that are most unfavourable, especially in terms of the adequacy of nutrition. Many different systems of keeping goats occur in different parts of the world, and they may be both appropriate and efficient. However, improvements in productivity may be achieved by simple changes in methods of management, nutrition, disease prevention and health care (Gall, 1996). Review of small holder goat production systems in Africa shown that most most people who keep dairy goats keep a few for household use; and the commercial producers, while they may have large numbers of goats in their herds, are relatively few in number (Wilson *et al.*, 1992).

The difficulties commercial goat producers face include the need to manage successfully the whole spectrum of production, processing and marketing. This is because there may be no co-operative ventures or State controls over goat milk production, comparable to those that apply to the cow milk industry. Commercial ventures are also faced with problems of organization, inadequate facilities, and in particular, labour requirements, as a result of the large number of goats required to ensure economic viability. In few cases

the dairy goats are the sole source of income for some families. It is apparent that most people who keep dairy goats do so for a household supply of milk, with perhaps a surplus sold locally as milk or cheese. In France there are more than 80 recognized varieties of goat cheese (Singh and Ludri, 2002).

2.2 The Value of Goat Milk

Goat milk varies in quality in a way similar to that of cow milk. For example, composition changes with breed, stage of lactation and feeding. If milk is produced unhygienically, it will affect its quality (Patton *et al.*, 2006). An example of the variability in compositional quality is given in Table 2.1.

Table 2.1 Variability in compositional quality of milk of different breeds of goats.

Country	**Breed**	**Total Solids (%)**	**Fat (%)**	**Protein (%)**	**Lactose (%)**
Australia	Saanen	12.24	4.01	3.10	4.93
Germany	Fawn	12.43	3.92	3.52	4.48
India	Barbari	-	4.11	3.76	4.80
Nigeria	Saanen	12.15	3.41	3.07	4.54
Nigeria	Red Sokoto	15.28	4.86	4.38	4.72
Nigeria	Dwarf	17.87	7.10	4.71	5.58
UK	(various)	13.2	4.5	2.9	4.1
USA	(various)	13.5	4.6	3.6	4.7

Source: Grummer,1991.

Comparisons of milk yield should be made in such a way as to take account of compositional quality. A system similar to the Fat Corrected Milk (FCM) procedure for dairy cows may be used (Grummer, 1991).

Analyses have been made of milk quality in Boergoats, and the mean milk fat and protein content were 7.7% and 4.3% respectively (Park *et al.,* 1986). Milk from goats on the milk recording scheme in South Africa and registered with the Breed Society (n = 263) had milk fat and protein contents of 3.1% and 2.65% respectively, for lactation yields of 981kg; milk from unregistered goats (n=281) had average contents of 3.4% and 2.53% respectively for lactation yields of 986kg (Park *et al*., 1986). Indigenous goats in first lactation averaged 8.89% milk fat and 5.36% protein, which was three and two times respectively the concentration in milk from Saanens kept under the same conditions (Donkin *et al*., 1990). Goat milk differs from cow milk in the amino acid content and composition of the proteins and therefore can have particular benefits in diets of children and adults who show sensitivity or allergic reactions to cow milk (Donkin, 1991). This is not to be confused with lactose intolerance reactions (Groenewald *et al.,*1995, Jandal,1996). Park (1991) reviewed the information available concerning the hypo-allergenic and therapeutic significance of goat milk. The incidence of allergy to cow milk in the United States is estimated at about 7% of children. Between 40% and 100% of patients allergic to cow milk proteins have been found to be tolerant to goat milk (Davison, *et al.,* 1991). Other advantages are the smaller fat globules, higher proportion of short and medium chain fatty acids and softer curd formation which are beneficial for digestibility and healthier lipid metabolism in comparison to cow milk. However, analyses indicate that one particular vitamin, folic acid, is deficient in goat milk (Jandal, 1996). Therefore, for infants relying on goat milk as the sole source of nutrients, a suitable supplement should be given to prevent anaemia (Davison *et al.,* 1991). There is some evidence of a greater bioavailability of iron in goat milk than in cow milk (Park *et*

al., 1986). In conclusion, it is clear that goat milk is a valuable source of nutrients and is in many ways comparable to cow milk. It is a potential resource that should be utilized.

2.3 The Place of Dairy Goats in Nigeria

In Nigeria goats are kept primarily for meat production or for mohair production and they are not a significant source of milk (Lamorde, 1998). There are probably only two or three thousand dairy goats of the recognized European breeds (Donkin and Armentano 1995).

In any developing country a major problem is always posed by the rapid increase of the population and the large proportion of people with small incomes. Improved medical facilities and primary health care reduce infant mortality and there is a massive increase in the proportion of children in the society. Mothers may reduce breast-feeding which can lead to a shorter interval between pregnancies. This may be as a result of lack of food in sufficient quantity, or as a result of lack of good quality food, or both, and has long-term consequences (Park, 1991). Milk is an ideal supplement to reduce any malnutrition (Davison *et al*., 1991).

Families may not be able to buy fresh milk or milk powder because of the cost or because it is not available. The obvious solution for people in rural areas is for them to increase milk production from animals that are already available. Dairy cows, as the traditional source of milk, are expensive, require elaborate feeding and management, and may produce more milk than required for the household. Beef cattle may be milked for the benefit of their owners, but yields are often so low that this will be to the detriment of the

calf. In addition, fertility levels may be such that a calf is born only every two or three years, and milk is only sporadically available.

A study in Kenya has shown that the introduction of dairy cows was only feasible when farmers had access to credit, health and nutrition technology, and that cows were not desirable for smallholder farmers. In contrast, dairy goats are more appropriate to the needs of subsistence production and their use would be in harmony with the concept of the household economy. Goats are cheaper; require less food; produce appropriate quantities of milk; breed at a younger age; have multiple births; are more easily handled by women and children, represent a smaller loss in the event of death; and produce a carcass of appropriate size for a household's needs (Devendra, 1996).

There is great potential for development of milk production from goats in the tropics (Sanz *et al.*, 1994), and Nigeria in particular. Projects for this purpose have already been established in recent years in countries like Kenya and Zimbabwe. In Kenya, Sanz *et al.*, (1994) have reported the difficulties and benefits of goat milk production monitored with 1300 farmers. In Malawi, research projects have been concerned with evaluating milk production from indigenous goat and crossbred goats. In Botswana, a survey has indicated that goat number have increased from 557, 000 to over 2 million between 1979 and 1990 (Sanz *et al.*, 1994). Goats are kept for milk as well as meat even though milk production is only about 400ml/day.

2.4 Factors affecting milk production in Goats

The term milk production may be described as the synthesis of milk constituents and their secretion by the alveoli into the alveolar lumen in association with water and mineral

elements derived directly from blood plasma. It includes also the transfer of milk from the alveolar fine ducts to cistern by the process of alveoli contraction known as milk ejection or let-down following stimulation of the teat. Milk yield on the other hand is the amount of milk removed from the cistern and teat canal by suckling or milking. Usually, not all the milk is removed. At least ten percent of the original volume of secreted milk is usually retained in the udder as residual milk (Akam *et al*., 1989) but quantity varies depending on the type of stimulus.

Milk production in mammals is under the influence of inherent factors and those factors external to the animals. The inherent factors are the genetic potential for milk secretion and the hormonal regulation of the development of the mammary gland, and of the initiation, establishment and persistence of lactation into the next breeding cycle (Dubey, 1992). External factors include diseases (e.g mastitis), the frequency and completeness of milk removal from the gland, climate conditions, diet and feeding management (Dubey, 1992).

2.4.0 Genetic Factors

2.4.1 Breed or Genotype

The breed of an animal has long been recognized as an important factor affecting the productivity and survival of the animal in a given environment (Morgan and Saul, 1981). Dillon *et al*., (2003) compared four different dairy cow breeds on a spring calving grass-based system of milk production and observed breed effect on milk production. The Dutch Holstein – Friesian breed significantly produced the highest yield of milk, the French Normandy produced the lowest while upgraded Irish Holstein Friesian and the

French Montbeliarde were intermediate. The review by Serradilla (2001) similarly shows breed effect on goat milk production with exotic breeds producing higher milk than the local breeds which had shorter lactation length. For example, in South Africa, while Saanen breed of goat produced 614kg of milk per lactation of 285 days, the local breed produced 23kg with a lactation length of 94 days. Serradilla (2001) also reported that the milk of the exotic breeds of goats contain less fat, protein and solid contents than that of the local breeds thus confirming the earlier observation by Mba *et al.* (1975) who compared the Nigerian indigenous breeds of goats, the Red Sokoto and WAD goats with the Saanen breed. Available information in literature indicate an inverse relationship between milk yield and milk fat content. Animals with high milk yield tend to have lower fat content and vice-versa (Oldenbroek, 1984; Dillon *et al*., 2003).

Sakul and Bovlan (1992) concluded from their evaluation of different sheep breeds for milk production in US that a better option to increase the milk production of the indigenous sheep breeds was to cross-breed with the dairy sheep breeds of Europe and Middle East rather than selection within the indigenous breeds over many generations. In Nigeria, NAPRI (1991) reported improved milk yield and lactation length in the indigenous Bunaji cows following cross breeding with the Friesian bulls. Kahi *et al*. (2000) in Kenya observed heterosis in F1 crossbreds between Sahiwal and Brown Swiss breeds. It has been discovered however, that heterosis for milk production seldom occurred but was frequently evident in birthweight and growth rate of animals (Hayman, 1972; Serradilla, 2001). For profit reasons, Kahi *et al*. (2000) stated that cross-breeding is being increasingly accepted and used for commercial beef and milk production in the tropics.

2.4.2 Age, Parity and Weight

Age and parity are factors usually evaluated for their effect on milk production. Several studies have shown that parity has significant effects on milk production. For example, Mourad (1992) found significant parity effect on milk yield of Alpine goats. Mourad (1986) cited by Mourad (1992) and Vij *et al*. (1993) also observed in goats and cattle that milk yield usually declined after reaching a maximum at the 5^{th} lactation. The separate studies by Ronningen (1967) cited by Mourad (1992) and Gall (1981) cited by Mourad (1992) on goats showed that the age effect is inseparable from the effect due to weight. While Ronningen (1967) as cited by Mourad (1992) concluded that the variation of milk yield was mainly due to age if weight was held constant, Gall (1981) cited by Mourad (1992) reported that if the age factor was held constant, body weight was the source of variation in milk yield with a regression coefficient of 4.76 units. Ehoche and Buvanendran (1983) concluded from their study on factors influencing milk yield in Red Sokoto does that the weight of the doe is the most important trait influencing milk yield and the subsequent kid growth. The authors posited that it was necessary to classify does by their weight at parturition to minimize experimental variation.

2.4.3 Stage of Lactation

Lactation is defined as the continuous secretion and storage of milk in the udder (Akam *et al*., 1989). Several workers have reported that stage of lactation significantly affects milk yield and composition (Casoli *et al*., 1989; Lal and Narayanan, 1993). Milk yield is highest in early lactation stage with the yield at this stage accounting for 50% of the total lactation yield. At the mid and late lactation the milk production is lower as the emphasis

on nutrient utilization is shifted from milk production to fat deposition and tissue growth (Rook and Thomas, 1983).

2.4.4 Hormonal Effects

Available reports showed that lactation and utilization of nutrients for lactation are under the influence of hormones. The role of prolactin in lactose synthesis has been documented (Kuhn, 1971; Singh and Ludri, 2002), and has been considered as a requirement along with growth hormone (GH) to establish lactation in goats (Singh and Ludri, 2002). During early lactation, GH (Bauman *et al.*, 1988), a major galactopoietic hormone in synergism with glucagons (a protein hormone) (Flakoll *et al.*, 1994: Donkin and Armentano, 1995) partition absorbed nutrients towards the mammary gland for milk synthesis. High levels of GH have been found to be associated with high levels of milk yield and non-estarified fatty acids (NEFA) (Reist *et al.*, 2003; Singh and Ludri, 2002). Glucagons stimulates hepatic gluconeogenesis, glycognenolysis, amino acid uptake and ureagenesis under condition of low energy intake and low blood glucose of early lactation (Flakoll *et al*., 1994; Donkin and Armentano, 1995; Bobe *et al*., 2003), while insulin actively partitions nutrients away from mammary gland towards body tissue during mid and late lactation which is associated with lower milk yield (Hart *et al*., 1978; Hart *et al*., 1979; Cowie *et al*., 1980).

The mammary teat is the most innervated of the gland. When it is stimulated either by suckling or milking, the neurohypophysis releases a hormone, oxytocin which by "ejection reflex" initiates milk let down by alveolar contraction. The concentration of oxytocin in blood increases within 1 to 2 minutes after udder stimulation. Stimuli such as

stress, fright and improper handling of animals have been reported to cause release of catecholamines (epinephrine and norepinephrine) which blocks the release of oxytocin or blocks the effect of oxytocin at mammary gland or both for milk let down (Lefcourt and Akers, 1984; Bruckmaier *et al*., 1997; Lefcourt *et al*., 1997).

2.5 External Factors Affecting Milk Production

Milk production traits are usually of low to moderate heritability, about 25-50%. Thus management and other factors external to the animal play important role in milk production (Otaru, 2009).

2.5.1 Frequency of Milking

Milk yield is dependent on the amount of secretory tissue and the rate of milk secretion (per unit of time) which in turn depends on milk removal from the lactating gland. According to Knight and Peaker (1984), Capuco et al. (2003) and Boutinaud *et al*. (2004) the maintenance of milk production and the shape of lactation curve depend primarily or ultimately on the number of mammary epithelial cells and the secretory activity of each cell. Studies have demonstrated that increase in frequency of milking is a good management tool to ensure lactation persistency (Henderson *et al*., 1985; Henderson and Peaker, 1987; Wilde *et al*., 1987; Wilde and Peaker, 1990; Peris *et al*., 1996; Peris *et al*., 1997). This is because increase in frequency of milking increases cell proliferation and differentiation (Wilde *et al*., 1987) and ultimately increases the number of secretory cells per lactating tissue (Wilde *et al*., 1987; Bencini *et al*., 2003). Feedback inhibitor of lactation (FIL) is a milk whey protein of -7kDa molecular weight (Wilde *et al*., 1995) produced in the alveoli and normally inhibits further synthesis and secretion of milk by

seretory cells of the alveoli when there is long milking interval during which milk accumulates in the udder (Knight and Peaker, 1984; Wilde *et al*., 1988).

The use of suckling plus frequent milking in early lactation has been found to increase both mammary cells proliferation and differentiation (Bar-Peled *et al*., 1995; Wilde *et al*., 1987) leading to sustained increase in milk yield in goats (Bar-Peled *et al.*, 1995). Even in mid and late lactation when some cells have become apoptotic (Knight and Peaker, 1984; Capuco *et al.*, 2003), increase in frequency of milking would produce higher milk yield provided there is better feeding and management (Wilde *et al*., 1987). However, increase in frequency of milking increases labour cost (Culotta and Schmidt, 1988) and delays early return to oestrus postpartum in cows in early lactation (Patton *et al*., 2006) and requires separation of kids or calves from their dams, a practice fraught with high mortality in the absence of adequate care for the young.

The cistern, the adjoining compartment to alveoli is, however, not affected by FIL and can store milk for longer interval (Wilde *et al*., 1995; Salama *et al*., 2003). The amount of milk stored in the cistern or the storage capacity of the cistern is determined by cisternal area reported to be positively correlated with parity (Rovai *et al*., 2002). Animals with large cisternal areas are milked faster with simplified routines, and are more tolerant of extended milking intervals (Knight and Dewhurst, 1994; Ayadi *et al*., 2003; Salama *et al*., 2003). Salama *et al.*, (2003) showed that primiparous goats milked once daily suffered greater losses (-30%) than older goats (-11%) milked at the same frequency. This has been attributed to the cisterns of primiparous goats which fill up sooner with autocrine feedback (Wilde and Peaker, 1990; Wilde *et al*., 1995; Salama *et al*., 2003; Salama *et al*., 2004).

2.5.2 Climatic Factors

Environmental factors which affect milk production include photoperiod, temperature, season and year.

2.5.3 Photoperiods

The galactopoietic effect of photoperiod has been reviewed (Dahl *et al*., 2000). Lactating dairy cows exposed to long-day photoperiods (16 to 18h of light) produce more milk and apparently had more persistent lactation than cows exposed to short-day of less than 12h light photoperiod. Available information indicates that the effect of photoperiods is mediated through systemic hormones, particularly prolactin, growth hormone and Insulin-like Growth Factor (IGF-1). Long-day photoperiod was associated with increases in secretion of IGF-1 which elicited high milk production response (Dahl *et al*., 1997). Studies (Hadsell *et al*., 1996; Dallard *et al*., 2005) have linked milk production response to the ability of IGF -1 to act as mammary mitogen and survival factor by regulating mammary epithelial cells proliferation and apoptosis. Tonner *et al*. (1995) cited by Capuco *et al*., (2003) suggested that the role of lactogenic hormones (Prolactin and growth hormone) was the suppression of the action of a binding protein (IGFBP-5) which binds to IGF-1 and enhances apoptosis by reducing the cell survival promoting activity of IGF-1 (Tonner *et al*., 1995 cited by Capuco *et al*., 2003).

2.5.4 Effect of Ambient Temperature

NRC (1981) reported that ambient temperatures above 25^{o}C affect feed intake and productivity. Tropical animals have, however, adapted to high ambient temperatures of the tropics. In Shika, Nigeria, milk yield by Freisian-Bunaji crosses declined sharply at

temperatures above 27^{o}C during early and mid-lactation (Alhassan and Buvanendran, 1985). In lactating cattle, for example, milk production and feed consumption are usually reduced in order to reduce body heat production. As reported by Hahn (1981), dairy animals are more susceptible to temperature rise than beef animals, and thus require more protection in terms of provision of shelter. A study by Barash *et al.*, (2001) on environmental effects on dairy cow production in the Mediterranean region (of 18-32^{o}C) shows that the daily yields of milk and milk protein were reduced by 0.38 and 0.01kg respectively per 10^{o}C rise in ambient temperature. Under the situation of heat-stress West (1999), Beede and Collier (1986) and Lu (1989) recommended that an increase in the nutrient concentration of the diet might be needed to counteract the reduction in nutrient intake to sustain productivity.

2.5.5 Interaction between Ambient Temperature and Type of Diet

Available information from several studies show that increase in nutrient concentration or not depends on the nature or type of the nutrient. For example, under higher environmental temperatures, Knapp and Grummer (1991) and Skaar et al. (1989) increased the concentrations of dietary fat and observed similar improvement in milk yield by reducing fibre concentration of diets fed to heat-stressed cows. The reports on milk yield response to varying concentration of crude protein in the diet of heat-stressed cows under 27-36^{o}C ambient temperature, have been conflicting (Hassan and Roussel 1975; Higginbotham *et al.*, 1989a,b, Taylor *et al*., 1998). What seems to have consistent effect is the proportion of rumen degradable protein (RDP) in the diet. NRC (2001) had recommended RDP concentration of 61 to 64% for cows not under heat stress. The study by Taylor *et al*., (1998), showed that milk yield, milk protein and body weight of mid

lactation cows under environmental temperatures of 36^{o}C were higher at 47% RDP compared with the those at 61%. Nianogo *et al*., (1991) conducted similar studies with cows in early lactation by reducing RDP per cent from 65 to 54, and observed body weight loss but little effect on milk yield. According to Higginbotham *et al*., (1989) excessive intake of RDP or CP can adversely affect milk production because the resulting energy expenditure for urea synthesis might reduce milk yield in cows.

2.5.6 Lactation Curve: Interaction between Inherent and Environmental Factors

Soysal *et al.,* (2004) defined lactation curves as graphs of daily milk yield against time (days of lactation). The shape of the curve is determined by the three major components of lactation curve. These components are time to peak yield, and persistency of lactation all of which are affected by intensity of selection and environmental factors. Peak period has been reported in lactation curves of some sheep and goats to be at 4th week of lactation (Ehoche and Buvanendran, 1983; Ruvuna *et al.,* 1994). Peralta-Lailson *et al.*, (2005) concluded that animals which have not been selected for milk production have no noticeable peak period. Earlier, Mandiki *et al.,* (1989) similarly stated that ewes that have not been selected have significant variation in body weight and udder morphology, cistern volume and changes in the autocrine control that regulates milk yield. Furthermore, Gutierrez and Blanco, (1996) cited by Peralta-Lailson *et al.,* (2005) observed that animals which have not been selected for milk production, have maximum production at the beginning of lactation, in fact, in the first day post-partum followed by decline in production.

Factors such as vegetation (Wahome *et al.,* 1994), season or year (Ruvuna *et al.,* 1995, Olorunju *et al.,*1994, Wahome *et al.,* 1994), parity (Wahome *et al.,* 1994, Olorunju *et al.,* 1994), littersize (Wahome *et al.,* 1994), age or weight of dam (Ruvuna *et al.,* 1995, Wahome *et al.,* 1994, Ehoche and Buvanendra 1983) and nutrition before and after parturition (Wilson *et al.,* 1971) on all or some of the components of lactation curve have been documented. This emphasizes the importance of developing good management practices or schemes to enhance milk production. Schemes such as increased milking frequency during first weeks of lactation, increased photoperiod, and good feeding which will improve maintenance of mammary cell numbers and persistency have been recommended (Capuco *et al.,* 2003).

2.6 Factors Associated with Feeds

Feed is the most important management factor that affects the productivity of farm animals. Inadequate and poor quality feeds will make it difficult for an animal to realize its genetic potentials for production in the form of fertility, growth rate or milk yield.

2.6.1 Quality of Feed

The quality of most commonly fed forages or roughage is characterized by either low energy or low protein density or both, and high level of fibre. There is thus a wide gap between the nutrient requirements of the animal for production and the levels of nutrient supplied by forages or roughages. Several studies have demonstrated that concentrate supplementation is required to complement forage nutrient supply, to enhance nutrient intake (Khalili *et al.,* 1994, Muinga *et al.,* 1995) and productivity in cattle (Khalili *et al.,* 1994, Muinga *et al.,* 1995), sheep (Ortega-Reyes *et al.,* 1992) and goats (Mba *et al.,*

1982, Ikhatua and Adu, 1984). Al Jassim *et al.*, (1999), fed graded levels (950, 1150 or 1350g per ewe daily) of concentrate to lactating Awassi ewes on basal diet of wheat straw (offered at 750g per ewe daily) and observed that the total milk yield during the 9 week test period increased with increasing level of concentrate, being 58.5, 70.4 and 93.3 kg for the low, medium and high concentrate levels, respectively. They did not observe any treatment effect on lamb growth rate, thus contradicting earlier report (Orr and Treacher, 1994) of significant effect of concentrate level on lamb growth rate. Al Jassim *et al.*, (1999) findings on ability of concentrate to reduce weight loss of lactating ewes were however similar to those of Orr and Treacher (1994).

Although concentrate supplementation improves animal performance, the degree of response depends on the nature of the basal roughage fed, with production response higher with good quality than with poor roughage (Khalili *et al.*, 1994, Orr and Treacher, 1994). Feed intake and milk yield in goats in late lactation were significantly increased by good quality silage compared to poor quality silage when both were supplemented with the same concentrate at the same level (400g hd/d) (Hussain *et al.*, 1996). Hussain *et al.*, (1996) showed that with good quality roughage, low to moderate levels of concentrate are adequate for milk production in lactating ruminants. The result of using model to study the effect of different levels and patterns of concentrate feeding on milk yield of dairy cows showed that increased concentrate usage elicited high total lactation milk yield but profit per cow declined (Doyle,1983). In addition, the author noted that given *ad libitum* access to silage, the economic benefits by flat-rate feeding of concentrate was comparable to stepped-feeding during lactation. In developing countries like Nigeria, concentrate supplements are expensive and are not readily available. The

use of legume forages as alternative supplements has been recommended (Preston and Leng, 1987). Legume forages supplementation to basal diets of roughage to cattle in confinement in Kenya (Muinga *et al.,* 1995), grazing cattle in Nigeria (Ehoche and Buvanendran,1983) and grazing goats in US and Mexico (Romero *et al.,* 1994) showed that in absolute terms, the supplements enhanced higher milk yield. Ehoche *et al.,* (2001) offered 3kg of groundnut haulms supplement per head to grazing Bunaji cattle daily under agro pastoral management and observed that daily milk off-take increased by 32% compared with those without supplement. Further increase of 20% was observed in addition to increased calf growth rate and reduced calf mortality when the supplemented animals were dewormed with anthelmintics. They concluded that adoption of joint forage legume supplementation and helminth control would increase milk offtake, calf growth and income of smallholder dairy farmers. Jones-Endley *et al.,* (1997) found that milk production by grazing dairy cows was more limited by the supply of ME than by CP. Given the variable contents of nutrients of biomass available for grazing especially in Nigeria, the productivity of animals will be enhanced by provision of supplemental energy to grazing. Adamu *et al.,* (1993) concluded from their work on Bunaji heifers grazing native pasture that dry and wet season supplementation of nitrogen, energy, common salt and phosphorus may be beneficial for animals grazing native pastures in the northern Guinea Savanna Zone of Nigeria.

2.6.2 Energy Limitation of Forage Legumes as Supplements

Comparative studies showed that although the cost of feeding was reduced by legume supplementation, legume supplements had lower energy concentration compared with concentrate supplements (Moseley *et al.,* 1994[b]; Mui *et al.,* 2002) and could not elicit

milk yield (Khalili and Varvikko, 1992; Richards *et al.,* 1994[a], Mui *et al.,* 2002) or growth rate (Yates and Panggabean, 1992; 1988; Richards *et al.,* 1994[a], Umunna *et al.,* 1995) to meet the potentials of animals as much as concentrate supplements. In Vietnam, Mui *et al.,* (2002) replaced concentrate for lactating goats on basal diet of chopped whole sugarcane, paragrass and dried cassava root with legume forages-flemingia (*Flemingia macrophylla*) or Jackfruit (*Artocapus heterophyllus*) at 0,20, 40,60 and 80% based on crude protein contents of the concentrate and foliages. They found that daily dry matter intake and milk yield decreased with increasing levels of replacement and attributed it to the attendant low dietary energy intake. Earlier in Kenya, further addition of 1kg of energy concentrate (maize bran) to stall fed cows significantly increased milk yield by 1kg over and above 5.5 kg milk produced daily by animals fed 2kg leucaena milk yield supplement (Muinga *et al.,* 1995). In contrast, Ondiek *et al.,* (2000) did not notice any significant differences in milk yield between dairy goats offered Leuecaena or Gliricidia based concentrate and. their counterparts offered commercial concentrate. The assertion has been made that goats need to select food of high nutrient content as they do not digest low quality roughage to the same extent as cattle, because of their smaller size. However, this view can be challenged by evidence presented by Orr and Treacher (1994), who reported that with forages low in nitrogen content and high in cell walls not properly supplemented, goats have a better digestive efficiency than other ruminants ascribed to the longer mean retention time of disgeta, higher concentration of cellulolytic bacteria and higher efficiency for recycling urea.

2.6.3 Effect of Energy Supplements on Milk Yield and Milk Composition

The most critical period in the production cycle of the dairy animal which affects its milk yield is the transition period. Grummer (1995) defined transition period as 3 weeks before calving to 3 weeks after calving. Furthermore, it is a period when metabolic and endocrine adjustments to support parturition and lactation take place (Moorby *et al.*, 2000: Rabelo *et al.*, 2003). Thus, good nutrition and management during this period are a requirement as they can improve lactation performance (Morand-Fehr and Sauvant, 1978; Chilliard, 1992; Drackley, 1999). More recent study by Patton *et al.,* (2004) showed that it was better to combine protected fat and glucogenic precursors in diet of transition cows to prevent prepartum depression and ensure positive energy balance and higher total lactation milk.

2.6.4 Metabolic Status during Transition Period

Several studies have indicated that metabolic status of animals during transition period triggers some hormonal changes which partition nutrients towards milk production (Mellor *et al.,* 1987). Occurrence of negative energy balance which is typical of this period when high nutrient demand is contrasted with low feed intake (Moorby *et al.*, 2000) is reported to be associated with low plasma insulin (Dewhurst *et al.*,2001; Block *et al.*, 2001), high plasma growth hormone (Block *et al.,* 2001) and glucagons, fetal and mammary tissue growth (Moorby *et al.,* 2000). Block *et al.,* (2001) had established that the onset of negative energy balance near parturition in dairy cows was induced by copious milk secretion and was associated with decreased plasma concentration of leptin. Liefers *et al.,* (2003) observed that when adjustment was made for liveweight and dry matter intake, higher milk yield was related to lower leptin production. Cows which produced more milk, consumed less feed, had more negative energy balance and lower

liveweight. Leptin is a 16-kDa protein hormone synthesized in the white adipose tissue (Ahima and Flier, 2000; Ingvartsen and Biosclaire, 2001; Spiegelman and Filer, 2001), and partakes in the regulation of energy homeostasis and acts primarily on the Central Nervous System (e.g the hypothalamus) (Block *et al.,* 2003; Reist *et al.,* 2003). Plasma level of leptin has been found to be positively associated with energy balance, body condition score, body weight, cholesterol, albumin, insulin, and IGF-1 (Reist *et al.,* 2003), it is negatively associated with DMI, triiodothyronine (Reist *et al.,* 2003), growth hormone and non-estirified fatty acids (NEFA) (McGuire *et al.,* 1995; Block *et al.,* 2001; Block *et al.,* 2003).

2.6.5 Amount of Energy Consumed as a Factor for Milk Production and Postpartum Weight Gains

Several studies with goats have shown that the amount of energy the animal consumed was the major feeding factor which was the most positively correlated with milk production whatever the composition of the diet (Morand-Fehr and Sauvant, 1978). Moreover, at all stages of lactation, milk production was found to depend on energy intake, and milk protein percent increases with energy intake while the reverse is true for milk fat content. The importance of good quality roughage as an essential component of diets for dairy goats to enhance intake and milk yield has also been documented (Morand- Fehr and Sauvant, 1978; Skjevdal, 1981 cited by Hussain *et al.,* 1996; Hussain *et al.,* 1996). Hussain *et al.,* (1996) fed good quality silage, hay or poor quality silage to pregnant Norwegian dairy goats supplemented with 400g concentrate per kg of milk to determine the effect on milk yield. They found that milk yield was higher in goats fed good silage than those fed either hay or poor quality silage which could not support high

persistency of milk yield. The protein, fat, and lactose contents were not generally affected, but there was high somatic cell count in milk of animals fed poor quality silage. The authors concluded that dairy goats should be fed good quality roughage *ad libitum* and supplemented with concentrate during late lactation to maintain production and replenish body conditions.

During early lactation, body weight loss is inevitable because of mobilization of body tissue (Bauman and Currie, 1980) as a result of inability of dietary energy to meet increased energy demand for milk production (Komaragiri and Erdman, 1997). This phenomenon of negative energy balance during early lactation is influenced by genetic merit for milk yield (Grainger *et al.,* 1985; Veerkamp *et al.,* 1994; Buckley *et al.,* 2000) and energy density or quantity of the feed offered (Cowan, 1982). Nutritional manipulation at this stage as demonstrated by the studies of Broster *et al.,* (1997) and Kokkonen *et al.,* (2005) are in part to reduce weight loss while enhancing high milk yield. In addition, Rabelo *et al.,* (2003) reported that high energy density diet significantly increased dry matter intake and milk production in dairy cows when offered immediately after calving and up to period not later than 20 days post-partum.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Location of the study

The study was conducted at the National Animal Production Research Institute, Ahmadu Bello University Shika, Zaria, Nigeria. Shika is located within the Northern Guinea Savannah Zone with an average annual rainfall and temperature of 1,107mm and 24.4^{o} C respectively. The mean monthly temperatures range from 18 to 34^{o} C with daily values and four distinct seasons as described by Ehoche (1987).

3.2 Experimental Animals and design

Twenty pregnant Red Sokoto does of age range, 2-3 years and average live weight of 27.52± 1.74 kg in the last trimester were used in a randomized complete block design to evaluate the effect of groundnut haulms and cowpea husk inclusion in a concentrate mixture on lactation performance. The animals were obtained from the flock of Red Sokoto goats of the Small ruminant Research Programme, National Animal Production Research Institute. There were four treatment groups of five animals per treatment and blocked according to parity.

3.3 Experimental diets

The experimental diets consisted of concentrate mixtures composed of maize offal, cotton seed cake (CSC), bone meal, salt and two legume supplements (groundnut haulms and cowpea husks), and were compounded to be iso-caloric. Groundnut haulms was purchased from open market in Kofa Doka and Dumbi, Zaria. Cowpea husks was purchased from an open market in Giwa. The remaining feed ingredients were obtained

from the stock of feeds supplied to the Institute, while *Digitaria smutsii* hay was obtained from the Forage Production Unit of the Institute. Wooly finger grass (*Digitaria smutsii, stent)* hay was fed as basal diet.

3.4 Management of animals

One week prior to the commencement of the feeding trial, the animals were dipped in acaricide (Asuntol®) solution against ectoparasites and dewormed with anthelmintic drug (Albendazole). The animals were weighed to get their initial weights and thereafter, they were housed in individual feeding pens and offered one of the four concentrate mixtures. During each feeding time, the dams were first given the concentrate mixtures at the rate of 1.8% of body weight (initial weights). *Digitaria smutsii* hay was offered at 2.7% of the body weight in separate troughs provided in the pens. The feeding levels gave hay to concentrate ratio of 60:40. Water was offered in 10 litre capacity plastic buckets to allow *ad libitum* water consumption and changed every morning. Every forthnight, water intake was measured for three consecutive days. The concentrate diets were offered to the animals daily at 0900h after the orts or left-over of the previous day's feeding had been collected and weighed.

After an initial adjustment period of 14 days, daily records were taken of water and the quantity of feeds offered and left-over in order to determined the voluntary feed intake. Weights of dams and their kids were taken forthnightly and the quantity of feeds offered adjusted accordingly.

Table 3.1 Proximate composition of the major feed ingredients (DM basis) %

Feedstuff	DM	CP	CF	EE	NFE	ASH
Maize offal	87.09	10.05	1.70	1.80	60.30	0.80
Cotton seed cake	94.60	21.84	23.50	5.78	34.98	5.14
Cowpea husks	93.46	12.12	34.00	0.68	57.86	7.16
Groundnut haulms	95.65	14.12	23.27	2.47	51.00	8.00

3.5 Milking of animals

After kidding, the dams and kids were weighed to know the parturition weight and birth weight. Milk yield measurement commenced after the kids were allowed to suckle the dams for the first one week postpartum to consume colostrum in order to provide immunity and to establish strong dam-kid relationship to forestall rejection of kids by their dams after overnight separation to measure milk yield (Otaru,2010). Hand milking of animals was done weekly for twelve weeks. The kids were separated from their dams for 12hrs over night (6pm-6am) and re-introduced to their dams after milking. The milk was collected into 1000ml graduated plastic cylinders, and weighed thereafter. Values obtained were multiplied by a factor of 2 to get the milk yield for 24hr. This procedure continued for 12 week postpartum after which the kids were weaned. One hundred mls of milk from each animal was sampled in early lactation, mid lactation and late lactation for the determination of milk composition.

3.6 Metabolism trial

Twelve Red Sokoto bucks of average weight of 19.84 ± 1.42kg and aged 1½ year old were obtained from the Goat project of the Small Ruminant Research Programme, National Animal Production Research Institute, Shika-Zaria, and used to measure nutrient digestibility and nitrogen balance of the diets in the feeding trial mentioned above. The animals were blocked by weight and randomly assigned to the dietary treatments in 3:3 above. There were three animals per treatment group.

3.7 Management of the animals

The animals were dewormed with Albendazole one week to the commencement of the trial. They were weighed before being placed in individual metabolism crates designed for separate collection of faeces and urine. The urine was collected into 5- litre capacity plastic jericans containing hydrochloric acid. The order and rate of feeding the concentrate mixtures and hay were as described in 3.4 above. After 14 days adjustment period, measurements of feed offered, feed left-over, total faeces and urine voided and water consumed were taken for a period of seven consecutive days.

3.8 Sample collection

For each animal, total urine output was collected into plastic containers containing 5ml of 0.2 N H_2S0_4 to trap or prevent loss of nitrogen (ILCA, 1993). Total faecal output from each animal was also collected and weighed fresh. Ten percent of each day's collection was oven dried at 60^0 C for 72 hours, bulked and stored in a refrigerator at -4^0 C. The urine sample was also refrigerated at -4 C and later analysed at the end of the trial. Final weights of the animals were taken at the end of the experiment.

3.9 Chemical analysis

The dried samples of the feed ingredients, diets, faeces were ground through 1mm sieve and further dried at 105^0 C for 12 hours to determine the dry matter content of samples. The nitrogen in the dried samples of feed ingredients, diets, faeces and urine was determined according to Kjeldahl procedure (AOAC 2000), while the fibre contents of the diets, feed ingredients and faecal samples were determined according to the procedure of Goering and van Soest (1970). Crude fibre (CF) Ether Extract (EE) and ash content of the feed ingredients, diets and faeces were determined according to AOAC (2000)

procedures. The samples were ashed by charring in a muffle furnance at 500^0C for 3hrs until whitish ash remained. Metabolizable energy values were determined by the equation: ME (MJ/kg/DM) = 11.78 + 0.0065 + (0.000665 EE) 2- CF (0.00414 EE) – 0.0118A (Alderman and Cottril, 1992).

Milk fat, solid-non-fat and total solids were determined according to Gerber method (volumetric), (1960). Moisture and protein contents of milk were determined according to AOAC (2000) procedure. Lactose content was determined by titremetric method.

3.10 Statistical analyses

Data on daily voluntary and nutrient intakes, average daily gain (ADG) , initial and final live- weights, nutrient digestibility coefficients, nitrogen retention and milk composition were analyzed using analysis of variance (ANOVA). Treatment means were separated using Duncan multiple range test (DMRT), (1985).

Table 3.2 Composition of the experimental diets (%)

Ingredients	Trt 1	Trt 2	Trt 3	Trt 4
Maize offal	60.00	60.00	60.00	60.00
Cotton seed cake	36.00	-	-	-
Groundnut haulms	-	36.00	-	18.00
Cowpea husks	-	-	36.00	18.00
Bone meal	2.50	2.50	2.50	2.50
Salt	1.50	1.50	1.50	1.50
Total	100.00	100.00	100.00	100.00

CHAPTER FOUR

4.0 Results

4.1.1 Chemical composition of experimental diets

The chemical composition of the individual feed ingredients are presented in Table 4.1 The results of the chemical analysis show that all the treatment diets had high dry matter (DM) contents with a mean value of 93.83%. Ether extract is higher in treatment 1 and low in treatment 3. Also, treatment 1 had the highest crude protein (CP) while treatment 3 is the lowest. Crude fibre (CF) concentration was highest in treatment 4 while, treatment 1 was the lowest. Neutral detergent fibre (NDF) concentration ranged from 47.23 in treatment 1 to 52.62% in treatment 3. Acid detergent fibre (ADF) concentration ranged from 29.82 in CSC treatment to 34.94% in treatment cowpea husks. Treatment 1 had the highest ash concentration while treatment 3 is the lowest.

The calculated chemical composition of the experimental diets (Table 4.1), shows that the crude protein (CP) content of the diets was highest in treatment 1 and lower in treatment 3. The metabolisable energy (ME) was higher in treatment 3 and lower in treatment 4.

4.1.2 Voluntary intake

The mean daily intakes of dry matter and water for the various treatments are given in Table 4.2 The total dry matter (DM) intake in absolute terms, ranged from 824.49 g/hd/d for treatment 3 to 948.20 g/hd/d for treatment 1. There was significant treatment effect on intake values on metabolic weight basis and intake as percent (%) body weight. Treatment 3 had significantly ($P<0.05$) lower intake values than treatment 1 (control),

and treatment 2, but similar to treatment 4 . Mean water intake ranged from 1.80 litres/day for treatment 1 (control), to 2.14 l for treatment 2.

4.2.0 Metabolism trial

4.2.1 Nutrient intake and digestibility

Mean daily nutrient intake and digestibility of Red Sokoto bucks are presented in Table 4.3 Dry matter and crude protein intakes in all the treatments are statistically similar ($P>0.05$). There was significant difference ($P<0.05$) in dry matter and crude protein digestibility. Similarly, there was significant treatment effect on digestibility values on acid detergent fibre (ADF) and ether extract (EE).

4.3.0 Nitrogen retention

Mean daily nitrogen intake and retention are shown in Table 4.4 There were significant ($P<0.05$) differences between diets with regards to total nitrogen intake, urine nitrogen output and total nitrogen output. There were however, no significant ($P>0.05$) differences between diets with regards to fecal nitrogen output, nitrogen balance and nitrogen retention.

4.4.0 Milk Yield and composition

Weekly profile of milk yield is shown in Table 4.5 Figure 1 shows the milk yield of Red Sokoto does fed concentrate diets containing groundnut haulms and/or cowpea husks. The peak milk production in all the treatments was at the 4^{th} week of lactation. Before the 4^{th} week of lactation, milk yield steadily increased. There was a steady drop in milk yield from the 4^{th} week to the 12^{th} week of lactation. The average daily milk production, total lactation yield and cost of feed consumed per animal per day are presented in Table 4.6

The total lactation yield and average daily milk production ranged from 39.24kg for treatment 3 to 43.61kg for treatment 1 (control) and 3.27 kg to 3.64kg respectively. For both variables, there was significant difference ($P<0.05$). In terms of cost of feed consumed per head per day, treatment 3 was the cheapest and treatment 1 (control), the most costly. Results of the milk composition of Red Sokoto does is shown in Table 4.7 In absolute terms, there was significant difference ($P<0.05$) on percentage values of moisture, milk fat, milk protein and lactose. Results of the milk composition of Red Sokoto goat milk at different stages of lactation is presented in Table 4.8 The values obtained for milk fat, solid-not-fat decreased slightly with advance in lactation with significant treatment effect ($P<0.05$). In contrast, milk protein increased slightly with advancement in lactation without significant treatment effect ($P> 0.05$). There was also slight decline in lactose contents with advancement in lactation with treatment effect ($P<0.05$). As moisture concentration increased with advancement in lactation, there was a corresponding decrease in total solids concentration which was statistically significant ($P<0.05$).

Table 4.1 Chemical composition of the experimental diets (dry matter basis) %

Parameters	Trt 1	Trt 2	Trt 3	Trt 4	*D.smutsii*
DM	90.86	92.29	94.39	93.61	93.75
CP	18.87	15.20	14.60	15.69	10.69
EE	15.59	13.55	11.00	14.00	10.11
CF	20.87	25.56	26.65	26.94	35.07
NDF	47.23	50.70	52.62	49.82	69.65
ADF	29.82	32.63	34.94	33.44	45.19
A	9.70	7.74	7.64	8.00	7.79

Calculated protein and energy contents of the experimental diets

	Trt 1	Trt 2	Trt 3	Trt 4
CP (%)	13.89	11.11	10.39	10.76
ME (MJ/Kg DM)	10.30	10.37	10.58	10.27

The ME values of the experimental diets were calculated as per Alderman and Cottril

(1992): (ME (MJ/KgDM) = 11.78+0.0065 CP + (0.000665 EE) 2 – CF (0.00414EE) 0.0118A

Where CP = Crude protein , EE = Ether extract, CF = Crude fibre and A = Ash

D.smutsii = Digitaria smutsii, CSC= Cotton seed cake, GH = Groundnut haulms, CH = Cowpea husks.

Table 4.2 Mean daily dry matter and water intake of Red Sokoto does fed concentrate diets containing groundnut haulms and/or cowpea husks

Parameters	Trt1	Trt2	Trt3	Trt4	SEM
Hay dry matter intake (g/hd)	508.09^{ab}	567.08^{a}	454.24^{b}	520.11^{ab}	39.13
Concentrate DM intake (g/hd)	440.11^{a}	350.30^{b}	370.25^{b}	375.00^{b}	30.31
Total DM intake (g/hd)	948.20^{a}	917.38^{ab}	824.49^{b}	895.11^{ab}	58.10
DM intake (kg)	85.33^{a}	82.56^{a}	74.20^{b}	80.56^{ab}	3.66
DM intake as % BW	3.84^{a}	3.72^{ab}	3.34^{b}	3.62^{ab}	0.24
Water intake (L)	1.80	2.14	2.00	2.10	0.19

a, b = Means within the same row bearing different superscripts differ significantly ($P<0.05$).

Table 4.3 Mean nutrient intake and apparent digestibility coefficient of Red Sokoto bucks fed diets containing groundnut haulms and/ or cowpea husks

Treatments	Trt1	Trt2	Trt3	Trt4	SEM
Nutrient intake (kg/day)					
Dry matter intake	0.43	0.40	0.38	0.40	0.05
Crude protein intake	0.04	0.04	0.03	0.04	0.02
Apparent digestibility of nutrients (%)					
Dry matter	65.66^{a}	57.70^{b}	46.67^{c}	58.44^{b}	1.01
Crude protein	63.39^{a}	59.26^{b}	50.67^{c}	60.70^{a}	1.74
Crude fibre	56.86	59.29	58.89	57.64	1.74
Neurtral detergent fibre	59.69	60.43	58.14	58.81	2.09
Acid detergent fibre	52.03^{a}	51.44^{a}	54.69^{a}	47.81^{b}	2.72
Ether extract	80.88^{d}	82.04^{c}	84.75^{a}	83.16^{b}	0.51
Ash	40.00	41.43	43.07	42.55	2.60

a,b,c = Means within the same row bearing different superscript letters differ significantly ($P<0.05$)

Table 4.4 Mean daily nitrogen intake and retention by Red Sokoto bucks fed concentrate diets containing groundnut haulms and/ or cowpea husks.

Parameters	Trt1	Trt2	Trt3	Trt4	SEM
Total nitrogen intake (g)	13.69^{a}	11.86^{b}	10.84^{c}	11.23^{bc}	0.32
Fecal nitrogen output (g)	6.84	5.92	5.38	6.32	0.76
Urine nitrogen output (g)	3.42^{a}	1.98^{b}	3.00^{ab}	2.44^{ab}	0.57
Total nitrogen output (g)	10.26^{a}	7.90^{b}	8.38^{ab}	8.76^{ab}	0.87
Nitrogen balance (g)	3.43	2.96	2.46	2.47	0.52
Nitrogen retention (%)	25.05	24.96	22.69	21.99	3.49

a,b,c = Means with different superscripts on the same row differ significantly ($P<0.05$).

Table 4.5 Weekly profile of milk yield (ml) of Red Sokoto does fed concentrate diets containing groundnut haulms and/or cowpea husks.

Week	Trt1	Trt2	Trt3	Trt4	SEM
1	520.00	510.44	500.00	500.00	15.00
2	535.10	530.00	500.00	520.00	15.00
3	570.00	550.00	510.00	520.00	15.00
4	595.21	580.44	520.00	540.76	15.00
5	540.00	520.00	500.00	500.44	15.00
6	510.00	500.00	475.00	480.00	15.00
7	488.76	400.22	400.00	425.00	15.00
8	440.00	420.00	324.00	385.10	15.00
9	390.00	400.00	310.00	360.00	15.00
10	330.33	360.22	250.00	360.00	15.00
11	290.00	260.00	220.00	290.00	15.00
12	220.00	210.00	200.00	200.00	15.00
Mean	452.45 [a]	436.78[a]	392.42[a]	423.44[ab]	15.00

a,b = Means within the same row bearing different superscripts differ significantly ($P<0.05$)

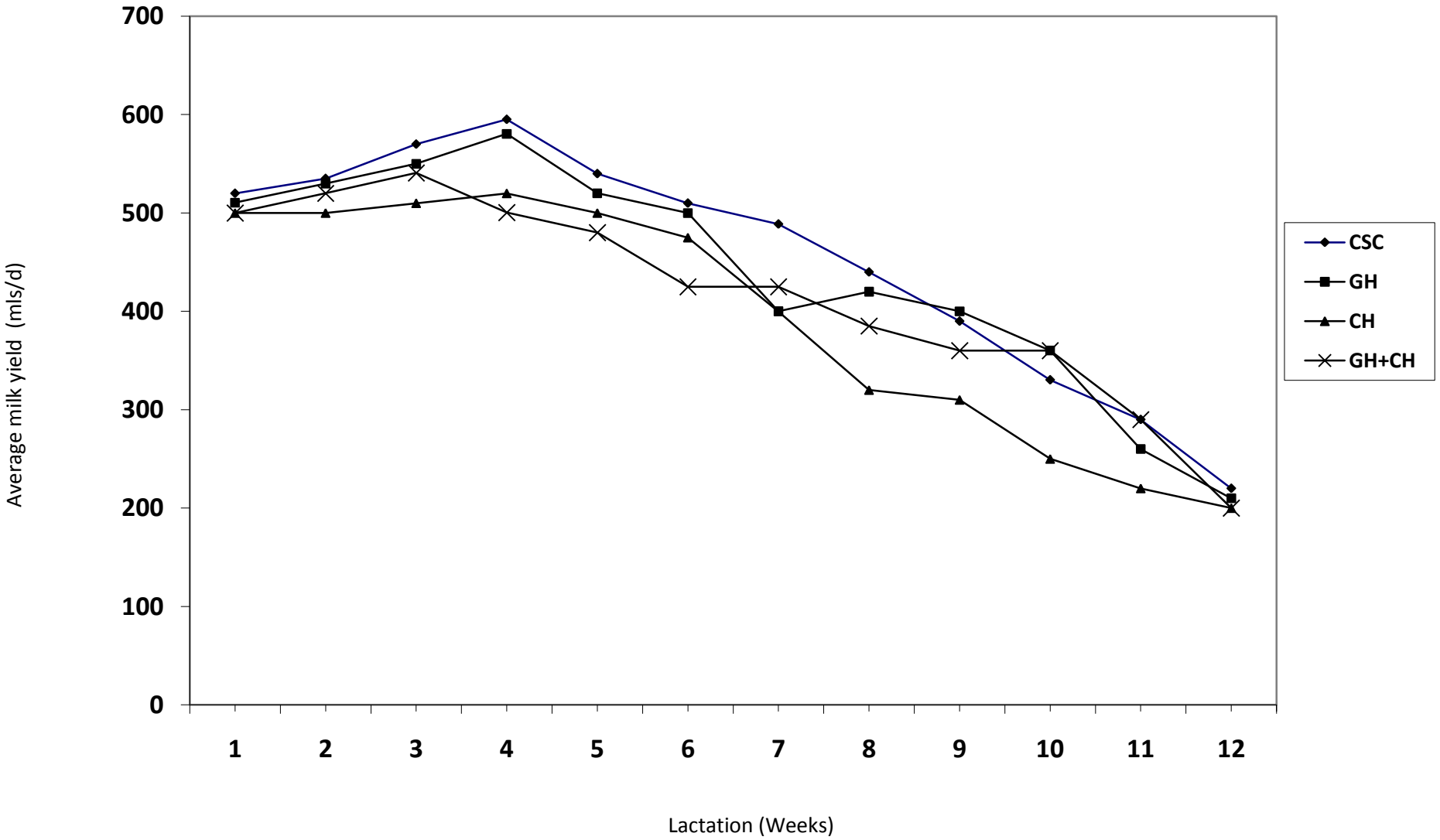


Figure 1: Milk yield of Red Sokoto does fed concentrate diets containing groundnut haulms and/or cowpea husks.

Table 4.6 Effect of supplementation on lactation length, total milk yield, average daily milk yield and cost of the experimental diets of Red Sokoto does

Parameters	Trt1	Trt2	Trt3	Trt4	SEM
Lactation length (days)	90	90 `	90	90	
Total milk yield (kg)	43.61^{a}	42.10^{a}	39.24^{b}	41.10^{ab}	1.30
Average daily yield (kg)	3.92^{a}	3.78^{a}	3.53^{b}	3.69^{ab}	0.10
Cost of feed/hd/day (N)	35.40^{c}	20.50^{b}	17.00^{a}	20.00^{b}	0.64

a, b = Means with different superscript letters on the same row differ significantly ($P<0.05$).

Naira (₦) = Nigeria currency (100 kobo make 1 naira and current exchange rate is 1 US$ to ₦165)

Table 4.7 Effect of supplementation on the milk composition of Red Sokoto does(%)

Parameters	Trt1	Trt2	Trt3	Trt4	SEM
Moisture	85.30^{c}	84.10^{d}	86.20^{b}	86.00^{a}	0.08
Milk fat	5.23^{a}	5.20^{a}	4.96^{b}	5.00^{b}	0.04
Milk Protein	4.48^{a}	4.40^{ab}	4.10^{b}	4.20^{ab}	0.17
Solid-not-fat	9.47	10.70	8.84	9.00	1.20
Total solids	14.70	15.90	13.80	14.00	1.70
Lactose	3.81^{ab}	3.84^{a}	3.74^{b}	3.86^{a}	0.04

a,b,c =Means with different superscripts on the same row differ significantly (P<0.005).

Table 4.8 Composition of Red Sokoto goat milk at different stages of lactation

	Lactation Period			
Constituents (%)	**Early**	**Mid**	**Late**	**SEM**
Moisture	82.00[c]	83.24[b]	84.97[a]	0.08
Milk fat	5.44[a]	5.00[b]	4.64[c]	0.03
Milk Protein	4.28	4.34	4.63	0.19
Solid-not-fat	10.65[a]	10.30[a]	9.80[b]	0.24
Total solids	16.64[a]	15.10[b]	14.20[c]	0.38
Lactose	3.92[a]	3.40[b]	3.80[a]	0.17

a,b,c =Means with different superscripts on the same row differ significantly (P<0.005).

4.5.0: Postpartum body weight changes

Mean liveweight gain of dams and their kids are shown in Table 4.9 Both dams and kids gained weight irrespective of the diet fed. Dams on treatments 2, 4 and 3 recorded the highest weight gain of 4.24, 4.12 and 3.92 kg respectively which was statistically significant ($P<0.05$). Treatment 1 (control) had the lowest weight gain of 2.34kg for dams. Kids of dams on treatment 1 (control), recorded the highest weight gain of 5.00kg. Kids on treatment 3 had the lowest weight gain of 4.02kg which was statistically ($P<0.05$) significant.

Table 4.9 Mean liveweight gain of dams and kids

Parameters (kg)	Trt1	Trt2	Trt3	Trt4	SEM
Doe					
Initial weight	21.94	22.00	21.96	21.98	0.66
Final weight	24.28[b]	26.24[a]	25.88[a]	26.10[a]	0.57
Weight gain	2.34[b]	4.24[a]	3.92[a]	4.12[a]	0.19
Kid					
Birth weight	2.12[a]	1.98[b]	2.10[a]	2.00[b]	0.04
Weaning weight	7.12[a]	6.78[b]	6.12[c]	6.84[b]	0.07
Weight gain	5.00[a]	4.80[b]	4.02[c]	4.84[b]	0.07

a,b,c,d = Means within the same row bearing different superscripts differ significantly ($P<0.05$).

CHAPTER FIVE

5.0 Discussion

5.1.1 Chemical composition

The quantity and type of ingredients used in compounding the diets influenced their chemical compositions. The inclusion of maize offal in diet CSC raised the protein level to a value of 13.89%. This value was lower than the recommended CP level of 15% for optimum production and maintenance (Nuru, 1985) and fell within the range of 8.9-16.0% recommended by NRC, (2001). Similarly, the inclusion of maize offal in diets GH, CH and GH+CH boosted the protein level of the diets to 11.11, 10.39 and 10.76% respectively. These values were within the recommended CP level of 8.9-16% for optimum maintenance and production (NRC, 2001; Nuru, 1985). The metabolisable energy (ME) value of approximately (11.0 MJ/kg DM) across treatments was higher than the 9.50 MJ/kg DM recommended for maintenance by INRA (1988).

5.1.2 Voluntary feed intake

The dry matter intake values (% body weight) in all the treatments agreed with those of Akinsoyinu *et al*., (1977) for goats, and Adu and Lakpini (1983[b]) for sheep. In contrast to a depression of feed intake observed by Adebowale (1981), supplementation with groundnut haulms, cowpea husk or both at 2.5% of body weight enhanced the intake of dry matter in this study.

5.1.3 Milk production

The peak milk yield in Red Sokoto goats at the 4th week of lactation (figure 1), agrees with the findings of Akpa (1999) who reported that peak milk yield in agro pastoral Red

Sokoto goats occurred at the 4th week of lactation. Also, this study is in agreement with previous reports of peak periods for milk yield in tropical goats (Ruvuna *et al.,* 1995). The average milk yield of 3.45kg/week while agreeing with the report of Akinsoyinu *et al.,* (1982) of 3.28kg/week and equivalent to the range of 450-550g reported by Nuru (1985), disagreed with 664g reported by Akpa (1999) and 620g Malau-Aduli *et al.,* (2004), for the same Red Sokoto goat breed. The differences in milk yield could be due to differences in management, diet type, milking frequency and or method of milking. Akpa (1999) report was based on the performance of Red Sokoto goats under the agro pastoral system of management which involves herding of the animals on daily basis and supplementing with agricultural waste and by-products and probably milked more frequently. The current study was conducted under intensive management system, and the animals were milked once on weekly basis. The values obtained for total solids, milk protein, milk fat, solids-non-fat and lactose are comparable to the values obtained by Akinsoyinu *et al.,* (1982), Djibrillou *et al.,* (1998), and Mba *et al.,* (1980). Meanwhile, the average milk protein values obtained in this study (4.30%) (Table 10) disagreed with the value (3.91%) reported by Mba *et al.,* (1975) for WAD goats. Milk fat, solid-non-fat and total solids, steadily declined from early to late lactation. This observation support the report of Mba *et al.,* (1975), but is at variance with the findings of Ahamefule *et al.,*(2004) which showed slight increase in milk fat, solid-non-fat and total solids from early to late lactation. Lactose concentration did not show any pattern, declining from early (3.92%) to mid (3.40%) and rising again in the late (3.80%) lactation. This observation was corroborated by Ahamefule *et al.,*(2004), for WAD sheep.

5.1.4 Liveweight gain of dams and kids

The effects of various crop residues on feed intake, liveweight gains and growth performance of ruminants have been reported by Adu and Lakpini (1983) and Ikhatua and Adu (1984). Adu and Lakpini (1983) obtained liveweight gains of 90.2g per day in Yankasa lambs fed sole diet of unchopped groundnut haulms. Similarly, Ikhatua and Adu (1984) reported that supplementation with groundnut haulms with concentrates further enhanced intake and performance of ruminants. Similar effects of supplementation with groundnut haulms, cowpea husk or both was observed in this study. The efficiency of conversion of feed to meat as reflected by liveweight gains was highest in does fed GH, CH and GH+CH and low in does fed CSC (control). The higher weight gains of does fed GH, CH and GH+CH over those fed the conventional concentrates (CSC) indicated that does in the latter group converted more of their feed to milk rather than meat as evidenced by their higher milk yield values. The observed mean liveweight gains of dams in this study (37.9g/day), disagreed with the report of Adebowale (1989), who included 40% untreated maize cobs in the diets of goats and obtained 24.9g/day weight gain. However, they agreed with the report of Adeneye and Oyenuga (1976), and Ikhatua and Adu (1984). In this present study, it was observed that the dam milk accounted for the growth rate of Red Sokoto kids. Other contributing factors such as the ability of the kids to eat from the dam's diet with advancing age and inherent genetic factors (Otaru, 2010), as a result of selection over the years within the Red Sokoto goats could have influenced growth rate as well. The range of weight gain by Red Sokoto bucklings weaned at 90 days of age (4.12-5.12kg) were comparable to the values of 4.01-6.25kg and 33.11 – 53.88g earlier reported for Red Sokoto bucklings weaned at 90 days by Malau-Aduli *et*

al., (2004) but lower than 7.56kg and 66.43g for the same breed of goat kids weaned at 90 days of age (Ehoche and Buranendran, 1983).

5.1.5 Digestibility of nutrients

The digestibility values obtained for DM, CP, NDF, ADF, CF and ash in this study were generally low to moderate (not exceeding 66%), are comparable to the range of values (42.00 to 69.50%) reported for goats, sheep and cattle (Khalili *et al*., 1994; Malau-Aduli *et al*., 2004), but higher than the range of 21.50 to 52.56% reported for goats and sheep (Murphy *et al*., 1994).

The mean digestibility values of ether extract of above 80% across treatments and the most digested was without significant treatment effect. The lack of treatment effect on the digestibility of EE disagreed with earlier report by Mba *et al.,* (1982) who observed that increasing concentrate level significantly affected ether extract digestibility in WAD kids fed *Gliricidia sepium* basal diet. The inclusion of cotton seed cake, groundnut haulms and cowpea husks in the concentrate diet might have accounted for the high digestibility of EE.

5.1.6 Nitrogen intake and retention

The percent nitrogen retention values across the treatment groups were statistically similar and in positive nitrogen balance. The non-significant treatment effect on the percent nitrogen retention conformed to earlier reports on sheep supplemented with mixture of corn oil and calcium or magnesium salt (Davison and Woods, 1963) and Red Sokoto goats supplemented with palm oil (Otaru, 2010). It however contrasted with the finding of Arieli (1994) who found that nitrogen retention was significantly reduced

compared to the control when whole cotton seed and oil seed was included in the diet at low or high level. Arieli (1994) explained that the lower nitrogen retention of sheep fed whole cotton seed was caused by higher urinary nitrogen loss which was associated with deficit of available energy for microbial protein synthesis.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

The wide variation in milk yield and growth rate in Red Sokoto goats were indications that their dairy and meat potentials are largely unimproved, which could be done through selection, nutrition and better management practices. This study confirmed that Red Sokoto does are able to subsist and make appreciable gains on crop-residue based diets.

It was concluded that GH, CH and GH+CH elicited as much favourable response in liveweight gain, milk yield and composition of Red Sokoto goat milk and can therefore replace the conventional concentrate (CSC), which may be too expensive for the peasant farmer to purchase without any adverse effect.

6.2 Recommendations

From the results of these studies, it is recommended that:

1. 36% of CSC can be replaced by GH or CH in a concentrate diet for lactating Red Sokoto Does.
2. Combination of GH+CH gave better performance and reduce cost of production.
3. Furthermore, GH was a better ration than CH and GH+CH and is therefore recommended to small ruminant farmer due to its high intake and digestibility by the animals.

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